Ecology of Benthonic Species

GEOLOGICAL SURVEY PROFESSIONAL PAPER 429-B

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By PATSY B. SMITH

RECENT FORAMINIFERA OFF CENTRAL AMERICA

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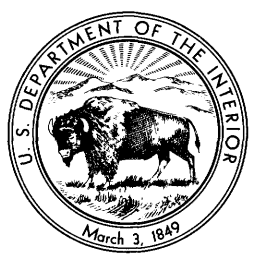
A discussion of depth distribution of Foraminifera and ecologic factors off El Salvador, including a comparison with other Pacific coast areas



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RECENT FORAMINIFERA OFF CENTRAL AMERICA

ECOLOGY OF BENTHONIC SPECIES

By PATSY B. SMITH

ABSTRACT

Benthonic foraminiferal faunas off El Salvador can be divided into six faunal zones: A, 0 to 30 meters; B, 30 to 60 meters; C, 60 to 150 meters; D, 150 to 600 meters; E, 600 to 1,300 meters; and F, 1,300 to more than 3,200 meters. The faunal composition of zones A, D, E, and F off Central America is similar to that of equivalent zones off California; zones B and C are characterized by different species in the two regions. Zonal boundaries are at greater depths off California than off El Salvador.

Physical and chemical factors that appear to influence distribution of Foraminifera are: depth; temperature, salinity, and oxygen content of the water; and nitrogen content and grain size of the bottom sediments. Salinity and oxygen values are very similar at corresponding zonal boundaries off California and off Central America. Temperature at these zonal boundaries is 5° to 10° higher in the shallow zones and 2° to 3° higher in the deep zones off Central America than off California, although the amount of seasonal variation is similar. Nitrogen values are similar in the two regions. Data on grain size are inadequate for comparison.

The significance of the factors varies from zone to zone. Zone A is characterized by wide variations in temperature and salinity, and the species of this zone are those that can tolerate such wide variations.

Zone B is subject to smaller seasonal variations, and its base is close to the bottom of the thermocline. It is characterized by different species off Central America than off California; water temperatures in this zone off Central America are higher than off California. Therefore species of this zone must be sensitive to the wide temperature difference between North American and Central American waters, though able to tolerate some variation in temperature and salinity.

Zone C is below the thermocline and therefore subject to little seasonal temperature variation. Like zone B, it is distinguished by different species off North and Central America. Species of this zone tolerate, or may even require, cooler water and smaller seasonal variation than those of shallower zones.

Zones D, E, and F are on the continental slope. Physical and chemical factors show little if any seasonal variation. Temperature decreases with increasing depth; oxygen reaches a minimum in zone D and then increases downward. Faunal differences between these zones must be controlled largely by downward decrease of temperature combined with uniform seasonal environment.

Zones A, B, and C have small depth ranges; zones D, E, and F have large ones. In these latter zones, infraspecific morphologic variations have been found, with deeper water forms (more than 800 meters) tending to have well-developed costae, keels, or carinae.

INTRODUCTION

In December of 1955 a suite of bottom samples was collected off El Salvador, Central America. (See Smith, 1963 and index map, fig. 1.) Sampling was done in cooperation with the Scripps Institution of Oceanography from their vessel *Spencer F. Baird.* Twenty-two core samples were taken on two traverses, at depths ranging from 20 to 3,200 meters. Samples were taken across the Continental Shelf at evenly spaced intervals, but stations on the slope were chosen by depths, and an attempt was made on the second traverse to duplicate sample depths of the first. There is great similarity of faunas from similar depths along the two traverses. Quantitative analyses of species of the genus *Bolivina* (Smith, 1963) from such paired samples demonstrates this similarity.

The region off El Salvador was chosen for two reasons: relatively short traverses include the entire width of the Continental Shelf and slope, and the bottom deposits consist mostly of volcanic detritus and hence are free from contamination by reworked fossil Foraminifera.

The top centimeter of each recovered core was removed and retained in alcohol to preserve living forms; this report describes the Foraminifera from these preserved samples. Determinations of temperature and chemical factors were made on the supernatent water. A complete discussion of sampling and laboratory methods is given by Smith, 1963.

Quantitative and qualitative variations found in species of the family Bolivinidae are described by Smith (1963). In this report the distribution of all benthonic Foraminifera and the ecologic factors off El Salvador are described and are correlated with data

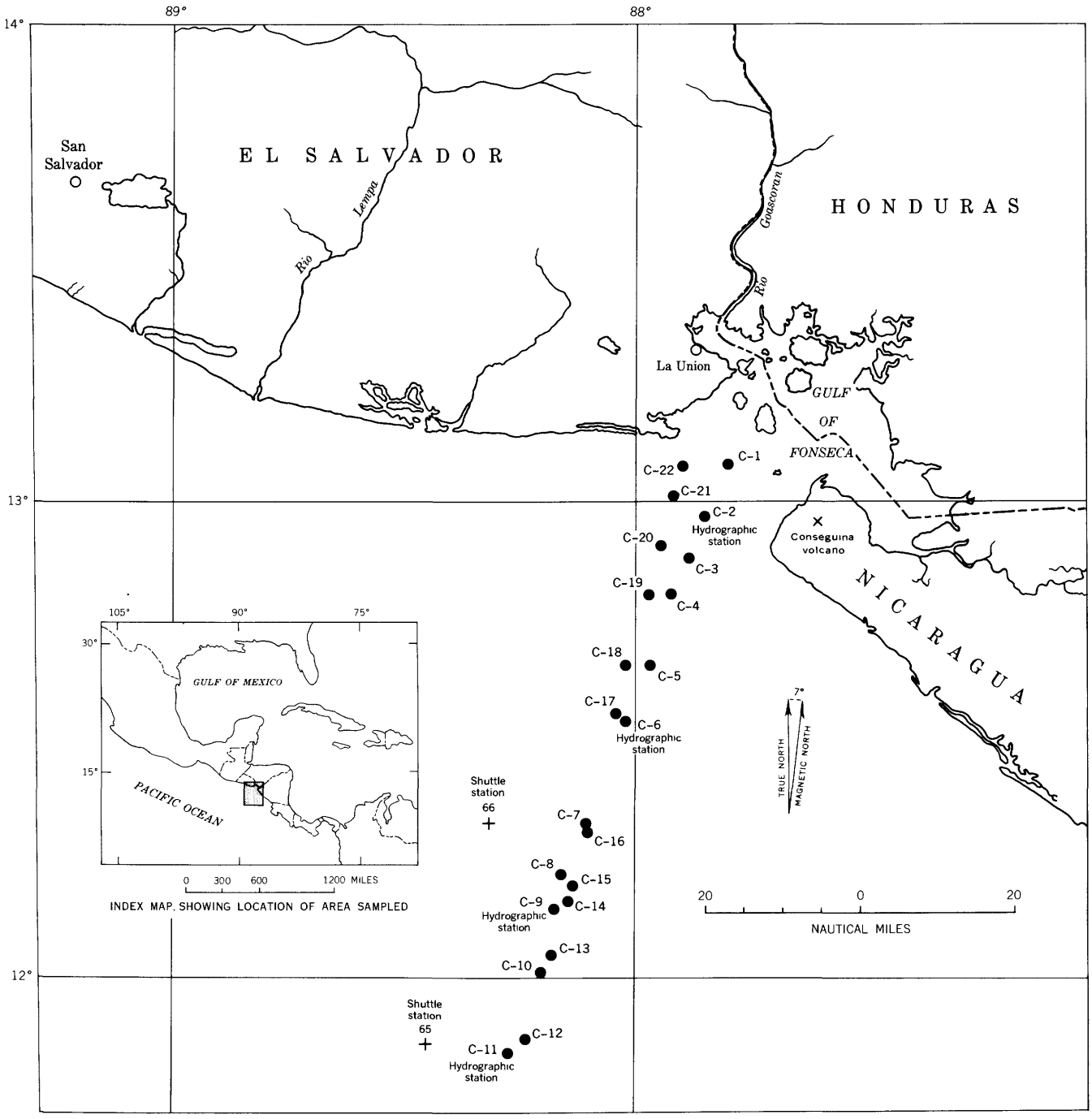

FIGURE 1.—Coast of El Salvador, showing positions of hydrographic stations and locations where samples were collected.

from other Pacific coast areas. To make such a correlation meaningful, specimens of species used by other authors in these Pacific coast areas were examined and these species are included in synonymies in the taxanomic part of this report.

ACKNOWLEDGMENTS

This work was made possible by the generous cooperation of the Scripps Institution of Oceanography. Sampling was done from the Scripps vessel *Spencer F. Baird*, on the Eastropic expedition, through the courtesy of Roger R. Revelle, director of the institution, and of Townsend Cromwell and Warren Wooster, who planned and organized the expedition. Max Silverman and Ray Ghelardi did the sampling. Water analyses were made by N. W. Rakestraw and D. M. Brown of the Scripps Institution.

Heinz Lowenstam of the California Institute of Technology furnished much helpful comment. O. L. Bandy of the University of Southern California helped greatly by discussions and by permitting me to compare my specimens with his eastern Pacific material.

Analysis of the light fraction of the bottom sediments was made by R. C. Erd of the U.S. Geological Survey.

To A. O. Woodford of Pomona College special acknowledgment is due for his analysis of heavy minerals and for his help and encouragement.

PREVIOUS WORK

Many excellent studies have been made of present-day Pacfic coast Foraminifera. Natland (1933) described the depth and temperature distribution of Foraminifera in Catalina Channel, off Southern California; Bandy (1953) described the distribution of Foraminifera and physical and chemical factors in three traverses off California; Crouch (1952) described the significance of temperature on foraminiferal distribution in the deep basins off southern California; Walton (1955) described Foraminifera and sediments of Todos Santos Bay, Baja California; Bandy and Arnal (1957) those off Central America; Resig (1958) those of Santa Cruz Basin, off southern California; and Uchio (1960) those off San Diego. Walton, Resig, and Uchio compared the distribution of living and dead faunas. Wherever possible, type specimens of Foraminifera described in the above papers were examined and compared with those off El Salvador.

Most of these papers discuss distribution of Foraminifera in relation to depth, temperature, and salinity. A few discuss the oxygen content of the water and grain-size and nitrogen content of the bottom sediments. A comparison of the physical and chemical data from five of these studies with comparable data from samples off El Salvador is included in this paper. Supplementary data are adapted from Revelle and Shepard (1939), Sverdrup and Fleming (1941), Emery and others (1952), Dill (1952), and unpublished data from the Scripps Institution of Oceanography.

Other papers describing distribution of Foraminifera have been helpful; Reiter (1959) and Zalesney (1959) described foraminiferal zonation in Santa Monica Bay, California, and McGlasson (1959) described the zonation around Catalina Island. In these papers the species were not illustrated, and I have not seen any of the specimens discussed therein; I therefore do not compare the data in these papers with my own.

Descriptive papers by Cushman and McCulloch (1939, 1940, 1942, 1948, and 1950), Lalicker and McCulloch (1940), and Cushman (1927) have been helpful, but they contain very few ecologic data except in regard to depth.

ECOLOGIC FACTORS

Physical and chemical factors believed to affect the distribution of Foraminifera are depth, temperature, salinity, and oxygen content of the bottom water, and organic content (approximately proportionate to the nitrogen content) and grain size of the sediments. The measurements on bottom-water samples described in this paper were made at the time of sampling (table 1) and are plotted graphically in figure 2. The analyses of bottom sediments described here were made later. The data for waters off El Salvador are described below; in a previous section (p. B2) they are compared with data from other Pacific coast areas.

TABLE 1.—*Depth, temperature, and chemical data for bottom-water samples*

[Determinations by N. W. Rakestraw and D. M. Brown, Scripps Inst. of Oceanography]

Sample	Depth (meters)	Temperature (°C)	Salinity (parts per thousand)	O_2 (milliliters per liter)	pH	Core length (inches)	Remarks
C-1	20	24	33.51	2.35	7.95	40	Green mud.
C-2 [1]	37	20	34.29	1.64	7.98	22	Green mud and sand.
C-3	46±					3	Shelly fine-grained sediments lost.
C-4	50±	15	34.47	.92	7.90	13	Silt and medium-fine sand.
C-5	74±					10	Shells present.
C-6 [1]	80	10	34.81	.61	7.90	21	Gray-green mud.
C-7	140					1	Sand.
C-8	450					1	Ash.
C-9 [1]	885±	5	34.56	.30	7.72	41	Gray-green mud.
C-10	1,700±	3			7.77	46	Green mud.
C-11 [1]	3,200±	1.7	34.68	2.48	7.82	41	Do.
C-12	3,100±	1.7	34.60	2.72	7.87	41	Do.
C-13	1,600±	3	34.61	1.28	7.79	44	Do.
C-14	800±	5	34.57	.54	7.70	39	Do.
C-15	435±	7	34.63	.38	7.71	13	Do.
C-16	144±					1	Sand.
C-17	82±	10	34.83	.58	7.86	17	Green mud.
C-18	64±	17	34.64	.86	7.79	11	Marly sand.
C-19	50±	15	34.47	1.15	7.87	13	Sandy clay.
C-20	47±	15	34.43	1.22	7.93	26	Silty sand and shells.
C-21	45					3	Do.
C-22	21±					51	Green mud.

[1] Hydrographic station occupied at this locality.

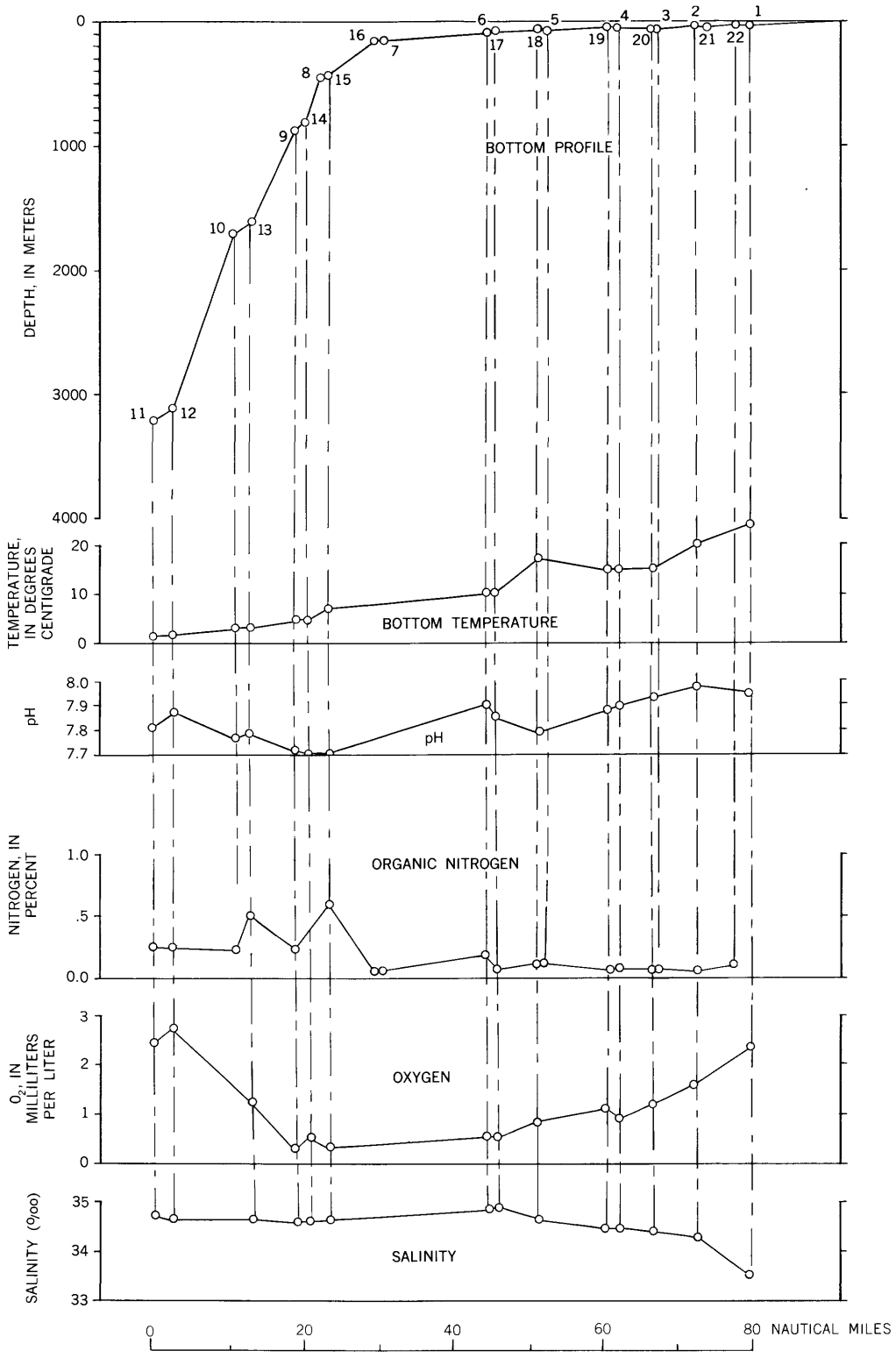

FIGURE 2.—Depth, temperature, and chemical profiles of bottom-water and sediment samples.

WATER SAMPLES

Four hydrographic stations were occupied along the first traverse, at which water samples were taken from various depths by means of Nansen bottles. (See map, fig. 1.) The same data were obtained for these samples as for bottom-water samples (table 2). Temperature and salinity data from two hydrographic stations occupied by the Shuttle expedition in June 1952 are given in table 3.

Data for hydrographic-station samples are included for two reasons: to describe the characteristics of the sea water as compared with the bottom water and to allow comparison with similar data provided in other papers on foraminiferal ecology. A complete description of the waters of the eastern tropical Pacific Ocean is given by Wooster and Cromwell (1958).

TABLE 2.—*Hydrographic data at core stations*

Depth (meters)	Temperature (°C)	Chlorinity (parts per thousand)	Salinity (parts per thousand)	pH	Oxygen (milliliters per liter)
Core Station C-2					
0	28. 4	18. 12	32. 74	8. 24	4. 75
8	28. 4	18. 15	32. 79	8. 28	4. 79
16	25. 4	18. 54	33. 49	8. 01	2. 85
Core Station C-6					
0	27. 2	18. 25	32. 98	8. 27	4. 69
20	27. 1	18. 25	32. 97	8. 26	4. 91
40	24. 4	18. 59	33. 58	8. 15	3. 36
60	15. 9	19. 25	34. 78	7. 89	0. 71
Core Station C-9					
0	27. 1	18. 18	32. 84	8. 22	4. 87
27	27. 1	18. 20	32. 88	8. 28	4. 87
42	26. 6	18. 36	33. 18	8. 24	4. 60
51	22. 2	18. 87	34. 09	8. 09	2. 64
60	16. 4	19. 24	34. 77	7. 97	1. 27
70	15. 5	19. 28	34. 84	7. 93	0. 82
80	14. 6	19. 30	34. 87	7. 88	0. 39
90	14. 2	19. 31	34. 89	7. 87	0. 22
196	13. 0	19. 28	34. 84	7. 86	0. 40
272	11. 6	19. 24	34. 76	7. 84	0. 20
365	9. 5	19. 17	34. 64	7. 79	0. 19
458	8. 1	19. 15	34. 61	7. 80	0. 12
Core Station C-11					
0	27. 1	19. 14	33. 03	8. 15	4. 64
25	27. 2	19. 15	33. 03	8. 19	4. 57
48	26. 5	19. 28	34. 97	8. 09	4. 58
95	13. 9	19. 29	34. 83	7. 85	0. 21
141	13. 0	19. 28	34. 85	7. 80	0. 41
231	12. 1	19. 36	34. 83	7. 79	0. 21
466	8. 4	18. 28	34. 60	7. 76	0. 08
702	6. 6	19. 28	34. 58	7. 73	0. 13
938	5. 3	19. 13	34. 57	7. 66	0. 30
1405	3. 9	19. 13	34. 57	7. 78	0. 28
1870	3. 0	19. 12	34. 65	7. 84	1. 79
2337	2. 4	19. 16	34. 62	7. 90	2. 37
2799	2. 3	19. 17	34. 63	7. 90	2. 55

TABLE 3.—*Temperature and salinity data from Shuttle expedition, June 1952*

Depth (meters)	Temperature (°C)	Salinity parts per thousand
Shuttle station 65; lat 11°51′ N., long 88°28′ W.; sounding (F) 3165		
0	28. 91	33. 62
10	28. 55	33. 62
26	21. 63	34. 54
51	16. 97	34. 77
77	14. 97	34. 90
102	14. 34	34. 91
152	13. 49	34. 92
202	12. 84	34. 88
300	11. 54	34. 79
401	10. 00	34. 71
498	8. 27	34. 62
502	8. 19	43. 64
599	7. 09	34. 58
604	7. 07	34. 58
750	6. 00	34. 54
801	5. 67	34. 54
852	5. 45	34. 56
901	5. 15	34. 56
952	4. 84	34. 55
1003	4. 60	34. 57
1054	4. 40	34. 56
1104	4. 17	34. 58
1207	3. 83	34. 60
1411	3. 20	34. 60
Shuttle station 66; lat 12°19′ N., long 88°19′ W.; sounding (F) 868		
0	29. 48	33. 49
10	28. 81	33. 85
24	27. 18	33. 91
49	17. 61	34. 73
72	15. 40	34. 88
96	14. 55	34. 89
144	13. 93	34. 89
191	13. 47	34. 88
240	12. 86	34. 85
288	12. 17	34. 81
386	10. 42	34. 70
483	8. 10	34. 62
580	7. 03	34. 58
678	6. 25	34. 57

A graphic comparison of bottom-water data with those from the four samples taken at hydrographic stations is made in figures 3–5. These diagrams indicate that the bottom-water samples differ more or less systematically from those of the overlying ocean water in temperature and oxygen content but do not differ much in salinity (which is fairly constant below 75 m).

Temperature measurements from core water (table 1), hydrographic-station samples (table 2), and bathythermographs at all core stations are shown in figure 3. At all stations the temperature of bottom water is lower than that of the water samples from comparable depths at hydrographic stations, indicating that caution must be used in substituting one for the other. The thermocline occurs between 60 and 80 meters. In June (table 3), the thermocline is between 25 and 50 meters. Other than this there is little variation between June and December water temperatures.

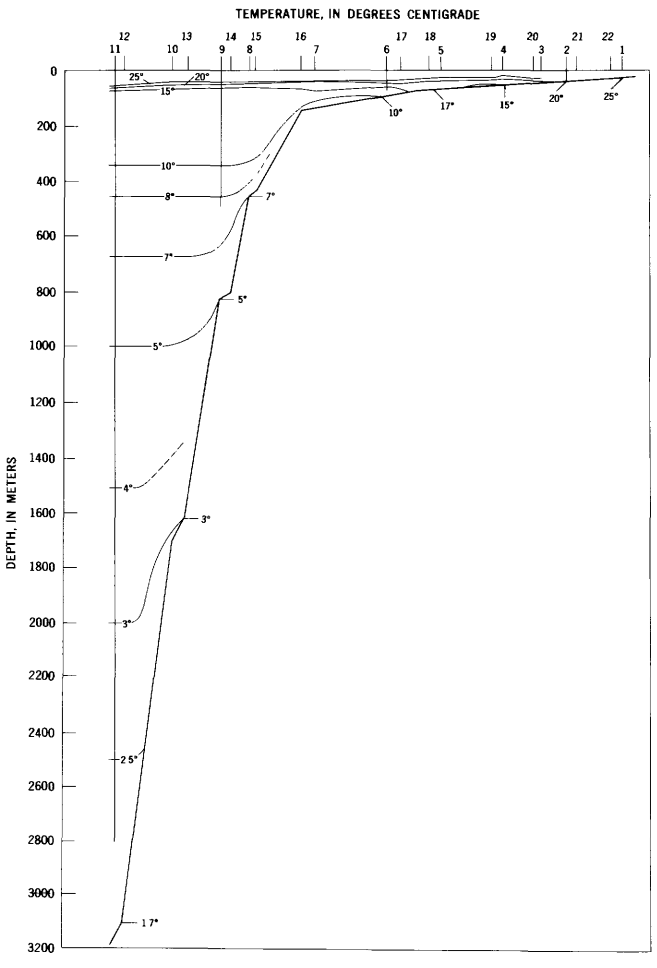

FIGURE 3.—Range in temperature, in degrees Centigrade, of water determined from bathythermographs, hydrographic-station samples, and bottom-water samples.

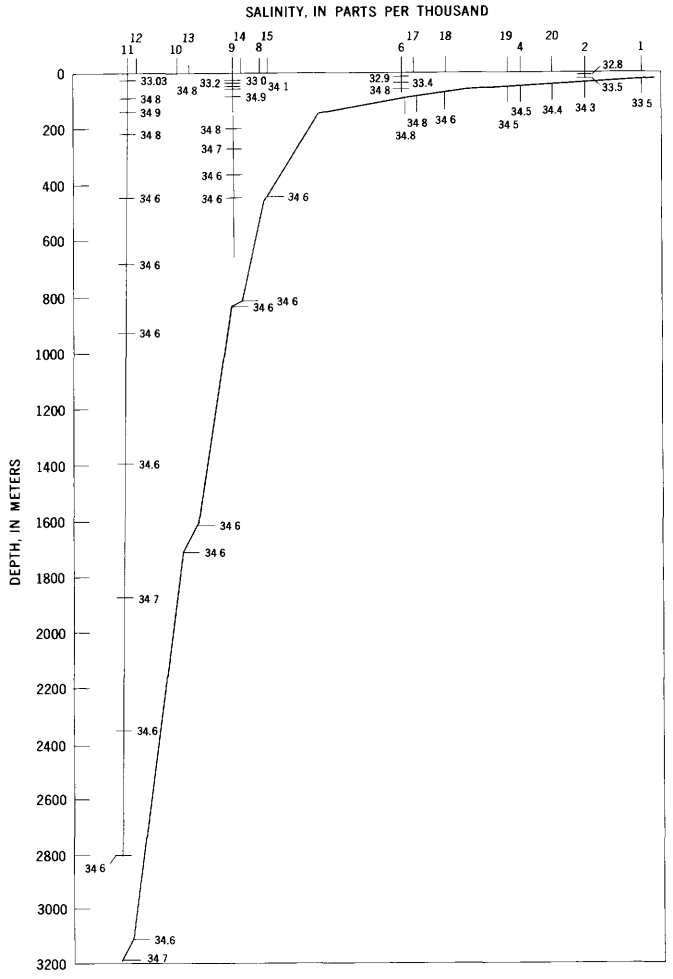

FIGURE 4.—Range in salinity, in parts per thousand, determined from hydrographic-station samples and bottom samples.

Salinity data for bottom-water samples and hydrographic-station samples obtained in December are shown in figure 4. Surface salinity increases from 32.7 parts per thousand near the outlet of the Gulf of Fonseca to 33.6 parts per thousand 80 miles from the coast. At all stations, the salinity of water from depths of 50 to 75 meters reach 34 parts per thousand or more; below that depth it remains quite constantly within the range 34.6 to 34.9 parts per thousand. Bottom salinities are similar to those of samples taken from similar depths at hydrographic stations. Water salinity in June —the end of the dry season—(table 3) is greater than it is in December down to depths of several hundred meters, owing to decreased rainfall and stream discharge in the preceding 6 months.

Distribution of oxygen from bottom-water and hydrographic-station samples is shown in figure 5. Oxygen content varies much less in the bottom water than in the water above it. In hydrographic-station samples, values of 4 ml per l (milliliters per liter) persist from depths of 0 to 50 meters; on the bottom, oxygen falls from 2.35 ml per l at 20 meters to 0.92 ml per l at 50 meters. Bottom-water oxygen values reach their minimum of 0.3 ml per l between 435 and 900 meters. In the hydrographic-station samples, oxygen values fall sharply below 50 meters, reaching their minimum of 0.08 ml per l at around 500 meters, and values less than 0.3 ml per l persist from depths of 200 to more than 1,600 meters. Below 1,600 meters the oxygen content of all water samples rises, reaching values greater than 2.5 ml per l at the greatest depths sampled.

BOTTOM SEDIMENTS

Sediment-size analyses were made by the Oil and Gas Laboratory of the U.S. Geological Survey, and the results are given in table 4. The data from table 4 are plotted as frequency curves, and samples from the same depth on the two traverses are superimposed (fig. 6). Samples on the shelf are predominantly fine or very fine sand, but samples contain relatively high

TABLE 4.—*Grain size of bottom sediments off El Salvador*

[Analyses by Oil and Gas Laboratory, U.S. Geol. Survey]

Sample and depth	Grain size (mm) percentages														
	>2.0	>1.0	>0.70	>0.50	>0.35	>0.25	>0.175	>0.125	>0.088	>0.062	>0.050	>0.025	>0.005	>0.002	>0.000
C–1 (20 m)	4.4	0.3	0.8	3.6	7.1	9.4	6.1	6.8	12.5	[1] 24.3	[1] 24.7				
C–2 (37 m)	.1	.4	2.1	5.2	6.9	13.7	18.1	18.3	10.0	10.8	[1] 14.4				
C–4 (50 m)	.9	.8	.6	1.2	4.3	10.4	9.9	15.3	20.2	17.7	[1] 18.7				
C–19 (50 m)	1.4	1.9	1.6	2.6	4.0	10.0	13.0	24.4	19.5	11.0	[1] 10.6				
C–18 (64 m)	16.1	2.3	1.3	1.7	2.6	8.2	11.0	11.9	21.3	16.4	[1] 7.2				
C–17 (82 m)	.4	.4	.8	1.9	2.9	6.5	9.8	18.8	24.5	18.0	[1] 15.1				
C–6 (80 m)	.2	1.0	1.4	2.8	4.7	14.2	17.3	18.9	19.6	12.3	[1] 7.6				
C–15 (435 m)							3.0	4.0	5.7	17.6	[1] 69.7				
C–8 (450 m)	.1	.1	.1	.2	.2	.7	1.7	3.7	6.1	11.7	10.6	21.9	27.1	6.8	9.0
C–14 (800 m)						.9	9.4	16.8	19.2	15.8	[1] 37.9				
C–9 (885 m)				.1	4.3	8.5	10.1	18.0	23.5	15.1	[1] 20.4				
C–12 (3,100 m)								3.8	5.0	10.8	[1] 80.4				
C–11 (3,200 m)						.2	1.4	3.8	5.9	16.9	[1] 71.8				

[1] Figures ending at this point indicate total percentage of silt and clay.

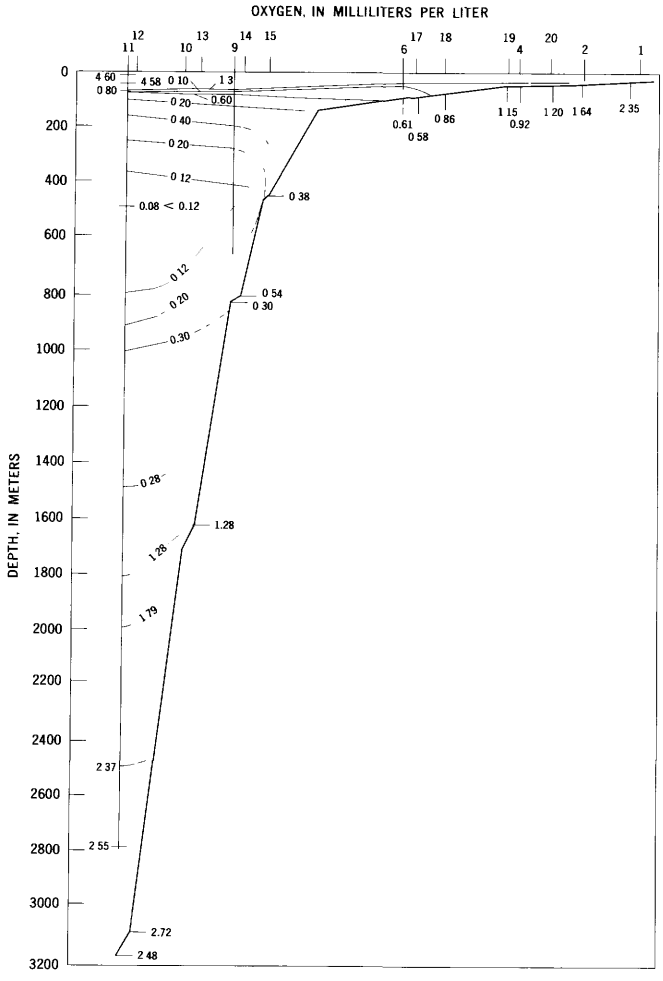

FIGURE 5.—Oxygen content, in milliliters per liter, of water from hydrographic-station samples and bottom-water samples.

percentages of granule and medium sand-size particles. On the continental slope, sediments are predominantly silt and clay, although samples from 800 to 885 meters are largely very fine sand.

Mineral composition of the sediments was determined on the very fine sand fraction. Composition of the light fraction was determined by R. C. Erd, of the U.S. Geological Survey. It consists of high percentages of quartz and feldspar with lesser amounts of volcanic glass. These constitute the bulk of all samples, but the percentage of glass increases as water deepens.

Heavy-mineral analyses of the very fine sand fractions were made by A. O. Woodford. The percentage of heavy minerals in this fraction decreases slightly on the slope with increasing depth, but the mineral composition remains remarkably uniform (fig. 7). The heavy minerals include opaque minerals, (mostly magnetite), hypersthene, augite, hornblende, and minor amounts of olivene and miscellaneous minerals. The percentages of these minerals are similar to those of the calcic volcanic rocks of El Salvador (Williams and Meyer-Abich, 1955).

NITROGEN

Nitrogen content is a measure of the organic matter present in the sediments. Nitrogen analyses were made on the bottom samples taken off El Salvador, using the micro-Kjeldahl method. Nitrogen values (table 5)

TABLE 5.—*Percentage of nitrogen in samples of sediment*

[Analyst, E. J. Forslow, Hazelton Nuclear Science Corp., Palo Alto, Calif.]

Sample	Nitrogen (percent)	Sample	Nitrogen (percent)
C–2	0.07	C–12	0.28
C–3	.07	C–13	.51
C–4	.07	C–15	[1].61
C–5	.12	C–16	.05
C–6	[1].19	C–17	[1].07
C–7	.05	C–18	.12
C–9	[1].24	C–19	.06
C–10	[1].23	C–20	.06
C–11	.27	C–22	.10

[1] Sample size inadequate to assure accurate values.

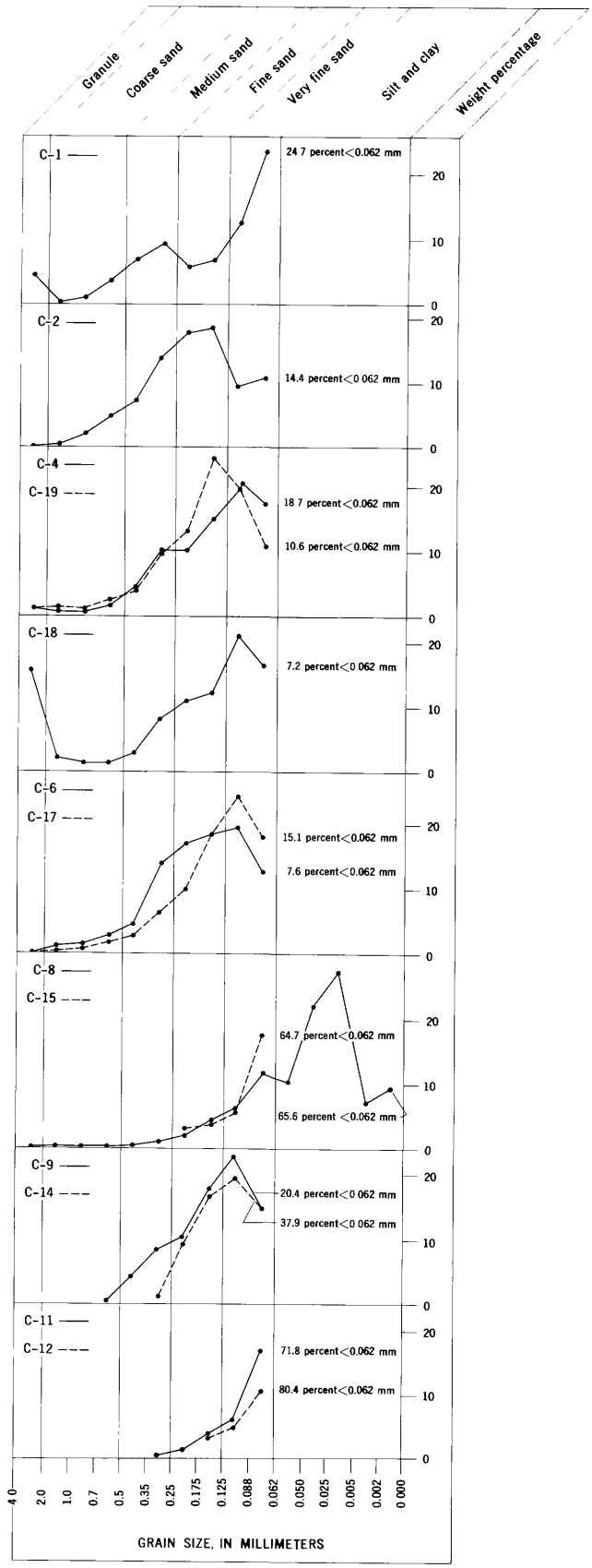

FIGURE 6.—Grain-size frequency curves for samples of sediment.

on the Continental Shelf range from 0.05 to 0.19 percent. Nitrogen percentage is higher on the slope, reaching the highest values (greater than 0.50 percent) near the oxygen minimum. Below this, values decrease, averaging 0.26 percent in the depth range of 1,700 to 3,200 meters. There is a correlation between grain size and nitrogen content of samples, the finer grained samples having a higher nitrogen content than the coarser grained ones.

LIVING SPECIMENS

Alcohol was added to the samples soon after collection to preserve protoplasm in the Foraminifera, and rose Bengal was added to the samples to determine whether any protoplasm was present (Walton, 1952). Living populations are much smaller than those reported by Uchio (1960) from off San Diego, or by

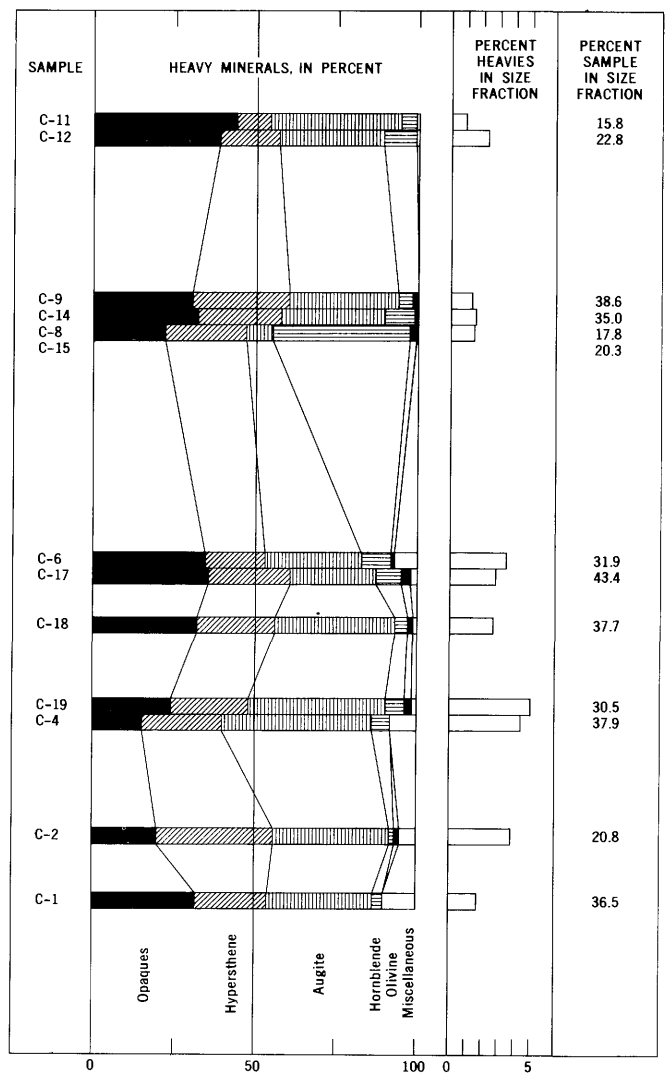

FIGURE 7.—Heavy minerals in the 0.125 to 0.062 size fraction of samples of sediment.

Walton (1955) from Todos Santos Bay, Baja California. Total living populations are shown in table 6. Living populations on the Continental Shelf range from 2 specimens per 100 to 4 living specimens per 10,000 dead. On the upper part of the continental slope, living populations average 1 specimen per 100, whereas lower on the slope the living population is as high as 73 per 100.

For most species the total depth range is greater for dead specimens than for living specimens. For the living specimens, however, the range is generally similar to the range of abundant dead specimens, so that for purposes of zonation the range of abundant dead specimens and range of living specimens are equated.

FORAMINIFERA OFF EL SALVADOR

FAUNAL ZONATION

The foraminiferal faunas off El Salvador can be divided into six faunal zones with increasing depth of water. Because the boundaries between these zones do not correspond with boundaries of marine environments, such as the neritic zone, or the edge of the Continental Shelf, zones are given letter designations; zone A is the shallowest, zone F the deepest.

Faunal zones in this paper are based on the restricted or most abundant occurrence of several species. The exact position of zonal boundaries is uncertain and can only be stated to be between sample localities. The relative abundance of species in all samples is shown in figure 8, in which the species are arranged in order of abundance, those occurring abundantly in shallow water being listed first. The presence of living specimens is also indicated. Faunas fall into six groups, and each group is considered to characterize a faunal zone.

Zone A is restricted to depths less than 40 meters (samples C–1, C–2) and is characterized by extremely abundant *Streblus beccarii. Nonionella basispinata*, *Elphidium tumidum*, *E. spinatum*, and *Textularia panamensis* occur mainly in this zone.

Zone B is present on the inner part of the Continental Shelf, to depths of more than 60 meters (samples C–20 to C–18); it is in this zone that *Bolivina vaughani*, *Hanzawai concentrica*, *Cancris sagra*, *Textularia secasensis*, *Planulina exorna*, and *Bulimina denudata* are most abundant.

Zone C occupies the outer shelf and upper slope, from depths of approximately 65 to 130 meters (C–6, C–17), and is characterized by great abundance of *Bolivina striatula*, *Epistominella exigua*, *Cassidulina minuta*, *C. oblonga* and *Cancris panamensis.*

Zones D, E, and F are on the continental slope. Zone D (samples C–7, C–16) at depths between about 130 to 400 meters, is characterized by *Bolivina acuminata*, *B. interjuncta bicostata*, *Uvigerina incilis*, *Angulogerina semitrigona*, *Epistominella bradyana*, *Pullenia salisburyi*, and *Cassidulina laevigata.*

Zone E (samples C–15 to C–9), at depths of approximiately 400 to 1,200 meters, is distinguished by the restricted occurrence of *Uvigerina excellens*, *Bolivina pseudobeyrichi*, *Cassidulina tumida*, *Gyroidina multilocula*, *G. nitidula*, and *Epistominella obesa.* Many other species occur only rarely above or below Zone E, including *Angulogerina carinata*, *Bolivina humilis*, *B. subadvena*, *B. argentea*, *B. seminuda. Cassidulina cushmani* occurs abundantly in the lower part of Zone E and upper part of zone F.

Zone F (samples C–13 to C–11), at depths of about 1,600 to greater than 3,200 meters, is characterized by the restricted occurrence of *Uvigerina auberiana*, *Bulimina subacuminata*, *B. mexicana*, *Pullenia bulloides*, *Nonion affine*, *Gyroidina altiformis*, and *Ehrenbergina undulata. Epistominella smithi* and *Cibicides mckannai* are more abundant in this zone than in any other.

SPECIFIC VARIATION

Both the abundance and the morphology of foraminiferal species vary with depth of water. The abundance of tests of species is shown in table 6, and species are listed systematically. The number of living specimens is also shown. Generally, where abundant dead specimens of a species are found, living specimens occur also. The depth range generally extends to greater depths for dead specimens than for living specimens, probably owing to downslope drift of dead tests.

In many species, morphology as well as abundance varies with depth. What physical advantages are conferred upon the individual by these variations is not clear, and whether all such variations are observable in other areas is not known. These variations are summarized below, and, where possible, are illustrated by drawings (figs. 9–17).

Reophax dentalinaformis.—This species reflects the grain size of the sediment in which it occurs. Specimens from C–6 (fig. 9*A*), where median grain size is 0.175 mm, incorporate larger sand grains in the wall than do those from C–9 (fig. 9*B*), where median grain size is less. In the deeper samples the wall is composed mainly of micas.

Reophax bilocularis.—Specimens from shallow depths (47 to 82 m) incorporate crystals of hypersthene, augite, and magnetite in the test (fig. 10*A*); deeper water specimens are composed entirely of foraminiferal tests (fig. 10*B*). The species of Foraminifera incorporated in the wall at each depth represent the fauna of that depth.

683–709 O—64——2

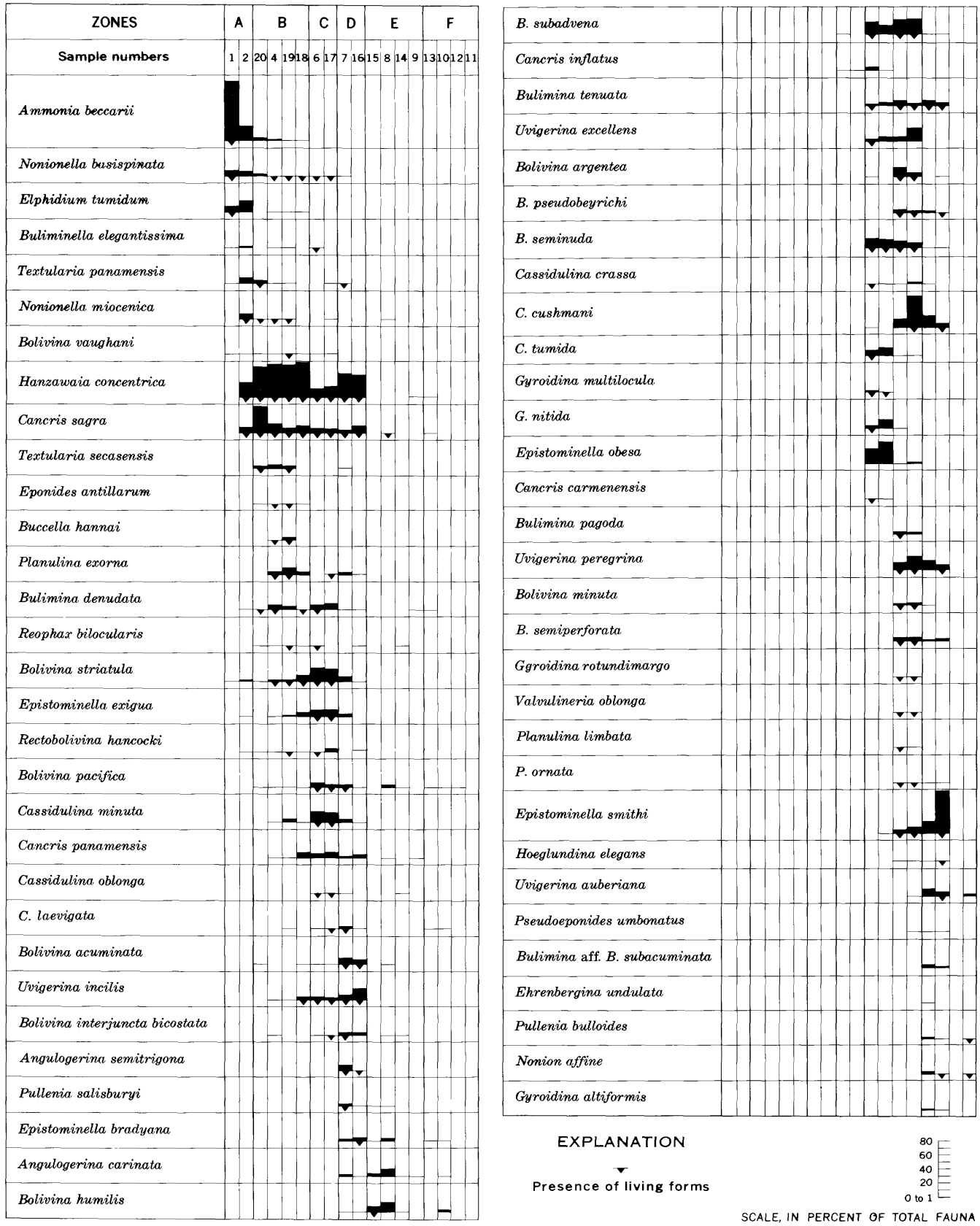

FIGURE 8.—Relative abundance off El Salvador of Foraminifera significant in zonation.

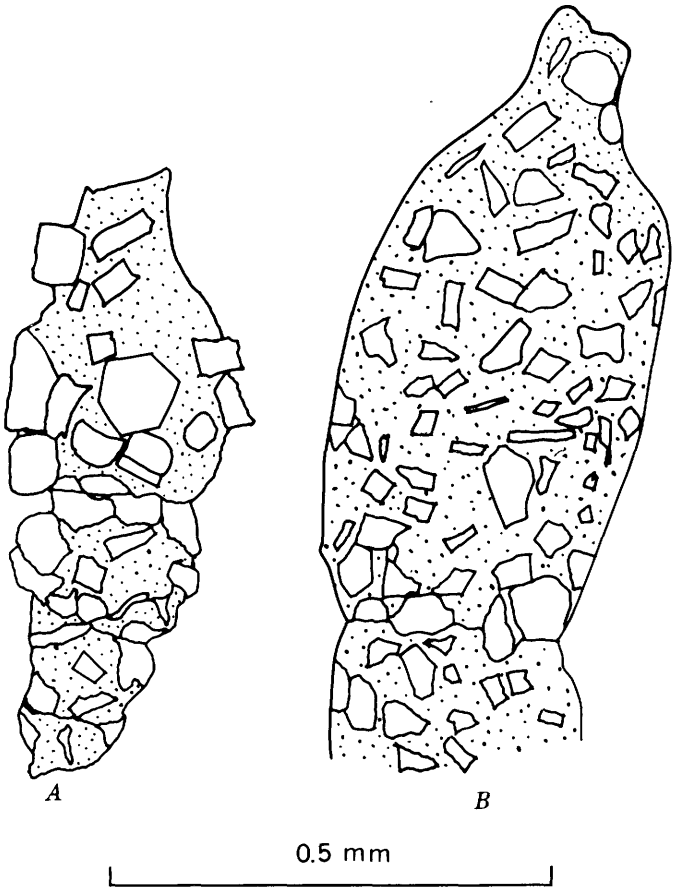

FIGURE 9.—*Reophax dentalinaformis*. *A*, Specimen from sample C–6, showing coarse wall texture and rough outline. *B*, Part of specimen from C–9, showing smooth texture and outline. Stippled areas represent matrix of fine clastic material and cement.

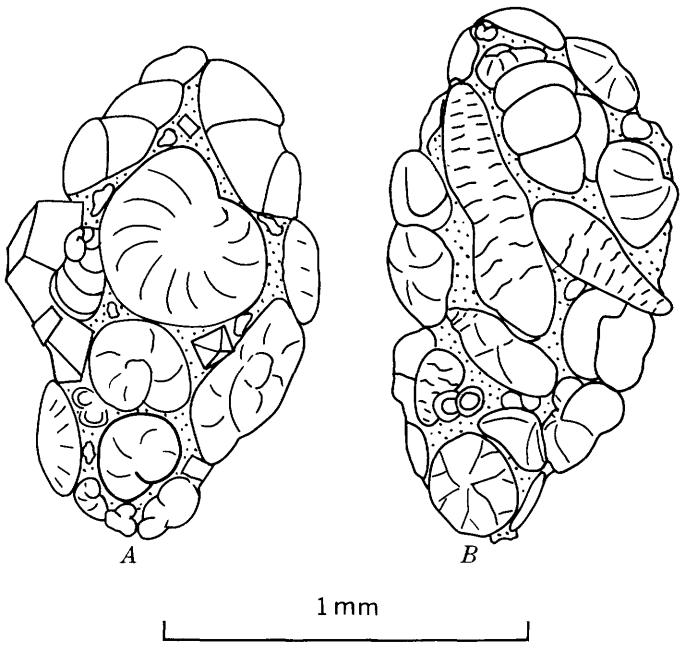

FIGURE 10.—*Reophax bilocularis*. *A*, Specimen from C-6 shows crystals incorporated in the test wall. *B*, Specimen from C-15 is composed entirely of tests of Foraminifera.

Bulimina denudata.—Specimens from depths of 37 to 82 meters show a well-developed overhang at the base of the chambers and well-developed spines (fig. 11*A*). Specimens from deeper water show little overhang and less well developed spines (fig. 11*B*).

Uvigerina peregrina.—Specimens with spines on all or part of the test (fig. 12*A*) are more abundant in C–14 and C–9 (800 to 900 meters); those with smooth costae all over the test (fig. 12*B*) are more abundant in deeper samples (C–13, C–10). All samples, however, show a complete gradation between these two forms.

Angulogerina carinata.—Specimens from C–7 and C–16 (140 to 150 meters) have thin translucent walls and well-developed carinae (fig. 13*A*). Those from deeper samples (435 to 1,700 meters) have thick opaque walls and lack well-developed carinae (fig. 13*B*).

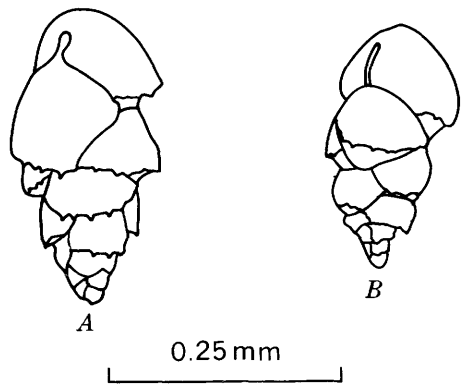

FIGURE 11.—*Bulimina denudata*. *A*, Specimen from C–6 shows well-developed overhang. *B*, Specimen from C–9 shows poorly developed overhang.

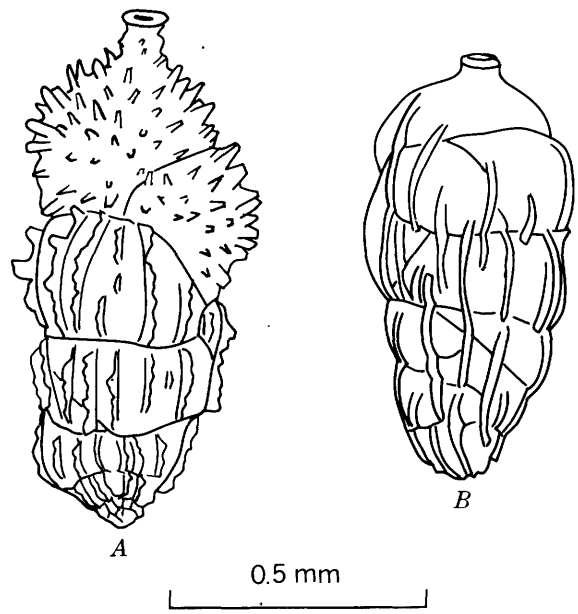

FIGURE 12.—*Uvigerina peregrina*. *A*, Specimen from C–14, with spines and serrate costate. *B*, Specimen from C–10, with smooth costae.

Table 6.—*Distribution of*

[Number of living specimens shown in parentheses. Number of dead specimens calculated from split sample (except for samples C-10,

Species	Zone A		Zone B				Zone C
	C-1 20 meters	C-2 37 meters	C-20 47 meters	C-4 50 meters	C-19 50 meters	C-18 64 meters	C-6 80 meters
Arenaceous species:							
Saccammina cf. *S. comprima*							
Reophax bilocularis			X	560	380 (3)	130	260 (2)
R. dentalinaformis				X	X		X (1)
R. scotti							
Haplophragmoides cf. *H. evolutus*					X (1)		
H. lenticularis							
Textularia agglutinans		12	60	60		X	260
T. candeiana		4			260		
T. panamensis	60	130	260 (3)	190	640		
T. secasensis			160 (1)	960	1,400 (1)		
Bigenerina hoeglundi				X		X (3)	X (19)
Gaudryina excolata					X	X	1,000
Eggerella pusilla							
Goesella flintii							
Tritaxilina cf. *T. atlantica*							
Trochammina rotaliformis		4		X	130		
Porcellaneous species:							
Quinqueloculina auberiana		8	100	X	130 (1)	260 (1)	X
Q. cf. *Q. venusta*	X	16	X	60	X		
Miliolinella circularis				190	260 (1)		260
Scutuloris sp.	X	30		380	130 (1)		
Nummoloculina irregularis							
Spiroloculina soldanii		X (1)	60	X	260	X	
Triloculina tricarinata							
Quinqueloculina sp.				X	X		X
Hyaline species:							
Lagena acuticosta							
L. clavata							
L. distoma							
L. filacosta				X	130 (1)	130	
L. hispida							
L. laevis							
L. striata							
L. sulcata		4	60	130 (1)	X		X (1)
L. submagnifica							
Fissurina bicarinata							
F. lucida							
F. marginata							
Dentalina pauperata							
Robulus cushmani					X (1)	130	
Saracenaria angularis							260
Bulimina affinis							
B. auriculata							
B. denudata		X	X	1,300 (1)	1,700 (3)	5,600	13,000 (1)
B. marginospinata							
B. mexicana							
B. pagoda							
B. aff. *B. subacuminata*							
B. tenuata							
Buliminella curta							
B. elegantissima	60	20		X	380		4,100 (5)
Virgulina bramlettei							
V. complanata							
V. cornuta							
V. mexicana							
V. punctata	190	20 (1)		130 (2)	380 (5)	510	1,000 (3)
V. sandiegoensis	X	12 (1)	X (1)	X (1)	640 (1)	380	3,800 (1)
V. seminuda							
Globobulimina pacifica							
Uvigerina auberiana							
U. excellens							
U. incilis				X	380	3,800 (1)	18,000 (3)
U. peregrina							
Angulogerina agrestis					X (1)		
A. carinata							
A. semitrigona							
Bolivina acuminata			X			130	1,300
B. argentea							
B. bradyi							260
B. humilis							
B. inflata			X	60 (1)	X (1)		260
B. interjuncta bicostata				130			2,000

Foraminifera off El Salvador

C-11, C-12, C-13, and C-16) and rounded off to two significant figures. X indicates species not present in split of sample.]

Zone C	Zone D		Zone E				Zone F			
C-17 82 meters	C-7 140 meters	C-16 144 meters	C-15 435 meters	C-8 450 meters	C-14 800 meters	C-9 885 meters	C-13 1,600 meters	C-10 1,700 meters	C-12 3,100 meters	C-11 3,200 meters
			25		X (8)	X				(1)
650			12			X				
			12 (1)	X	X	X (17)	2		3 (1)	(2)
			(1)							
X (1)			36			X				
					X	X (3)				
X										
130	30 (1)									
	60									
260 (2)		(1)								
640	350	2								
	30	1								
			80	X		160				
					X		2			
130										
	100									
130	30									
								1		
	X									
	60									
	30	1								
							3			
							11	2		
							1	1		
							2			
							1			
							2			
X					X	X				
							1			
							1	1		
							1	1		
							1	1		
							1			
X (1)	130 (1)	2			X		1	(1)		
260										
					60 (2)	260	3	6	1	
			4			100				
11,000 (6)	160	1				30	2			
					320 (2)	380	10	1 (1)		
								1		
					900 (1)	700				
							40	20		
					2,600 (1)	860 (5)	40 (2)	20 (1)		
			50 (3)	860	60	60				
260										
					X	60 (1)	1 (5)	(1)		
							13 (1)	1		
					X	30				
							13	6		
1,300 (8)	60									
1,300	30	1								
					X (2)		5			
			12 (1)	32	X (2)	130 (7)	6 (1)	6	(1)	
						60	83	59 (4)		2
			50 (2)	1,300	2,200	3,100				
7,800 (10)	900 (2)	68 (2)								
					4,400 (4)	6,600 (6)	112	82 (7)		
	160 (2)	2	110	2,600	190	100		1		
	900 (1)	46 (2)								
800	930 (2)	28 (2)		30						
			X		4,900 (1)	1,400 (2)		2		
130				30						
	30	3	170 (1)	3,900	X			33		
260		2		30						
1,600 (2)	480 (4)	10		290	60					

Table 6.—*Distribution of Foraminifera*

[Number of living specimens shown in parentheses. Number of dead specimens calculated from split sample (except for samples C-10,

Species	Zone A		Zone B				Zone C
	C-1 20 meters	C-2 37 meters	C-20 47 meters	C-4 50 meters	C-19 50 meters	C-18 64 meters	C-6 80 meters
Hyaline species—*Continued*							
B. minuta							
B. pacifica			X	60	130	130	14,000 (2)
B. plicatella		4			X	X	260
B. pseudobeyrichi							
B. seminuda							
B. semiperforata							
B. spinea							
B. striatula	X	40	X	640 (1)	1,200 (9)	4,900 (1)	53,000 (45)
B. subadvena							
B. tongi filacostata				X		X	3,800
B. vaughani	X	4	X	60	260 (1)	128	2,600
B. (Loxostomum) boltovskoyi							
B. (Loxostomum) mayori	X	4					
B. (Loxostomum) salvadorensis							
Suggrunda eckisi				X	X	130	2,800
Rectobolivina hancocki		4	X	130	260 (1)	512	3,600 (3)
Cassidulina crassa							
C. cushmani							
C. laevigata					130		3,600
C. minuta				60	1,700	900	44,000 (2)
C. oblonga							3,100 (1)
C. tumida							
Cassidulinoides aff. *C. mexicanus*							
C. simplex							
C. tenuis							
Ehrenbergina cf. *E. undulata*							
Chilostomella cushmani							
Pullenia bulloides							
P. aff. *P. elegans*							
P. salisburyi							
P. subcarinata							
Hoeglundina elegans							
Cushmanella primitiva		8		X	X	130	
Nonion affine							
N. grateloupi		4 (1)			X (8)	38	X
Nonionella basispinata	2,000 (1)	80	160	130 (1)	510 (2)	X (1)	510 (12)
N. miocenica		100 (11)	60 (12)	260 (4)	640 (13)		
Gyroidina altiformis							
G. multilocula							
G. nitidula							
G. rotundimargo							
Buccella hannai				130 (1)	1,000 (2)		
Eponides antillarum			X	130 (3)	130 (2)	260	
E. repandus					X	X	
E. turgidus							
Pseudoeponides umbonatus							
Epistominella bradyana							
E. exigua		4		X	380	3,500	100 (1)
E. obesa							
E. smithi							
Patellina corrugata					X (1)		
Rosalina columbiensis				190	510	260	
Hanzawaia concentrica		260 (12)	1,900 (11)	2,500 (6)	2,300 (142)	5,500 (12)	14,000 (41)
Valvulineria glabra							
V. oblonga							
V. vilardeboana							
Cancris carmensis							
C. inflata							
C. panamensis				130 (1)	130	4,900 (1)	21,000 (16)
C. sagra		90 (2)	1,900 (20)	2,500 (6)	2,300 (142)	5,500 (12)	14,000 (41)
Ammonia beccarii	23,000 (26)	270	220	590	640	640	
Elphidium spinatum	130	4		X	X		
E. tumidum	2,100 (4)	190		130	X	260	
Planulina exorna				830 (2)	3,700 (4)	2,400	
P. limbata							
P. ornata							
Cibicides floridanus						130	510
C. gallowayi							
C. mckannai							
Dyocibicides biseralis					260	260	770
Total population	27,000	1,300	5,600	20,000	43,000	68,000	281,000
Total living population	(31)	(29)	(42)	(56)	(243)	(24)	(172)

off El Salvador—Continued

C-11, C-12, C-13, and C-16) and rounded off to two significant figures. X indicates species not present in split of sample.]

Zone C	Zone D		Zone E				Zone F			
C-17 82 meters	C-7 140 meters	C-16 144 meters	C-15 435 meters	C-8 450 meters	C-14 800 meters	C-9 885 meters	C-13 1,600 meters	C-10 1,700 meters	C-12 3,100 meters	C-11 3,200 meters
					1,500 (1)	1,700 (1)	1			1
2,700 (1)	190 (2)	5		800	X		8 (5)	2	1	
	X									
			X	130	900 (1)	600 (1)	6	3 (1)		
			300 (31)	2,900 (1)	4,000 (5)	2,700 (2)	4	15		1
					1,900 (2)	2,100 (5)	17	38		
								1		
29,000 (54)	60	1								
	100		380 (3)	2,900	8,600 (1)	8,400 (2)	5	4 (1)		
2,200 (2)	320 (2)	11	8	100				1		
380				30						
			120 (3)	420						
			12 (6)	130						
1,400 (1)	130	7	X	190	260	350	1	7		1
2,300 (8)		2								
			8 (2)	320	700	1,200	7			
			X		6,000	17,000 (2)	143	66 (6)		
2,600 (2)	450 (1)	9					19	7		
22,000 (3)	480	1								
2,600 (2)	60				190					
			190 (2)	2,600	320	420				
								1		
	X	1								
				30						
							1			
			20 (1)	60	510 (8)	130 (30)	1	4	(5)	(1)
							14	6		(1)
						30				
	160 (1)	3	20	30						
					X (1)					
					60	130	10	7 (2)		
130	30									
							36	11 (4)		(2)
X (8)	30									
380 (13)	100									
380										
							2	7		
			50 (6)	30 (1)						
			60 (1)	2,600	X					
					60 (3)	190 (2)				
					320	100	1	9	1	
						60	6	6		
	260	14 (2)	10	540			3	6		
12,000 (6)	260									
			490	7,400	260	450				
				30	2,200 (5)	3,400 (4)	132	732 (14)		
	30 (1)									
5,600 (59)	190 (4)	26 (2)				60	6			
						30				
					X (3)	100 (6)				
					380	256 (1)	9	4		
			40 (1)	130						
	30	4	100	260						
11,000 (62)	320	19		350		30				
5,600 (59)	190 (4)	26 (2)		X (1)			2			
	100									
2,000 (4)	260	1								
					X (3)	130				
					130 (1)	X (2)	4	4		
510	160	1								
	30									
					130	60	18	6		
770										
147,000 (241)	12,000 (28)	405 (14)	2,400 (65)	24,000 (2)	42,000 (57)	44,000 (100)	820 (14)	1,194 (45)	12 (7)	11 (8)

Bolivina pseudobeyrichi.—Specimens from C–15 and C–8 (fig. 14*A*) lack the broad fragile keel found on specimens from deeper water (fig. 14*B*). For a discussion of size variation see Smith, 1963.

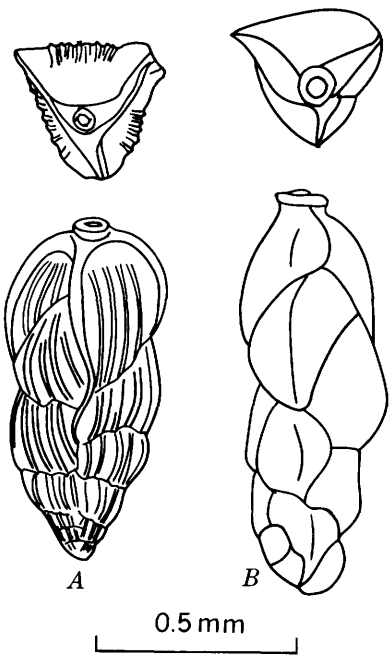

FIGURE 13.—*Angulogerina carinata. A,* Specimen from C–7, with carinae and costae. *B, Specimen* from C–9, lacking ornamentation and with thick opaque wall.

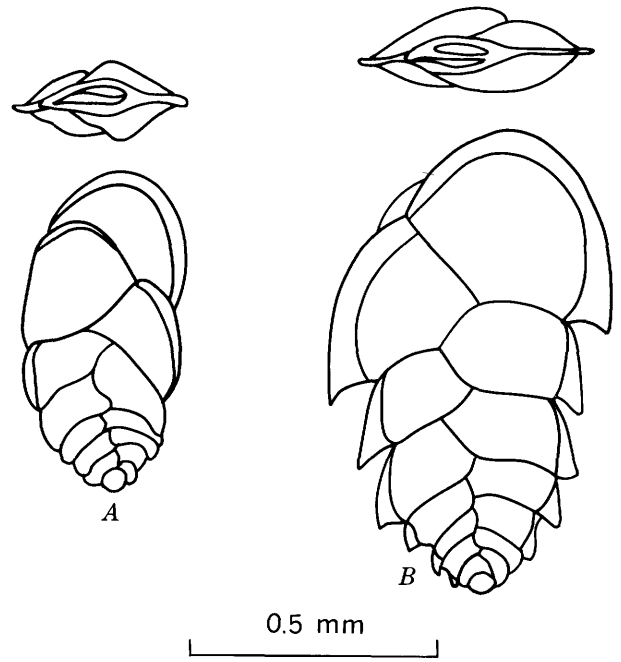

FIGURE 14.—*Bolivina pseudobeyrichi. A,* Specimen from C–8, lacking broad keel. *B,* Specimen from C–14, with broad keel.

Bolivina seminuda.—This species shows variation in the number of chambers with clear areas. Many specimens have clear areas only on the last pair of chambers (fig. 15*A*), and many have clear areas on all chambers (fig. 15*B*). Both variants occur in all samples, but the former prevails in C–15 and C–8 (435 to 450 meters), whereas the latter prevails in deeper samples. For an enlarged discussion of quantitative and qualitative variations in this species, see Smith, 1963.

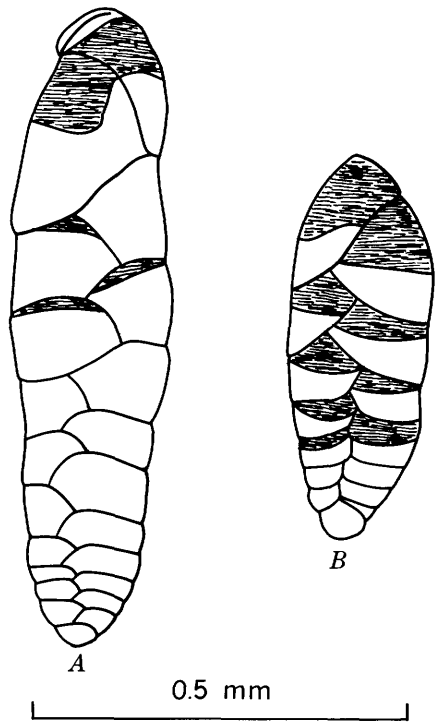

FIGURE 15.—*Bolivina seminuda. A,* Specimen from C–15 with clear areas only on last chambers. *B,* Specimen from C–15 with clear areas on nearly all chambers.

Bolivina subadvena. Specimens are larger and more robust in C–9 and C–14 (800 to 885 meters) than in deeper or shallower samples. For a complete discussion and documentation of this variation, see Smith, 1963.

Suggrunda eckisi.—The length decreases slightly with increasing depth of water (Smith, 1963).

Cassidulina laevigata.—Specimens from depths of 80 to 150 meters (fig. 16*A*) lack the well-developed carina present on specimens from deeper water (fig. 16*B*).

Cassidulina tumida.—Specimens from C–15 and C–8 (435 to 450 meters) have a broadly rounded periphery (fig. 17*A*); those from C–9 and C–14 (800 to 885 meters) have a wide serrate keel (fig. 17*B*).

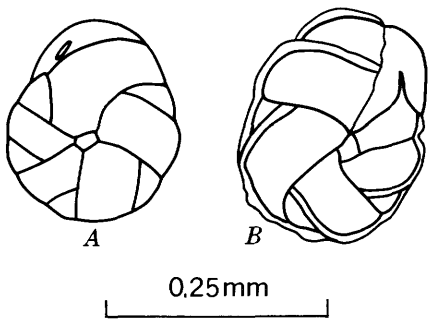

FIGURE 16.—*Cassidulina laevigata*. *A*, Specimen from C–6, with no carina. *B*, Specimen from C–10, with well-developed carina.

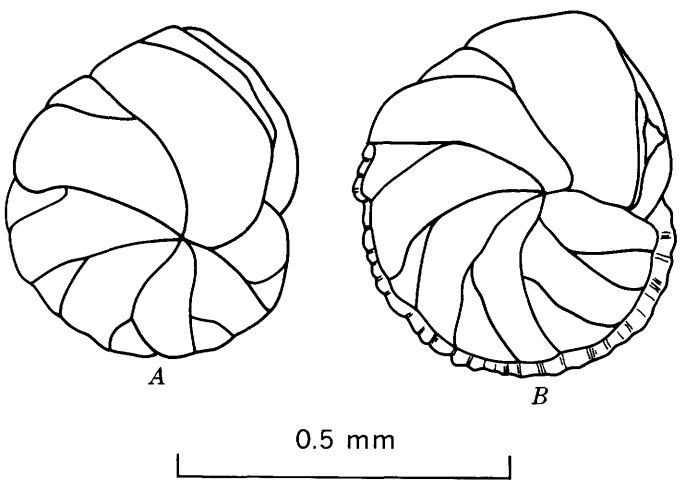

FIGURE 17.—*Cassidulina tumida*. *A*, Specimen from C–8, with rounded perhiphery. *B*, Specimen from C–14, with serrate keel.

FAUNAL DISTRIBUTION ALONG THE PACIFIC COAST

COMPARISON BETWEEN AREAS

The faunas off El Salvador have many similarities with those of other areas off the Pacific coast of North and Central America. In table 7, a comparison is made between El Salvador faunas and those of several other Pacific coast areas: Central America (Bandy and Arnal, 1957), Todos Santos Bay, Baja California (Walton, 1955), San Diego (Bandy, 1953; Uchio, 1960), Catalina Channel (Natland, 1933), Point Arguello (Bandy, 1953), and San Francisco (Bandy, 1953). To facilitate comparison between areas traverses in these areas are divided into faunal zones with faunal compositions similar to those off El Salvador. These zones are mainly the same as those defined by Bandy (1953) and by Bandy and Arnal (1957) but differ slightly from those described by Natland (1933), Walton (1955), and Uchio (1960). A comparison of the zonal nomenclature used by these authors is given in figure 18.

Zone A corresponds to the shallow part of Bandy and Arnal's "Inner Shelf Fauna," Walton's depths of less than 10 fathoms, the shallow part of Bandy's "middle neritic zone," Uchio's fauna 1, and Zone I and part of Zone II of Natland. This zone is characterized by *Streblus beccarii* and several species of *Elphidium* and *Nonionella*. Its depth in all areas is 0 to 20 or 30 meters.

Zone B corresponds to the deeper part of Bandy and Arnal's "Inner Shelf fauna," Walton's 10 to 30 fathoms, Bandy's "middle neritic zone," the upper part of Uchio's fauna 2, and part of Natland's Zones II and III. The faunal composition of this zone varies with latitude. Off Central America and Baja California, it is characterized by *Hanzawaia concentrica* and *Cancris sagra* plus *Bolivina vaughani* and *Bulimina denudata*. Off California, it is characterized by *Buliminella elegantissima* (which has a greater range in the southern areas) and abundant *Cassidulinas*. Zone B is restricted to depths of less than 60 meters off Central America, Baja California, and San Diego. Farther north, it extends to depths of about 100 meters.

Zone C corresponds to the "Outer Shelf fauna" of Bandy and Arnal, depths of 30 to 100 fathoms of Walton, the "'lower neritic zone" of Bandy, parts of Uchio's faunas 2 and 3, and the deeper part of Natland's Zone III. Off Central America the zone is characterized by *Bolivina striatula*, *B. pacifica*, *Cancris panamensis*, and *Cassidulina minuta*. Off Baja California and California, *Bolvina striatula* and *B. pacifica* are accompanied by abundant *Bulimina denudata*, *Bolivina acuminata*, *Uvigerina tenuistriata*, and Cassidulinas. The base of this zone is around 150 meters off Central America and 200 to 250 meters off California.

Zones D and E correspond to the upper and middle bathyal zones of Bandy and Arnal, to the bathyal zone of Bandy, to Zone IV of Natland, the deeper part of fauna 3 and fauna 4 of Uchio, and to depths greater than 100 fathoms of Walton. As noted by Bandy and Arnal, Foraminifera found at these depths in the waters off Central America can be divided into two groups, each characterized by species that are observed to live together in waters to the north. Zone D is equivalent to the "upper bathyal zone" of Bandy and Arnal, and to depths between 100 to 350 fathoms of Walton. It is characterized off Central America by *Bolivina acuminata*, *B. interjuncta bicostata*, and *Epistominella bradyana*.

Zone E. equivalent to the "Middle Bathyal Zone of Bandy and Arnal, is characterized by *Bolivina subadvena*, *B. semiperforata*, *B. minuta*, *Bulimina tenuata*, *Uvigerina excellens*, *U. peregrina*, *Cassidulina cush-*

Table 7.—*Composition of Pacific*

[Species names are those used by authors, with

Zone	Depth in meters	El Salvador	Depth in meters	Central America (Bandy and Arnal, 1957)	Depth in meters	Todos Santos Bay, Baja California (Walton, 1955)	Depth in meters	San Diego (Bandy, 1953)
A	0 to 20	*Ammonia beccarii* *Elphidium tumidum* *E. spinatum* *Nonionella basispinata* *Textularia panamensis*	0 to 20	*Streblus tepidus*= (*Ammonia beccarii*). *Rotorbinella versiformis* *Textularia vola*= (*T. secasensis*). *Cushmanella primitiva*	0 to 20	*Quinqueloculina* sp. *Elphidium translucens* *E. spinatum* *Eggerella advena*	12 to 30	*Nonionella basispinata* *N. miocenica stella* *Trochammina pacifica* *Rotalia lomaensis* *Elphidium translucens*
B	30 to 60	*Hanzawaia concentrica* *Cancris sagra* *Textularia secasensis* *Bolivina vaughani* *Planulina exorna* *Bulimina denudata*	20 to 50	*Hanzawaia nitidula*= (*H. concentrica*). *Virgulina schreibersiana* *Bulimina denudata* *Bolivina vaughani* *Cancris sagra* *Nonionella atlantica* *Rectobolivina hancocki*	20 to 60	*Elphidium tumidum* *Discorbis* spp. *Dyocibicides biseralis* *Reophax curtus* *Rotalia* spp. *Buliminella elegantissima* *Cibicides fletcheri*	30 to 60	*Rotalia versiformis* *Cassidulina californica* } <30 percent *C. limbata* } <30 percent *C. quadrata* *C. tortuosa* *Nonionella miocenica stella.* *Eponides frigidus* *Trochammina pacifica* *Cibicides fletcheri*
C	60 to 150	*Cassidulina minuta* *Bolivina striatula* *Epistominella exigua* *Cassidulina oblonga* *Cancris panamensis* *Bolivina pacifica*	50 to 150	*Planulina ornata*= (*P. exorna*). *Angulogerina bella* *Discorbis panamensis*= (*Cancris panamensis*). *Uvigerina incilis* *Bolivina acutula*= (*B. striatula*). *Cassidulina minuta* *Cibicides mckannai*= (*C. floridanus*).	60 to 200	*Bolivina acuminata* *B. striatella*= (*B. striatula*). *Nonionella miocenica stella* *Reophax scorpiurus*= (*R. dentalinaformis*). *Nonionella basispinata* *Cassidulina tortuosa* *Planulina exorna* *Cibicides mckannai* *Bulimina denudata*	60 to 250	*Cassidulina californica.* } >30 percent *C. quadrata* } >30 percent *C. limbata* *C. tortuosa* *Angulogerina angulosa* *Bolivina advena acutula* = (*B. striatula*). *B. acuminata* *B. pacifica* *Bulimina denudata*
D	150 to 600	*Bolivina acuminata* *B. interjuncta bicostata* *Angulogerina semitrigona* *Uvigerina incilis* *Epistominella bradyana* *Pullenia salisburyi* *Cassidulina laevigata*	150 to 600	*Epistominella bradyana* *Bolivina acuminata* *B. humilis* *B. seminuda* *Uvigerina hancocki* *Cassidulina subglobosa* *Epistominella obesa*	200 to 650	*Valvulineria araucana* *Virgulina seminuda* *Reophax horrida* *Bolivina argentea* *Uvigerina peregrina* vars.	250 to 1,000	*Planulina ornata* *Quinqueloculina lamarckiana.* *Q. angulostriata* *Spiroloculina dentata* *Pyrgo inornata* *Poroeponides cribrorepandus.* *Textularia conica* *T. foliacea*
E	600 to 1,300	*Angulogerina carinata* *Bolivina humilis* *B. subadvena* *B. seminuda* *Uvigerina excellens* *Gyroidina multilocula* *G. nitidula* *G. rotundimargo* *Epistominella obesa* *Cassidulina crassa* *C. tumida* *Cancris inflata* *Bolivina minuta* *B. semiperforata* *Planulina ornata* *P. limbata* *Valvulineria oblonga* *Uvigerina peregrina* *Cassidulina cushmani* *Bolivina pseudobeyrichi* *Bulimina tenuata*	600 to 1,300	*Cassidulina delicata*= (*C. cushmani*, in part) *Bolivinita minuta*= (*Bolivina minuta*). *Bolivina plicata*= (*B. subadvena*). *Valvulineria inaequalis*= (*V. oblonga*). *Uvigerina excellens* *U. peregrina* vars. *Globobulimina pacifica* *Bolivina spissa*= (*B. semiperforata*). *Bulimina affinis* *Chilostomella* spp. *Epistominella smithi* *Buliminella exilis tenuata* = (*Bulimina tenuata*).	650 to 1,100	*Chilostomella ovoidea* *Bolivina spissa*= (*B. semiperforata*). *B. minuta* *Cassidulina laevigata* *C. delicata*= (*C. cushmani*). *Bulimina exilis tenuata* *Virgulina bramlettei* *Loxostomum pseudobeyrichi*= (*Bolivina pseudobeyrichi*). *Valvulineria inaequalis*= (*V. oblonga*). *Höglundina elegans*		
F	1,300 to 3,200	*Epistominella smithi* *Pullenia bulloides* *Nonion affine* *Gyroidina altiformis* *Bulimina mexicana* *Ehrenbergina undulata* *Uvigerina auberiana* *Hoeglundina elegans* *Virgulina bramlettei* *V. mexicana* *V. complanata* *Bulimina subacuminata* *Eponides umbonatus*	1,300 to 2,000	*Uvigerina proboscidea vadescens*= (*U. auberiana*). *U. senticosa* *Bulimina clava* *B. pagoda hebespinata* *Ehrenbergina undulata* *Höglundina elegans* *Virgulina bramlettei* *V. nodosa*= (*V. complanata*).				

coast foraminiferal faunas

changes for this report shown in parentheses]

Depth in meters	San Diego (Uchio, 1960)	Depth in meters	Catalina channel (Natland, 1933)	Depth in meters	Point Arguello (Bandy, 1953)	Depth in meters	San Francisco (Bandy, 1953)
0 to 25	*Elphidium* spp. *Buliminella elegantissima* *Nonionella basispinata* Miliolids	0 to 30	*Streblus beccarii*= *(Ammonia beccarii).* *Buliminella elegantissima* *Elphidium hughesi*= *(E. tumidum).* *Nonion scaphum* *Elphidium spinatum*			0 to ?	*Streblus beccarii*= *(Ammonia beccarii).*
24 to 60	*Rosalina campanulata* *R. columbiensis* *Cibicides fletcheri* *Cassidulina tortuosa* *Hanzawaia nitidula*= *(H. concentrica).*	30 to 90	*Ammobaculites pacifica* *Haplophragmoides pacifica* *Cassidulina tortuosa* *C. limbata* *Angulogerina semitrigona* *Planulina ornata* *Cibicides pseudoungeriana* =*(C. floridanus).* *C. basiloba* *Cancris auricula*= *(C. sagra).*	50 to 100	*Nonionella miocenica stella.* *Buliminella elegantissima* *Eponides frigidus* *Nonionella basispinata* *Bulimina denudata*	36 to 120	*Elphidiella hannai* *Buliminella elegantissima* *Gaudryina arenaria* *Nonionella miocenica stella.* *Eponides frigidus*
60 to 230	*Bolivina acutula*= *(B. striatula).* *B. filacostata* *Angulogerina angulosa* *Bolivina acuminata* *Cassidulina depressa* *Cancris auricula*= *(C. sagra).*	90 to 280	*Cassidulina californica* *C. quadrata* *Eponides repandus* *Bolivina advena striatella*= *(B. striatula).* *B. pacifica* *B. acuminata* *Uvigerina tenuistriata* *Cibicides gallowayi*	100 to 200	*Uvigerina hollicki* *U. tenuistriata* *Cassidulina limbata* *Angulogerina angulosa* *Bulimina denudata*	120 to 250	*Uvigerina hollicki* *U. tenuistriata* *Angulogerina angulosa* *Proteonina atlantica* *Nonionella labradorica* *Globobulimina pacifica* *Bolivina pacifica* *Nonionella miocenica stella.* *N. basispinata* *Cassidulina californica* *C. limbata*
230 to 1,188	*Virgulina bramlettei* *Valvulineria glabra* *Bulimina subacuminata* *Gyroidina gemma* *Eponides subtenerus* *Uvigerina auberiana* *Cibicides spiralis* *Bolivina subargentea*= *(B. argentea).* *Virgulina seminuda* *Bolivina spissa*= *(B. semiperforata).* *B. minuta* *Cancris inaequalis*= *(C. oblonga).* *Cassidulina delicata* *Uvigerina curticostata*= *(U. peregrina).* *Loxostomum pseudobeyrichi*= *(Bolivina pseudobeyrichi).* *Virgulina complanata*	280 to 2,000	*Pulvinulinella pacifica*= *(Epistominella smithi).* *Chilostomella grandis* *Epistomina elegans*= *(Hoeglundina elegans).* *Bolivina spissa*= *(B. semiperforata, in part).* *Cassidulina cushmani* *Bolivina argentea* *B. subadvena* *B. minuta* *B. interjuncta* *B. seminuda* *Uvigerina peregrina* *Bolivina pseudobeyrichi* *Gyroidina altiformis* *G. rotundimargo* *Virgulina bramlettei* *Valvulineria inaequalis*= *(V. oblonga).*	250 to 550	*Uvigerina peregrina* *Bolivina spissa*= *(B. semiperforata).* *Angulogerina angulosa*	250 to 1,850	*Epistominella evax* *Uvigerina peregrina*
				550 to 725	*Uvigerina peregrina* *Bolivina spissa*= *(B. semiperforata).* *Cassidulina delicata*= *(C. cushmani).* *Epistominella smithi* *E. pacifica*		
				750 to 1,850	*Uvigerina peregrina* *Bulimina striata mexicana* *Cassidulina translucens* *C. lomitensis*		
		2,000 to 2,600	*Bulimina rostrata* *Nonion umbilicatula*= *(N. affine).* *Pullenia bulloides* *Gyroidina soldanii* *Ehrenbergina bradyi* *Pulvinulinella culter*	1,850 to 3,800	*Uvigerina hispida* *U. senticosa* *U. proboscidea*= *(U. auberiana).* *Bulimina barbata*= *(B. marginospinata).* *B. rostrata* *B. striata mexicana* *Nonion pompilioides* *N. barleeanum*= *(N. affine).* *Gyroidina soldanii* *G. gemma*	1,850 to 2,100	*Epistominella pacifica* *Uvigerina proboscidea*= *(U. auberiana).* *U. hispida* *Bulimina striata mexicana.* *Buliminella exilis*= *(Bulimina tenuata).* *Eponides tener*= *(Pseudoeponides umbonatus).* *Bulimina affinis* *Cassidulina delicata*= *(C. cushmani).*

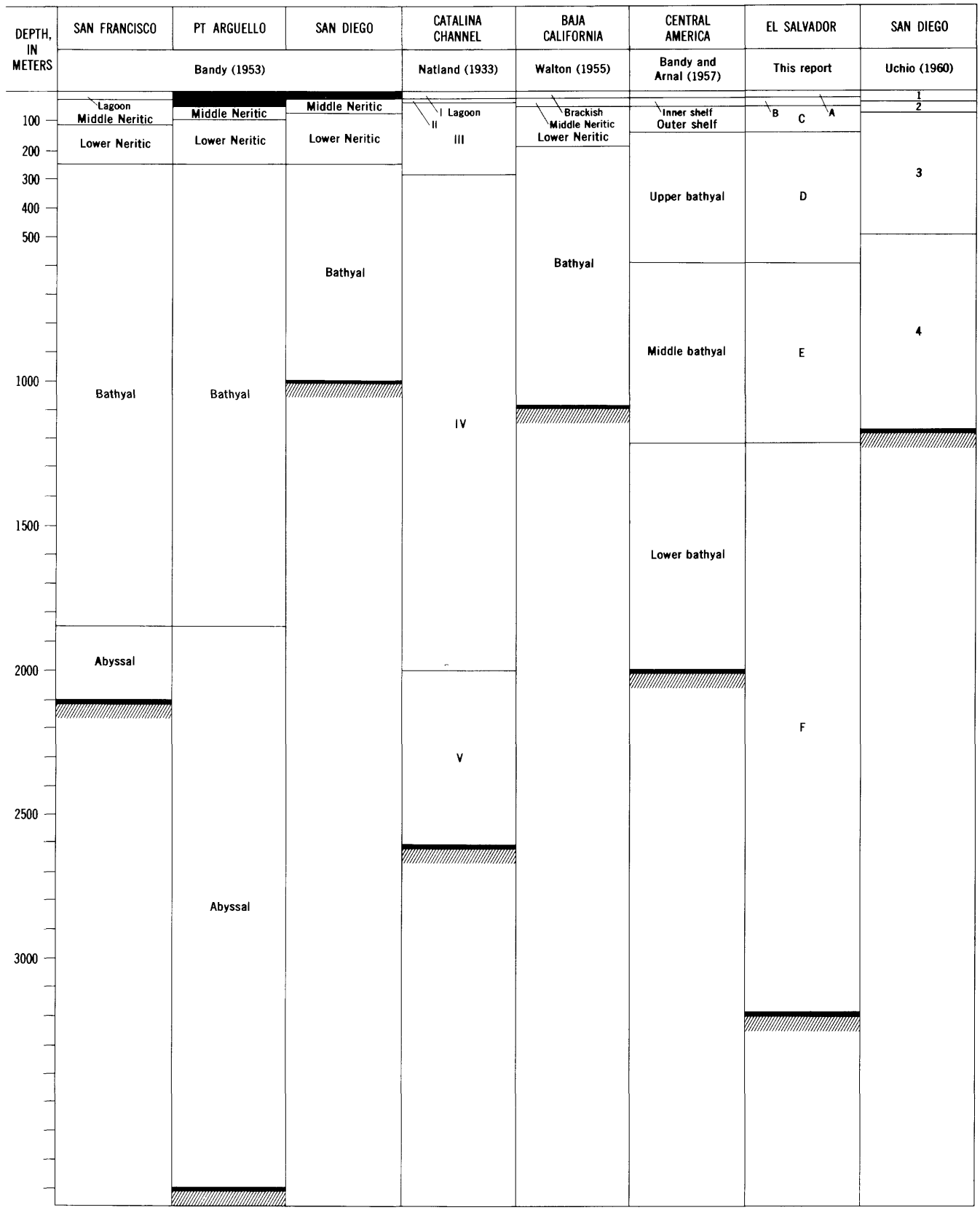

FIGURE 18.—Zonal nomenclature used for various areas off the west coast of North and Central America.

mani, *Valvulineria oblonga*, *Gyroidina* spp., and numerous other species.

Off California the faunal composition of the zone equivalent to D and E is very similar to that of the combined zones off El Salvador. The lower boundary of zone E off Central America is about 1,300 meters; off California it is between 1,800 and 2,000 meters.

Zone F is equivalent to Bandy and Arnal's "Lower Bathyal zone," Natland's Zone V, and Bandy's abyssal zone. It is characterized by *Epistominella smithi*, *Nonion affine*, *Pullenia bulloides*, *Ehrenbergina* spp., *Uvigerina auberiana*, *Bulimina subacuminata*, and *B. mexicana*. The faunal composition is very similar in all areas along the coast. Neither in this nor in other studies have indications been found of a deeper faunal zone.

SPECIES DISTRIBUTION

Many of the foraminiferal species present off the Pacific coast of Central America are also present off California, whereas others are apparently restricted to low latitudes. The depth distribution of Central American species along the coast of both Central and North America is shown on plate 7. The sampled areas are numbered from north to south. Data for areas 1, 2, and 5 are from Bandy (1953); for area 3 from Resig (1958); for area 4 from Natland (1933); for area 6 from Uchio (1960); for area 7 from Walton (1955); for area 8 from Bandy and Arnal (1957); and for area 9 from this report. The location of these areas is given on plate 7.

Some of the species present in all the sampled areas have very similar depth ranges in all of them. This is particularly true of the deep water species, where the physical and chemical conditions are more similar throughout the studied area. Abundant occurrences of other species, however, are restricted to shallower depths off Central America than off California, a trend that is reflected in the boundaries of faunal zones. These species include *Buliminella elegantissima*, *Nonionella basispinata*, *Bolivina acuminata*, *Bulimina denudata*, and *B. tenuata*.

Many Central American species are not reported off California. The species that are abundant off Central America, yet unreported from the waters to the north, are: *Rectobolivina hancocki*, *Uvigerina incilis*, *U. excellens*, *Cassidulina minuta*, *Bolivina humilis*, *Epistominella obesa*, *Cancris panamensis*, and *C. carmenensis*.

Conversely, a large number of species (not shown on pl. 7) are present off California but not found off Central America. Perhaps the most conspicuous of these are the Cassidulinas (*C. californica*, *C. tortuosa*, and *C. limbata*), which form an important part of the America is shown on plate 1. The sampled areas are fornia. Other California species missing off Central America are *Uvigerina tenuistriata* and *Bulimina rostrata*.

ECOLOGIC FACTORS OFF THE PACIFIC COAST

Physical and chemical data for the studied traverses off Central and North America are plotted against depth in figures 19–23. Where possible these data were taken from reports that also described the Foraminifera. Where such data were not supplied in these reports, they were adapted from the following sources: Revelle and Shepard (1939), Sverdrup and Fleming (1941), Emery and others (1952), Dill (1952), and Scripps Institution of Oceanography Reference 56–28 (1956).

Figure 19 shows water temperatures and wherever possible their annual range. Except where noted, these data are from hydrographic stations, not bottom samples. As might be expected, temperatures at depths down to 3,000 meters are higher off Central America than at corresponding depths off North America. The annual maximum and minimum temperatures at zonal boundaries are shown in table 8; temperatures at these boundaries are 5° to 10° higher off Central America than off California. Seasonal variation of several degrees takes place to depths of about 300 meters; below that the temperatures are nearly constant. The most extreme seasonal variation occurs in zones A and B.

The salinity is very similar in the waters of all of the traverses except San Francisco Bay (fig. 20). The seasonal variation is highest in zone A, where the salinity is lowest and is subject to dilution by rain and river water. In deeper zones variation of salinity is negligible (table 8).

Oxygen percentages in the surface water are higher off California than off Central America (fig. 21), but values at the faunal zone boundaries are similar in all traverses (table 8). The available data indicate that some annual variation occurs down to the oxygen minimum, which is in zone D off Central America and in the undifferentiated zone D–E off California. The minimum oxygen percentage is lower off Central America than off North America.

Data on grain size of bottom sediments are available for only three traverses (fig. 22), and its importance in controlling the abundance of Foraminifera in general and of particular species is uncertain. McGlasson (1959, p. 231, and fig. 15) presents interesting evidence that certain species prefer sediments of certain grain size: * * * *Rotorbinella versiformis* and *Buliminella elegantissima* are more common in sediments with median diameters greater than 0.500 mm, whereas *Bulimina denudata* and *Bolivina acum-*

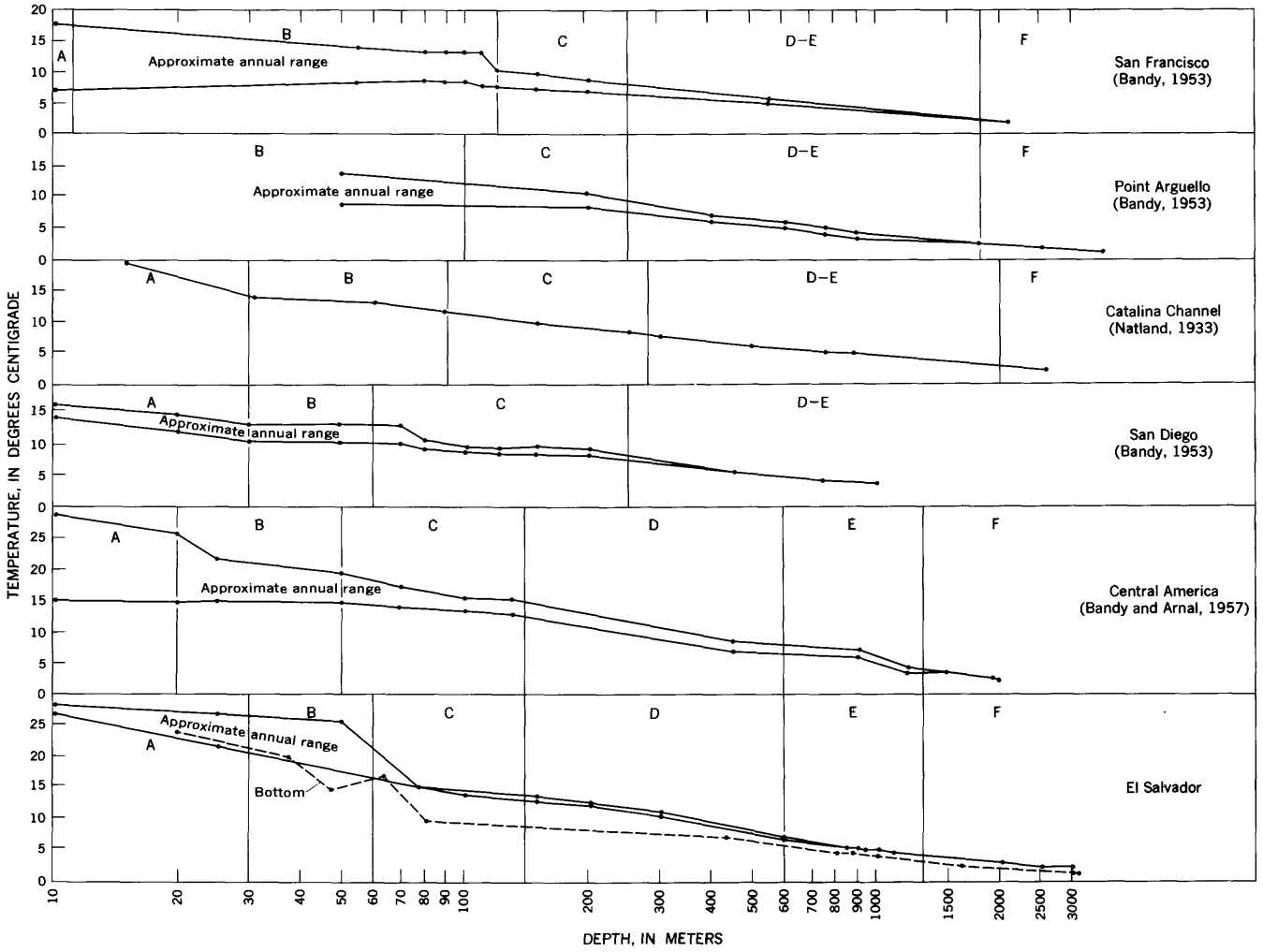

FIGURE 19.—Temperature of water, in degrees Centigrade, off western North and Central America.

inata are common in sediments with median diameters less than 0.125 mm. These views apparently agree with available data on sediments off El Salvador, but much more work of the type done by McGlasson will be needed before final conclusions can be drawn.

Hendrix (1958) inferred from study of Miocene and Pliocene sedimentary deposits in southern California that shell thickness in Foraminifera decreases with decreasing grain size of the matrix. This opinion does not appear to be borne out by examination of living specimens from off El Salvador. These included specimens of several species from samples C–15 and C–14. Shell thickness varies widely between different species in the same sample, but in any given species it remains constant regardless of grain size of sediments. The small amount of work done here on wall thickness indicates that it is a relatively constant specific character—that it differs more in shells of different species within one sample than in shells of the same species between samples.

Nitrogen values for five traverses are presented in figure 23. Values from samples taken off San Francisco are from unpublished analyses by Roger R. Revelle. Point Arguello data are from Dill (1952). Values in Catalina Channel and off San Diego are extrapolated from a map (fig. 8) made by Revelle and Shepard (1939) and those for the El Salvador traverse are from analyses of the bottom samples taken for Foraminifera. The total organic content, which is indicated by the percentage of nitrogen, is influenced by the rate of sedimentation currents, oxygen content of bottom water, and grain size of sediment; abundant organic detritus is found at places where deposition of inorganic detritus goes on slowly, up-welling currents exist, oxygen content is low, and grain size is small. Off California, the high N values do not correspond closely with the O_2 minimum, and they increase with decreasing grain size. Off Central America, the N maximum does correspond with the O_2 minimum and increases

TABLE 8.—*Physical and chemical factors off western North and Central America at surface of water and faunal-zone boundaries*

[Data from figs. 19–21]

Zonal boundary	San Francisco	Point Arguella	Catalina Channel	San Diego	Central America	El Salvador [1]
Annual temperature range (°C)						
Surface	7–14			14–16	15–29	27–28
A–B	?		14	11–14	15–26	21–27
B–C	8–10	8–12	11	10–13	15–20	16–21
C–D	6–8	7–9	8	8–9	12–15	13–14
D–E					6.5–7	6.5
E–F	2	2	3		4	4
Annual salinity range (parts per thousand)						
Surface	20–30		33.5	33.5	33–34.5	33–34
A–B	?		33.5	33.8	33–34.5	34–34.5
B–C	33.5–34	33.5–34	34	34	34.5	34.5
C–D	33.5–34	33.8–34.2	34.2	34.2	34.5	34.8
D–E					34.6	34.6
E–F	34.5	34.5			34.7	34.5
Oxygen (annual range where known, in milliliters per liter)						
Surface			6.5		5.3	4.8
A–B			4.4–6.6	5.0–5.7	4.0	4.5
B–C	2.5–6.0	2.5–5.0	2.5–3.0	3.0–4.0	2.5	3.5
C–D	2.0–3.0	1.5–3.0	0.7	1.2	0.5	0.3
(O_2 minimum)	(750m=0.3)	(750m=0.5)	(650m=0.3)	(600m=0.4)	(400m=0.2)	(450m=0.08)
D–E					0.4	0.3
E–F	1.7	1.5			>1.5	0.5

[1] Hydrographic station values used, in conformity with other areas.

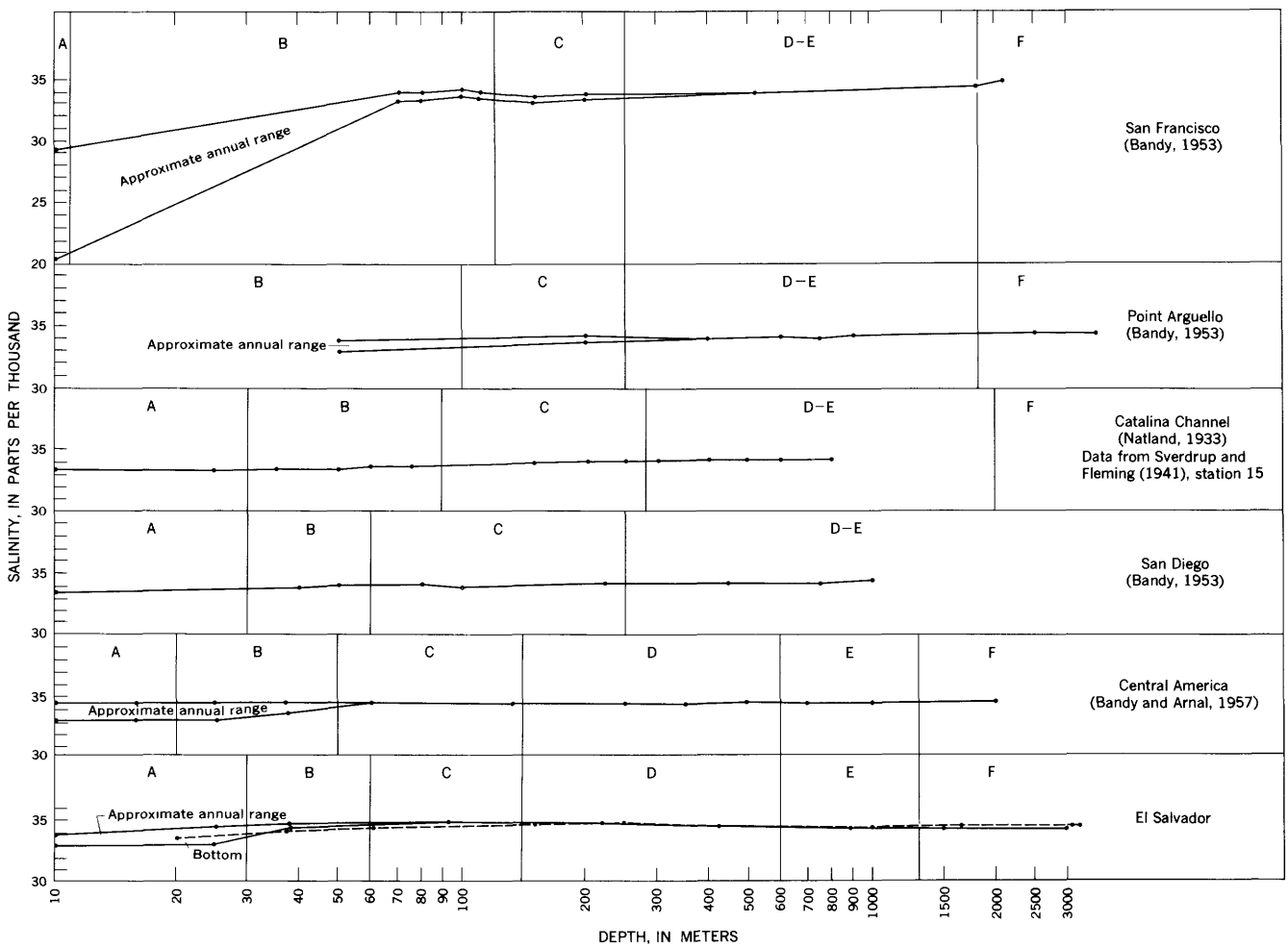

FIGURE 20.—Salinity of water, in parts per thousand, off western North and Central America.

with decreasing grain size, although the correlation is not as good as off California.

PLANKTONIC FORAMINIFERA

Planktonic Foraminifera are abundant in all samples, although no estimates of their numbers have been made. All species are present in the Equatorial West Central Fauna described by Bradshaw (1959, p. 53, text fig. 34). Species present are *Globigerina bulloides*, *G. eggeri*, *G. quinqueloba*, *Globigerinoides ruber*, *G. sacculifer*, *Globigerinella aequililateralis*, *Orbulina universa*, *Globorotalia cultrata*, and *Pulleniatina obliquiloculata*.

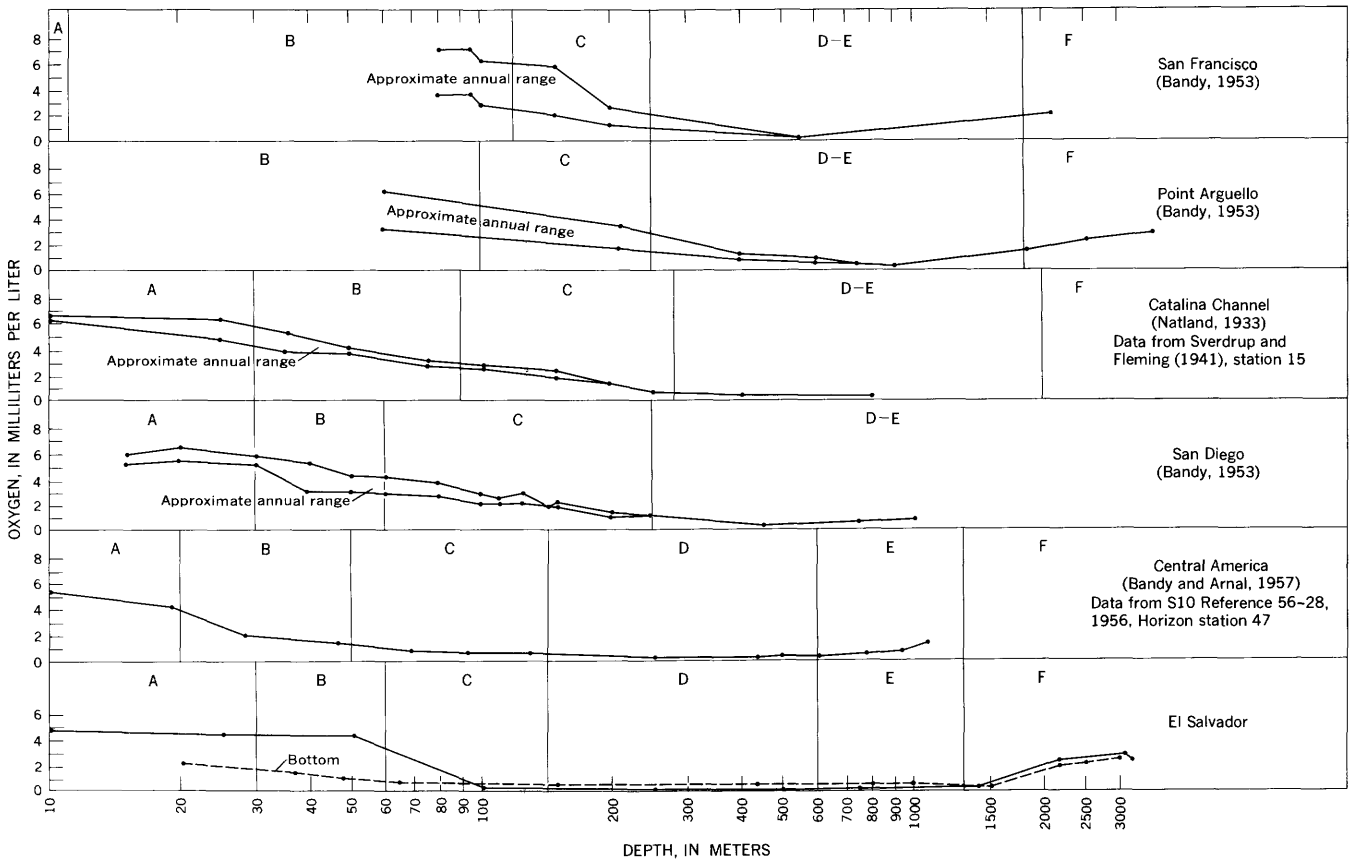

FIGURE 21.—Oxygen content, in milliliters per liter, of water off western North and Central America.

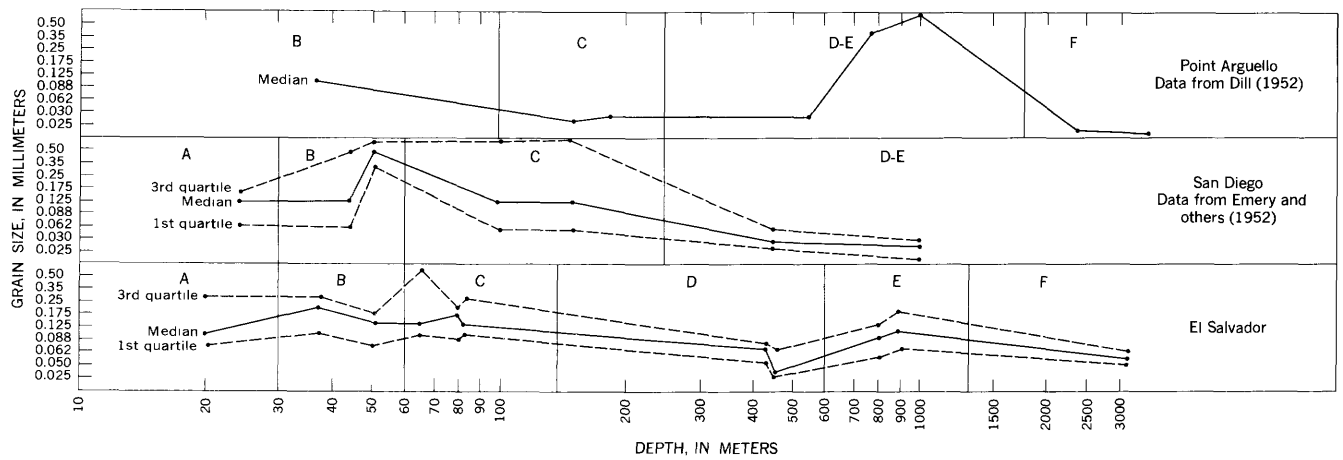

FIGURE 22.—Grain size of bottom sediments, in millimiters, off western North and Central America.

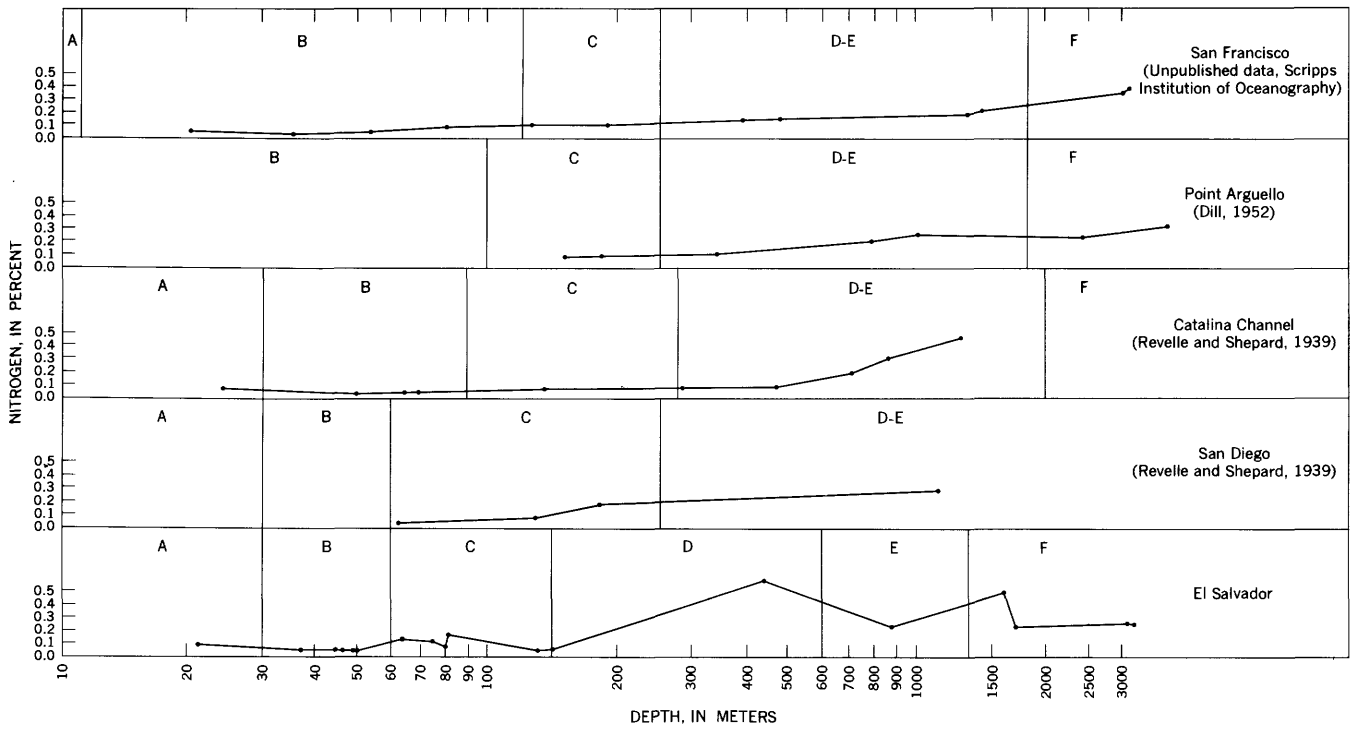

FIGURE 23.—Nitrogen content of bottom sediments, in percentage, off western North and Central America.

CONCLUSIONS

Foraminiferal faunas off North and Central American can be divided into faunal zones, each containing a characteristic assemblage of species. Five persistent zones are recognized across the Continental Shelf and slope. The species composition of each zone is remarkably uniform throughout the area although a few species in zones B and C are geographically restricted. Those restricted to southern waters apparently cannot tolerate the lowest temperatures reached in northern waters, whereas those restricted to northern waters cannot survive the highest temperatures reached farther south. Temperature may not be the only controlling factor, but of the factors measured, it appears to be the only one showing significant differences between the two areas.

A given species inhabits a limited ecologic niche, in which it finds the physical and chemical conditions that it needs in order to live and reproduce. Competition with other forms for food may play an important part in limiting its range. Certain environmental factors may be more critical for one species than for another; some species apparently respond to light, some to changes in salinity, some to changes in temperature or oxygen, and possibly others to changes in depth. The effect of depth, however, is hard to estimate separately because other factors vary with depth. The effect of habitat is thus a very complicated problem.

Zonal boundaries off North America differ in depth and temperature from those off Central America. Off Central America, where temperatures are much higher at given depths than they are off California, all the zonal boundaries are shallower. This probably indicates that, for the faunas that characterize these zones, the average temperature is much less important than the seasonal variation in temperatures. This appears to be true, also, of other environmental factors.

Salinity and oxygen content are similar at corresponding zonal boundaries in all areas, and here again the average values appear to be less important than the seasonal variation, especially in zone A. Oxygen supply influences the amount of organic matter that is preserved for food and thus becomes an important factor at those depths, below the photic zone, at which no food plants are growing; a low oxygen content slows the oxidation of organic detritus (amount indicated by nitrogen values), and therefore makes more food available to bottom-dwelling organisms. Organisms that flourish at considerable depth must be able to get along with little oxygen.

Zone A is within the photic zone and the ocean floor is undoubtedly subject to turbulence. In this zone salinity is low and varies seasonally; temperature and oxygen are more variable than at greater depths, and food is probably abundant. The grain size of bottom sediment that is in this zone is variable, and the species

that thrive in zone A are those than can adapt themselves to a variety of conditions, such as low salinity, which would be unfavorable to species from other zones.

Zone B is also within the depth range where seasonal variations in the physical and chemical factors are important. Temperature, salinity, and oxygen supply vary with the season, though less than in zone A. The base of the zone is commonly near the base of the thermocline. Although organic detritus probably is not preserved very long here, zone B is still within the photic zone, so that food is available for benthonic creatures. Because many of the species that characterize this zone off Central America are different from those that characterize it off North America, the distribution of these species must be controlled by factors that differ between the two areas, probably in the main by temperature.

Zone C includes the outer part of the Continental Shelf and upper part of the slope, occupying different positions relative to the break in slope in different areas. It occurs at depths where seasonal variations in the ecologic factors are not so great as in zone B. It is below the thermocline, so that seasonal temperature variation is small. Variation in salinity is slightly greater than in shallower zones. The oxygen content is lower than in shallower zones, and the nitrogen content of the bottom sediments is greater. The nitrogen content, as an indication of organic matter present, becomes important at these depths, where light can barely penetrate; organic detritus becomes the food source for benthonic forms. Zone C, like zone B, contains different species at different latitudes. The species in this zone are probably less tolerant of variation in temperature and salinity than those in zone B.

Zone D is on the upper part of the continental slope and is below the photic zone. Here there is little seasonal variation in temperature, and salinity is virtually constant. The oxygen minimum is within this zone, abundant organic nitrogen is present, and the sediments are fine grained. Species inhabiting this zone probably require abundant organic detritus, uniform salinity, and little variation in temperature, and must be able to tolerate extremely low oxygen values.

Zone E is similar to zone D in physical and chemical characteristics, except for lower temperatures and greater abundance of organic material. Species characteristic of this broad zone, with its nearly uniform environment, are those requiring low uniform temperatures and high organic content and able to survive with little oxygen.

Off California, conditions are similar in the undifferentiated D-E zone to those in zones D and E off Central America. Why these zones cannot be separated off California is not understood. Perhaps the higher oxygen minimum is responsible; perhaps accidents of sampling have obscured the zonation off California, or have oversimplified the zonation off Central America.

Zone F is the deepest zone occurring in these traverses. The temperatures at its upper boundary are uniformly low (less than 4°C) and very similar throughout the zone and in all areas. The O_2 content is greater than that of zone E, but salinity and grain size are similar. Probably, therefore, the species that characterize zone F are those that can exist in very cold water, with other conditions showing no seasonal variations.

In the shallow zones (A, B, and C), where physiochemical factors vary greatly with increasing depth, species have small depth ranges and faunas change rapidly. These three zones occur in water less than 200 meters deep. The deeper zones (D, E, and F), where chemical and physical factors vary much less with changing depths, extend over a great depth range. In zones D, E, and F, where a single species can be collected at widely differing depths, there is much more opportunity for intraspecific variations to be detected; these variations may be due to slight environmental changes or t ogeographic isolation or both. Off El Salvador, in many of the species that vary (see p. B9–B17), the deeper water forms (more than 800 m) tend to have well-developed keels, carinae, or costae, whereas the same species from shallower water have rounded peripheries. The same type of variation may possibly occur in species from shallower zones, but if so it is too slight to be detected.

RELATIONS TO FOSSIL FAUNAS

Living faunas from the continental slope are nearly identical with those described from the Charco Azul Formation of Panama, which were described by Coryell and Mossman (1942), who believe this fauna to be of the Pliocene age.

The upper Pliocene beds exposed on islands in the Gulf of California (Natland, 1950) contain faunas very similar to those of the slope off Central America, and the Pleistocene faunas of that region are similar to the living faunas found on the continental shelf off El Salvador.

The faunas collected off El Salvador are similar to the Pliocene and Pleistocene faunas of California, but with several marked differences. These fossil faunas lack the species that are now restricted to warmer

waters, particularly the large species of *Cancris* and *Valvulineria*. Both these genera, however, are abundantly represented in the Miocene of California, indicating that more tropical conditions existed then.

SYSTEMATIC DESCRIPTIONS

Genera are listed, with a few exceptions, according to the classification of Cushman (1948), but incorporating modifications of the lamellar Foraminifera made by Smout (1955) and by Reiss (1958). Synonymies include only those forms for which types or adequate illustrations were examined.

All illustrated specimens are deposited in the U.S. National Museum in Washington, D.C.

Family SACCAMMINIDAE

Genus SACCAMMINA M. Sars

M. Sars, 1869, Vidensk. selsk. Christiania, Forh., Aar 1868, p. 248.

Type species (by subsequent designation).—*Saccammina sphaerica* M. Sars, idem.

Saccammina cf. S. comprima (Phleger and Parker)

Proteonina atlantica Cushman. Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2052.

Differs from typical *S. comprima* (Phleger and Parker) (1951, pt. 2, p. 2, pl. 1, fig. 3) by being more elongate.

Occurrence: 435 to 885 m.

Family REOPHACIDAE

Genus REOPHAX Montfort

Montfort, 1808, Conchyliologie systématique et classification méthodique des Coquilles, Paris, F. Schoell, v. 1, p. 331.

Type species.—Reophax scorpiurus Montfort (1808, p. 331, text figure).

Reophax bilocularis Flint

Plate 1, figure 1

Reophax bilocularis Flint, 1897, U.S. Natl. Mus. Rept., 1897, p. 273, pl. 17, fig. 2.

Reophax agglutinans Cushman. Cushman and McCulloch, 1939, Allan Hancock Pacific Exped. Repts., v. 6, no. 1, p. 59, 60, pl. 3, figs. 1–3.

Test large, composed of 1 to 3 chambers.

Occurence: 47 to 885 m; most abundant from 50 to 82 m. Reported by Cushman and McCulloch off California and Mexico at depths of 30 to 1,200 m.

Illustrated specimen: length 1.44 mm, width 0.90 mm, from sample C–6.

Reophax dentalinaformis Brady

Plate 1, figure 2

Reophax dentalinaformis Brady, 1881, Micros. Soc. Quart. Jour., v. 21, p. 49.

Brady, 1884, *Challenger* Rept., Zoology, v. 9, p. 293, pl. 30, figs. 21, 22.

Phleger and Parker, 1951, Geol. Soc. America Mem. 46, pt. 2, p. 2, pl. 1, fig. 6.

Uchio, 1960, Cushman Found. Foram, Research Spec. Pub. 5, pl. 1, fig. 4.

Reophax scorpiuris Montfort. Walton, 1955, Jour. Paleontology, v. 29, p. 1013, pl. 99, fig. 4.

[not] *R. dentalinaformis* Brady of Cushman, 1920, U.S. Natl. Mus. Bull. 104, pt. 2, p. 18, 19, pl. 5, figs. 4, 5.

Tests large, with chambers only slightly inflated. Wall fine grained, although specimens from sample C–6 and shallower depths include some sand grains.

Occurrence: Off El Salvador, 50 to 3,200 m. Reported by Brady from the North Atlantic mostly deeper than 1,800 m. Reported by Phleger and Parker in the Gulf of Mexico at depths of 38 to 357 m.

Illustrated specimen: length 1.84 mm, width 0.37 mm, from sample C–9.

Reophax scotti Chaster

Reophax scotti Chaster, 1892, Southport Soc. Nat. Sci. 1st rept. 1890–91, p. 57, pl. 1, fig. 1.

Höglund, 1947, Zool. Bidrag Från Uppsala, v. 26, p. 94–96, fig. 72.

Cushman and McCulloch, 1939, Allan Hancock Pacific Exped. Repts., v. 6, no. 1, p. 61, 62, pl. 3, fig. 11.

Reophax gracilis (Kiaer). Walton, 1955, Jour. Paleontology, v. 29, p. 1013, pl. 99, fig. 5.

Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2052.

Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, pl. 1, fig. 6.

Species is rarely found because of its fragility.

Occurrence: 435 m.

Family LITUOLIDAE

Genus HAPLOPHRAGMOIDES Cushman

Cushman, 1910, U.S. Natl. Mus. Bull. 71, pt. 1, p. 99.

Type species.—Nonionina canariensis d'Orbigny, 1839, *in* Barker-Webb and Berthelot, Histoire Naturelle des Îles Canaries, v. 2, pt. 2, Foraminifères, p. 128, pl. 2, figs. 33, 34.

Haplophragmoides cf. H. evolutus Natland

Umbilical area, sutures near umbilicus deeply depressed. Wall finely arenaceous. Differs from typical form (Natland, 1938, p. 138, pl. 3, figs. 5, 6) by having peripheral part of chambers more distinctly lobed.

Occurrence: 50 to 885 m.

Haplophragmoides lenticularis Natland

Haplophragmoides lenticularis Natland, 1938, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 4, p. 138, pl. 3, figs. 3, 4.
Alveophragmium lenticulare (Natland). Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, pl. 1, figs. 24, 25.

Test with sutures only slightly depressed, wall smooth, of uniform fine-grain size.

Occurrence: 800 to 885 m.

Family TEXTULARIIDAE

Genus TEXTULARIA Defrance

Defrance, 1824, *in* Blainville, Mollusques, *in* Vers et zoophytes, *in* Dictionaire des sciences naturelles: Paris, F. G. Levrault, v. 32, p. 177.

Type species (by monotypy).—*Textularia sagittula* Defrance, 1824, Atlas, Zool., in Conchyliologie et malacologie: pl. 13, fig. 5.

Textularia agglutinans d'Orbigny

Plate 1, figures 7a, b

Textularia agglutinans d'Orbigny, 1839, *in* De la Sagra, Histoire Physique Politique Naturelle de l'Île de Cuba, Foraminifères, p. 144, pl. 1, figs. 17, 18, 32, 34.
Lalicker and McCulloch, 1940, Allan Hancock Pacific Exped. Repts., v. 6, no. 2, p. 117, pl. 13, figs. 2a–c.

Wall coarsely grained.

Occurrence: 25 to 80 m. Reported by Lalicker and McCulloch off Mexico, Ecuador, at depths of 15 to 25 m.
Illustrated specimen: length 1.10 mm, width 0.47 mm, from sample C–4.

Textularia candeiana d'Orbigny

Plate 1, figures 4a, b

Textularia agglutinans d'Orbigny, 1839, *in* De la Sagra, Histoire Physique Politique Naturelle de l'Île de Cuba, Foraminifères, p. 143, pl. 1, figs. 25–27.
Lalicker and McCulloch, 1940, Allan Hancock Pacific Exped. Repts., v. 6, no. 2, p. 121, pl. 13, figs. 7a–c.

Test tapering rapidly in width and thickness to initial end. Wall coarsely arenaceous.

Occurrence: 37 to 50 m. Reported by Lalicker and McCulloch from the Gulf of California south to Peru, at depths of 6 to 90 m.
Illustrated specimen: length 1.07 mm, width 0.75 mm, from sample C–19.

Textularia panamensis Cushman

Plate 1, figures 6a, b

Textularia panamensis Cushman, 1918, U.S. Natl. Mus. Bull. 103, p. 53, pl. 20, figs. 1a, b.
Lalicker and McCulloch, 1940, Allan Hancock Pacific Exped. Repts., v. 6, no. 2, p. 136, 137, pl. 15, fig. 18.

Test very flat, chambers uninflated. Some specimens with strong median ridge, others flat. Presence of ridge apparently not related to ecology or generation. Wall generally fine grained but with some larger grains.

Occurrence: 20 to 140 m. Described originally from the Miocene of the Panama Canal Zone. Reported by Lalicker and McCulloch from the Gulf of California to Peru, at depths of 18 to 90 m.
Illustrated specimen: length 1.20 mm, width 0.80 mm, from sample C–2.

Textularia secasensis Lalicker and McCulloch

Plate 1, figures 5a, b

Textularia secasensis Lalicker and McCulloch, 1940, Allan Hancock Pacific Exped. Repts., v. 6, no. 2, p. 141, pl. 16, figs. 24a–c.
Textularia vola Lalicker and McCulloch. Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2053.

Species distinguished by subacute lobed periphery.

Occurrence: 47 to 140 m. Reported by Lalicker and McCulloch from the Gulf of California to Colombia, at depths of 4 to 275 m.
Illustrated specimen: length 0.94 mm, width 0.60 mm, from sample C–4.

Genus BIGENERINA d'Orbigny

d'Orbigny, 1826, Annals des Sci. Naturelles, ser. 1, v. 7, p. 261.

Type species.—*Bigenerina nodosaria* d'Orbigny, 1826, pl. 11, figs. 9–11.

Bigenerina hoeglundi Uchio

Bigenerina hoeglundi Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, p. 56, pl. 2, fig. 13.

Found only as a living form, owing probably to its fragility. Similar to *Textularia caribaea* d'Orbigny (1839a, p. 145, pl. 1, figs. 28, 29).

Occurrence: 50 to 144 m.

Family VERNEUILINIDAE

Genus GAUDRYINA d'Orbigny

d'Orbigny, 1839, *in* De la Sagra, Histoire Physique Politique Naturelle de l'Île de Cuba, Foraminifères, p. 109.

Type species (by subsequent designation).—*Gaudryina rugosa* d'Orbigny 1840, Geol, Soc. France Mem. 1, v. 4, p. 44, pl. 4, figs. 20, 21.

Gaudryina excolata Cushman

Plate 1, figure 9

Gaudryina excolata Cushman, 1936, Cushman Lab. Foram. Research Spec. Pub. 6, p. 16, pl. 3, fig. 3.
Gaudryina atlantica (Bailey). Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2051.

Wall fine grained.

Occurrence: 50 to 144 m.
Illustrated specimen: length 1.15 mm, width 0.58 mm, from sample C–6.

Family VALVULINIDAE

Genus EGGERELLA Cushman

Cushman, 1933, Cushman Lab. Foram. Research Contr., v. 9, p. 33.

Type species.—*Verneuilina bradyi* Cushman, 1911 U.S. Natl. Mus. Bull. 71, pt. 2, p. 54, text fig. 87.

Eggerella pusilla (Göes)

Plate 1, figures 3a, b

Verneuilina pusilla Göes, 1896, Harvard Coll. Mus. Comp. Zoology Bull., v. 29, no. 1, p. 39, pl. 5, figs. 6–8.

Eggerella pusilla (Göes). Cushman, 1937. Cushman Lab. Foram. Research Spec. Pub. 8, p. 51, pl. 5, figs. 16, 17.

Cushman and McCulloch, 1939, Allan Hancock Pacific Exped. Repts., v. 6, no. 1, p. 96, 97, pl. 10, figs. 2, 3,

Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, pl. 2, fig. 19.

More slender and finer textured than *E. advena* (Cushman) (1922a, p. 141).

Occurrence: 140 to 144 m. off El Salvador. Reported by Cushman and McCulloch from Alaska to Columbia, 90 to 160 m.

Illustrated specimen: length 0.53 mm, width 0.18 mm, from sample C–7.

Genus GOESELLA Cushman

Cushman, 1933, Cushman Lab. Foram. Research Contr., v. 9, p. 34.

Type species.—*Clavulina rotundata* Cushman, 1931, U.S. Natl. Mus. Proc., v. 44, no. 1973, p. 635, pl. 79, fig. 3.

Goesella flintii Cushman

Goesella flintii Cushman, 1936, Cushman Lab. Foram. Research Spec. Pub. 6, p. 34, pl. 5, fig. 8.

Cushman and McCulloch, 1939, Allan Hancock Pacific Exped. Repts., v. 6, no. 1, p. 98, pl. 10, figs. 4–9.

Walton, 1955, Jour. Paleontology, v. 29, p. 1009, pl. 100, figs. 10, 11.

Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, pl. 2, fig. 24.

Occurrence: Off El Salvador, 435 to 885 m. Reported by Cushman and McCulloch from the Farallones to Peru, at depths of 75 to 380 m.

Genus TRITAXILINA Cushman

Cushman, 1911, U.S. Natl. Mus. Bull. 71, p. 71.

Type species (by monotypy).—*Clavulina caperata* Brady, 1881, Micros. Soc. Quart. Jour., v. 21, p. 54. =*Tritaxia caperata* (Brady). Brady, 1884, *Challenger* Rept., Zoology, v. 9, p. 390, pl. 49, fig. 127.

Tritaxilina cf. T. atlantica Cushman

Specimens smaller than those described by Cushman (1922b, p. 79, 80, pl. 15, figs. 1, 2) from the Caribbean (697 m).

Occurrence: 800 to 1,600 m.

Family MILIOLIDAE

Genus MILIOLINELLA Weisner

Weisner, 1931, Die Foraminiferes der deutschen Südpolar-Expedition 1901–03, *in* Drygalski, E. von, Deutsche Sudpolar-Expedition 1901–03. Berlin u. Leipsig, Deutschland, de Gruyter, v. 20 (Zoologie, v. 12), p. 63, 65, 107.

Type species.—*Vermiculum subrotundum* Montagu, 1803, Testacea Britannica, p. 521. =*Serpula subrotunda dorso elevato* Walker and Boys, 1784, Testacea minuta rariora, p. 2, pl. 1, fig. 4.

Miliolinella circularis (Bornemann)

Plate 1, figure 13

Triloculina circularis Bornemann, 1855, Deutsche geol. Gesell. Zeitschr., v. 7, p. 349, pl. 19, fig. 4.

Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 16.

Miliolinella circularis (Borenmann). Oinomikado and Stache, 1948, Rept. comm. treatise on Marine Ecology and Paleoecology, 1947, 1948, no. 8, p. 107.

Occurrence: 40 to 144 m.

Illustrated specimen: length 0.33 mm, width 0.25 mm, from sample C–4.

Genus SCUTULORIS Loeblich and Tappan

Loeblich and Tappan, 1953, Smithsonian Misc. Colln., v. 121, no. 7, p. 41.

Type species.—*Scutuloris tegminis* Loeblich and Tappan, ibid., p. 41, 42, pl. 5, fig. 10.

Scutuloris sp.

Plate 1, figures 12a, b

Test small (generally less than 0.2 mm in length), about 1½ times as long as broad; chambers quinqueloculine, not inflated; periphery broadly rounded; sutures only slightly indented, white appearing; wall with silvery granular appearance; aperture with low tooth. This is probably an undescribed species.

Occurrence: 20 to 80 m.

Illustrated specimen: length 0.20 mm, width 0.15 mm, from sample C–4.

Genus NUMMOLOCULINA Steinmann

Steinmann, 1881, Neues Jahrb. Mineralogie Geologie u. Paläontologie, v. 1, p. 31, 41, 42.

Type species.—*Biloculina contraria* d'Orbigny, 1846, Foram. Fossiles Vienne, p. 266, pl. 14, figs. 4–6.

Nummoloculina irregularis (d'Orbigny)

Biloculina irregularis d'Orbigny, 1839, Voyage dans l'Amérique Méridionale, v. 5, pt. 5, Foraminifères, p. 67, pl. 8, figs. 20, 21.

Nummoloculina irregularis (d'Orbigny). Phleger, Parker, and Pierson, 1953, Swedish Deep-Sea Exped. Repts., v. 7, pt. 1, p. 28, pl. 5, figs. 19, 20.

Occurrence: 1,700 m.

Genus QUINQUELOCULINA d'Orbigny

d'Orbigny, 1826, Annals des Sci. Naturelles, ser. 1, v. 7, p. 301.

Type species (by subsequent designation).—*Serpula seminulum* Linné, 1758, Syst. Nat., ed. 10, v. 1, p. 786, pl. 2, figs. 1a–c.

Quinqueloculina auberiana d'Orbigny

Plate 1, figures 10a, b

Quinqueloculina auberiana d'Orbigny, 1839, *in* De la Sagra, Histoire Physique Politique Naturelle de l'Île de Cuba, Foraminifères, p. 193, pl. 12, figs. 1–3.

Occurrence: 37 to 140 m.

Illustrated specimen: length 0.62 mm, width 0.38 mm, from sample C–18.

Quinqueloculina cf. Q. venusta Karrer

Plate 1, figures 11a, b

Karrer, 1868, K. Akad. Wiss. Wien Sitzungsber, v. 58, p. 147, pl. 2, fig. 6.

Occurrence: 20 to 50 m.

Illustrated specimen: length 0.40 mm, width 0.22 mm, from sample C–4.

Quinqueloculina sp.

Plate 1, figures 8a, b

Test small, about twice as long as broad; chambers not inflated, sharply defined; margin strongly angulated; sutures depressed; wall finely arenaceous; aperture with low rounded tooth.

Occurrence: 50 to 144 m.

Illustrated specimen: length 0.44 mm, width 0.27 mm, from sample C–18.

Genus SPIROLOCULINA d'Orbigny

d'Orbigny, 1826, Annals des Sci. Naturelles, ser. 1, v. 7, p. 298.

Type species (by subsequent designation).—*Spiroloculina depressa* d'Orbigny 1826, p. 298 (not figured). (Parker, Jones, and Brady, 1871, Annals and Mag. Nat. History, London, ser. 4, v. 8, pl. 8, fig. 23.)

Spiroloculina soldanii Fornasini

Plate 1, figures 14a, b

Spiroloculina soldanii Fornasini, 1886, Geol. Soc. Italy Bull., v. 5, p. 25.

Fornasini, 1894, I foraminiferi della collezione Soldani, pl., fig. 1.

Cushman and Todd, 1944, Cushman Lab. Foram, Research Spec. Pub. 11, p. 37, pl. 6, figs. 5–9.

Parker, 1954, Harvard Coll. Mus. Comp. Zoology Bull., v. 111, no. 10, p. 498, 499, pl. 4, fig. 16.

Occurrence: 37 to 140 m.

Illustrated specimen: length 1.20 mm, width 0.73 mm, from sample C–4.

Genus TRILOCULINA d'Orbigny

d'Orbigny, 1826, Annals des Sci. Naturelles, ser. 1, v. 7, p. 299.

Type species (by subsequent designation).—*Miliola* (*Miliolites*) *trigonula* Lamarck, 1804, Annals du Museum, v. 5, p. 351, no. 3.

Triloculina tricarinata d'Orbigny

Triloculina tricarinata d'Orbigny, 1826, Annals des Sci. Naturelles, v. 7, p. 299, model no. 94.

Occurrence: 140 m.

Family TROCHAMMINIDAE

Genus TROCHAMMINA Parker and Jones

Parker and Jones, 1860, Annals and Mag. Nat. History, London, ser. 3, v. 4, no. 23, p. 347.

Type species (by monotypy).—*Nautilus inflatus* Montagu, 1808, Testacea Britannica, Supp., p. 81, pl 18, fig. 3.

Trochammina rotaliformis J. Wright

Trochammina inflata (Montagu) var., Balkwill and Wright, 1885, Royal Irish Acad. Trans., v. 28 (Sci.), p. 331, pl. 13, figs. 11, 12.

Trochammina rotaliformis J. Wright, 1911, *in* Heron-Allen and Earland, Royal Micros. Soc. Jour., p. 309.

Cushman, 1920, U.S. Natl. Mus. Bull. 104, pt. 2, p. 77, pl. 16, figs. 1, 2.

Cushman and McCulloch, 1939, Allan Hancock Pacific Exped. Repts., v. 6, no. 1, p. 107, 108, pl. 12, fig. 2.

Wall always extremely fine grained.

Occurrence: 25 to 80 m. Reported by Cushman and McCulloch from Alaska to Peru, at depths of 15 to 20 m.

Family LAGENIDAE

Genus LAGENA Walker and Boys

Walker and Boys, 1784, Testacea minuta rariora, p. 2.

Type species (by subsequent designation).—*Lagena sulcata* Walker and Jacob=*Serpula* (*Lagena*) *striata sulcata rotunda* Walker and Boys 1784, pl. 1, fig. 6.

Lagena acuticosta Reuss

Lagena acuticosta Reuss, 1861, K. Akad. Wiss. Wien Sitzungsber., v. 44, p. 305, pl. 1, fig. 4.

Occurrence: 1,600 m.

Lagena clavata (d'Orbigny)

Oolina clavata d'Orbigny, 1846, Foram. Fossiles Vienne, p. 24, pl. 1, figs. 2, 3.

Occurrence: 1,600 to 1,700 m.

Lagena distoma Parker and Jones

Lagena distoma Parker and Jones, MS. Brady, 1864, Linnean Soc. Trans., v. 24, p. 467, pl. 48, fig. 6.

Occurrence: 1,600 to 1,700 m.

Lagena hispida Reuss

Lagena filacosta Reuss, 1863, K. Akad. Wiss. Wien Sitzungsber. v. 44, ab. 1 (1862), p. 328, pl. 4, figs. 50–51.

Lagena hispida Reuss

Lagena hispida Reuss, 1862, K. Akad. Wiss. Wien Sitzungsber. v. 44, p. 335, pl. 6, figs. 77–79.
Occurrence: 1,600 m.

Lagena laevis (Montagu)

Vermiculum laeve Montagu, 1803, Testacea Britannica, p. 524.
Lagena laevis (Montagu). Brady, 1884, *Challenger* Rept., Zoology, v. 9, p. 455, pl. 56, figs. 7–14, 30.
Occurrence: 1,600 m.

Lagena striata (d'Orbigny)

Oolina striata d'Orbigny, 1839, Voyage dans l'Amérique Méridionale, v. 5, pt. 5, Foraminifères, p. 21, pl. 5, fig. 12.
Occurrence: 1,600 m.

Lagena submagnifica Cushman and Gray

Lagena submagnifica Cushman and Gray, 1946, Cushman Lab. Foram. Research Spec. Pub. 19, p. 22, pl. 4, figs. 12–15.
Cushman and McCulloch, 1950, Allan Hancock Pacific Exped. Repts., v. 6, no. 6, p. 355, pl. 48, fig. 1.
Occurrence: 1,600 m.

Lagena sulcata (Walker and Jacob)

Serpula (*Lagena*) *sulcata* Walker and Jacob, 1798, *in* Konmacher, "Adams' Essays on the microscope," Ed. Z, London, p. 634, pl. 14, fig. 5.
Occurrence: 37 to 885 m.

Genus FISSURINA Reuss

Reuss, 1850, K. Akad. Wiss, Wien, Math. =naturl. Kl. Denkschr., Wien, v. 1, p. 366.

Type species (by monotypy).—*Fissurina laevigata* Reuss, 1850, pl. 46, fig. 1.

Fissurina bicarinata Terquem

Fissurina bicarinata Terquem, 1882, Soc. geol. France Mem. 3, v. 2, p. 31, pl. 1, figs. 24a, b.
Occurrence: 1,600 to 1,700 m.

Fissurina lucida (Williamson)

Entosolenia marginata Montagu var. *lucida* Williamson, 1858, Recent British Foraminifera, Ray Soc., London, p. 10, pl. 1, figs. 22, 23.
Occurrence: 1,600 to 1,700 m.

Fissurina marginata (Montagu)

Vermiculum marginatum Montagu, 1803, Testacea Britannica, p. 524.
Fissurina marginata (Montagu). Williamson, 1858, Recent British Foraminifera, Ray Soc., London, p. 9, pl. 1, figs. 19–28.
Occurrence: 1,600 to 1,700 m.

Genus DENTALINA d'Orbigny

d'Orbigny, 1826, Annals des Sci. Naturelles, ser. 1, v. 7, p. 254.

Type species.—*Nodosaria obliqua* d'Orbigny, 1826, model no. 5.

Dentalina pauperata d'Orbigny

Dentalina pauperata d'Orbigny, 1846, Foram. Fossiles Vienne, p. 46, pl. 1, figs. 57, 58.
Loeblich and Tappan, 1953, Smithsonian Misc. Colln., v. 121, no. 7, p. 57, pl. 9, figs. 7, 8.
Occurrence: 800 to 1,600 m.

Genus ROBULUS Montfort

Montfort, 1808, Conchyliologie systématique et classification méthodique des Coquilles, Paris, F. Schoell, v. 1, p. 215.

Type species.—*Robulus cultratus* Montfort, ibid., p. 214, text fig.

Robulus cushmani Galloway and Wissler

Robulus cushmani Galloway and Wissler, 1927, Jour. Paleontology, v. 1, p. 51, pl. 8, fig. 11.
Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 149.
Resig, 1958, Micropaleontology, v. 4, p. 307.

Umbilical area clear, 10 to 13 chambers in last whorl in adult form. Rare, only a few adult specimens found.

Occurrence: 50 to 1,700 m.

Genus SARACENARIA Defrance

Defrance, 1824, *in* Blainville, Mollusques, *in* Vers et zoophytes, *in* Dictionnaire des sciences naturelles: Paris, F. G. Levrault, v. 32, p. 176.

Type species (by monotypy).—*Saracenaria italica* Defrance, ibid., Atlas, Zool. in Conchyliologie et malacologie: pl. 13, fig. 6.

Saracenaria angularis Natland

Plate 2, figures 1a, b

Saracenaria angularis Natland, 1938, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 4, p. 143, pl. 5, figs. 1, 2.
Occurrence: 80 to 82 m.
Illustrated specimen: length 0.60 mm, width 0.33 mm, from sample C–6.

Family BULIMINIDAE

Genus BULIMINA d'Orbigny

d'Orbigny, 1826, Annals des Sci. Naturelles, ser. 1, v. 7, p. 269.

Type species.—*Bulimina marginata* d'Orbigny, ibid., pl. 7, figs. 10-12.

Bulimina affinis d'Orbigny

Plate 2, figures 2, 3

Bulimina affinis d'Orbigny, 1839, *in* De la Sagra, Histoire Physique Politique Naturell de l'Île de Cuba, Foraminifères, p. 105, pl. 2, fig. 25–26.

Crouch, 1952, Am. Assoc. Petroleum Geologists Bull., v. 36, p. 826, pl. 1, fig. 15.
Walton, 1955, Jour. Paleontology, v. 29, p. 1003, pl. 102, fig. 15.
Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2050.
Globobulimina hoeglundi Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, p. 64, pl. 6, figs. 7, 8.

A deep water form, with a large fragile test. Microspheric form rapidly tapering to an acute initial end; megalospheric form with large (0.2 mm) initial chamber, relatively little change in diameter throughout length.

Occurrence: 800 to 3,100 m.
Illustrated specimens: megalospheric, length 0.80 mm, width 0.32 mm, from sample C–14; microspheric, length 0.87 mm, width 0.40 mm, from sample C–14.

Bulimina auriculata Bailey

Plate 2, figures 4a, b

Bulimina auriculata Bailey, 1851, Smithsonian Contr., v. 2, p. 12, pl., figs. 25–27.
Cushman and McCulloch, 1948, Allan Hancock Pacific Exped. Repts., v. 6, no. 5, p. 249, pl. 31, fig. 4.
Bulimina ovata d'Orbigny. Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 124.

Large, fragile, and rare.

Occurrence: 435 to 885 m.
Illustrated specimen: length 1.24 mm, width 0.80 mm, from sample C–9.

Bulimina denudata Cushman and Parker

Plate, 2, figure 12

Bulimina pagoda var. *denudata* Cushman and Parker, 1938, Cushman Lab. Foram, Research Contr., v. 14, p. 57, pl. 10, figs. 1, 2.
Bulimina denudata Cushman and Parker. Walton, 1955, Jour. Paleontology, v. 29, p. 1003, pl. 102, fig. 8.
Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2050.
[not] *Bulimina denudata* Cushman and Parker. Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, pl. 6, fig. 3.
Occurrence: 37 to 1,600 m.
Illustrated specimen: length 0.38 mm, width 0.16 mm, from sample C–6.

Bulimina marginospinata Cushman and Parker

Plate 2, figure 6

Bulimina marginospinata Cushman and Parker, 1938, Cushman Lab. Foram. Research Contr., v. 14, p. 57, pl. 9, fig. 11.
Bulimina barbata Cushman. Bandy, 1953, Jour. Paleontology, v. 27, p. 176, pl. 24, fig. 10.

Differs from *B. barbata* Cushman (1927, p. 151, pl. 2, fig. 11) by having more delicate spines and more inflated chambers.

Occurrence: 800 to 1,700 m.
Illustrated specimen: length 0.60 mm, width 0.33 mm, from sample C–14.

Bulimina mexicana Cushman

Bulimina striata var. *mexicana* Cushman, 1922, U.S. Natl. Mus. Bull. 104, pt. 3, p. 95, pl. 21, fig. 2.
Bandy, 1953, Jour. Paleontology, v. 27, p. 176, pl. 24, fig. 13.
Resig, 1958, Micropaleontology, v. 4, p. 305.
Bulimina mexicana Cushman. Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, pl. 6, fig. 4.

Species rare. Test with strong costae extending from top of chambers, produced into short spines at basal overhang.
Occurrence: 1,700 m.

Bulimina pagoda Cushman

Plate 2, figure 5

Bulimina pagoda Cushman, 1927, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 1, p. 152, pl. 2, fig. 16.
Crouch, 1952, Am. Assoc. Petroleum Geologists Bull., v. 36, p. 826, pl. 2, fig. 4.
Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2050.
Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, pl. 6, fig. 5.
Occurrence: 800 to 885 m.
Illustrated specimen: length 0.38 mm, width 0.16 mm, from sample C–14.

Bulimina aff. B. subacuminata Cushman, Stewart, and Stewart

Bulimina clava Cushman and Parker. Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2050.

Differs from typical *B. subacuminata* Cushman, Stewart, and Stewart (1930, p. 65, pl. 5, figs. 2, 3) by having longer spines, higher costae. Differs from *B. mexicana* by having less numerous costae, which do not extend to top of chamber.

Occurrence: 1,600 to 1,700 m.

Bulimina tenuata (Cushman)

Plate 2, figures 8a, b

Buliminella subfusiformis var. *tenuata* Cushman, 1927, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 1, p. 149, pl. 2, fig. 9.
Bulimina exilis var. *tenuata* (Cushman). Cushman and McCulloch, 1948, Allan Hancock Pacific Exped. Repts., v. 6, no. 5, p. 248, pl. 31, fig. 2.
Walton, 1955, Jour. Paleontology, v. 29, p. 1003, pl. 102, fig. 6.
Bulimina tenuata (Cushman). Crouch, 1952, Am. Assoc. Petroleum Geologists Bull., v. 36, p. 828, pl. 2, fig. 10.
Buliminella exilis (H. B. Brady). Bandy, 1953, Jour. Paleontology, v. 27, p. 176, pl. 25, fig. 9.
Buliminella exilis var. *tenuata* Cushman. Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2050.

Buliminella tenuata Cushman. Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, pl. 6, fig. 1

Occurrence: 435 to 1,700 m. Reported by Cushman and McCulloch from the coast to California to Ecuador.

Illustrated specimen: length 0.53 mm, width 0.17 mm, from sample C–9.

Family BULIMINELLIDAE

Genus BULIMINELLA Cushman

Cushman, 1911, U.S. Natl. Mus. Bull. 71, pt. 2, p. 88.

Type species.—*Bulimina elegantissima* d'Orbigny, 1839, Voyage dans l'Amérique Méridionale, v. 5, pt. 5, Foraminifères, p. 51, pl. 7, figs. 13, 14.

Buliminella curta Cushman

Buliminella curta Cushman, 1925, Cushman Lab. Foram. Research Contr., v. 1, p. 33, pl. 5, fig. 13.

Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2050.

Occurrence: 800 to 885 m.

Buliminella elegantissima (d'Orbigny)

Bulimina elegantissima d'Orbigny, 1839, Voyage dans l'Amérique Méridionale, v. 5, pt. 5, Foraminifères, p. 51, pl. 7, figs. 13, 14.

Buliminella elegantissima (d'Orbigny). Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 2.

Bandy, 1953, Jour. Paleontology, v. 27, p. 176, pl. 24, fig. 14.

Walton, 1955, Jour. Paleontology, v. 29, p. 1004, pl. 102, fig. 17.

Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2050.

Resig, 1958, Micropaleontology, v. 4, p. 305.

Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, pl. 6, fig. 2.

Occurrence: 20 to 82 m.

Family VIRGULINIDAE

Genus VIRGULINA d'Orbigny

d'Orbigny, 1826, Annals des Sci. Naturelles, ser. 1, v. 7, p. 267.

Type species (by monotypy).—*Virgulina squammosa* d'Orbigny, ibid., model no. 64. (Parker, Jones, and Brady, 1865, Annals and Mag. Nat. History, London, ser. 3, v. 16, pl. 2, fig. 66.)

Virgulina bramlettei Galloway and Morrey

Virgulina bramlettei Galloway and Morrey, 1929, Bull. Am. Paleontology, v. 15, no. 55, p. 37, pl. 5, fig. 14.

Walton, 1955, Jour. Paleontology, v. 29, p. 1017, pl. 102, fig. 18.

Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2053.

Virgulina schreibersiana Czjzek. Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 232.

Less elongate than *V. schreibersiana* Czjzek (1848, p. 147, pl. 13, figs. 18–21). Closely related to *V. pontoni* Cushman (1932, p. 17, pl. 8, fig. 7) but sutures not oblique to periphery.

Occurrence: 800 to 1,700 m.

Virgulina complanata Egger

Plate 2, figure 11

Virgulina schreibersiana Czjzek var. *complanata* Egger, 1893, K. bayer. Akad. Wiss Abh., Math.-physik Kl., Munchen, v. 18, pt. 2, p. 292, pl. 8, figs. 91, 92.

Virgulina complanata Egger. Phleger and Parker, 1951, Geol. Soc. America Mem. 46, pt. 2, p. 19, pl. 9, figs. 1–3.

Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, p. 63, pl. 6, fig. 13.

Virgulina nodosa R. E. and K. C. Stewart. Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2053.

Test small, chambers inflated. Differs from *V. nodosa* R. E. and K. C. Stewart (1930, p. 64, pl. 8, fig. 4) by having most of test untwisted and biserial.

Occurrence: 1,600 to 1,700 m.

Illustrated specimen: length 0.35 mm, width 0.08 mm, from sample C–10.

Virgulina cornuta Cushman

Virgulina cornuta Cushman, 1913, U.S. Natl. Mus. Proc., v. 44, p. 637, pl. 80, figs. 1a–c.

Cushman, 1921, U.S. Natl. Mus. Bull. 100, v. 4, p. 170, pl. 32, figs. 3–6.

Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 236.

Crouch, 1952, Am. Assoc. Petroleum Geologists Bull., v. 36, p. 828, pl. 2, fig. 13.

Occurrence: 800 to 885 m.

Virgulina mexicana Cushman

Virgulina mexicana Cushman, 1922, U.S. Natl. Mus. Bull. 104, pt. 3, p. 120, pl. 23, fig. 8.

Cushman, 1937, Cushman Lab. Foram. Research Spec. Pub. 9, p. 29, 30, pl. 5, fig. 4.

Occurence: 1,600 to 1,700 m.

Virgulina punctata d'Orbigny

Plate 2, figure 10

Virgulina punctata d'Orbigny, 1839, *in* De la Sagra, Histoire Physique Politique Naturelle de l'Île de Cuba, Foraminifères, p. 139, pl. 1, figs. 35, 36.

Cushman, 1937, Cushman Lab. Foram. Research Spec. Pub. 9, p. 23, pl. 3, figs. 25–27.

Parker, 1954, Harvard Coll. Mus. Comp. Zoology Bull., v. 111, no. 10, p. 513, pl. 7, fig. 11.

Sutures very oblique to periphery.

Occurrence: 20 to 140 m.

Illustrated specimen: length 0.52 mm, width 0.16 mm, from sample C–19.

Virgulina sandiegoensis Uchio

Plate 2, figure 7

Virgulina sandiegoensis Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, p. 63, pl. 6, figs. 17, 18.

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Similar to *V. texturata* Brady (1884, p. 415, pl. 52, figs. 6a, b) but apparently much smaller. Length of Brady's specimen 1.20 mm; length of this form less than 0.40 mm. Test extremely small, tapering from a sharp initial end though the later part of the test nearly parrallel sided in the mature form. Chambers very slightly inflated, and sutures only slightly oblique to the periphery. Wall thin, transparent, and very finely perforate.

Occurrence: 20 to 144 m.

Illustrated specimen: length 0.33 mm, width 0.12 mm, from sample C–6.

Virgulina seminuda Natland

Plate 2, figure 9

Virgulina sp. Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 201.

Virgulina seminuda Natland, 1938, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 4, p. 145, pl. 5, fig. 12.

Crouch, 1952, Am. Assoc. Petroleum Geologists Bull., v. 36, p. 828, pl. 2, fig. 15.

Virgulina tesselata Phleger and Parker, 1951, Geol. Soc. America Mem. 46, pt. 2, p. 19, pl. 9, figs. 15, 16.

Occurrence: 800 to 3,200 m. Phleger and Parker report *V. tesselata* in the Gulf of Mexico at depths of 200 to 1,000 m.

Illustrated specimen: length 0.38 mm, width 0.12 mm, from sample C–14.

Family GLOBOBULIMINDAE

Genus GLOBOBULIMINA Cushman

Cushman, 1927, Cushman Lab. Foram. Research. Contr., v. 3, p. 67.

Type species.—Globobulimina pacifica Cushman, ibid., pl. 14, fig. 12.

Globobulimina pacifica Cushman

Globobulimina pacifica Cushman, 1927, Cushman Lab. Foram. Research Contr., v. 3, p. 67, pl. 14, fig. 12.

Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 194.

Bandy, 1953, Jour. Paleontology, v. 27, p. 177.

Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2051.

Occurrence: 435 to 3,100 m.

Family UVIGERINIDAE

Genus UVIGERINA d'Orbigny

d'Orbigny, 1826, Annals des Sci. Naturelles, ser. 1, v. 7, p. 268.

Type species (by subsequent designation).—*Uvigerina pigmaea* d'Orbigny, ibid., p. 269, pl. 12, figs. 8, 9.

Uvigerina auberiana d'Orbigny

Uvigerina auberiana d'Orbigny, 1839, *in* De la Sagra, Histoire Physique Politique Naturelle de l'Île de Cuba, Foraminifères, p. 106. pl. 2, figs. 23, 24.

Phleger, Parker, and Pierson, 1953, Swedish Deep-Sea Exped. Repts., v. 7, no. 1, p. 37, 38, pl. 7, figs. 30–35.

Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, p. 65, pl. 7, fig. 11.

Uvigerina proboscidea var. *vadescens* Cushman. Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2053.

Test small, with extremely fine spines randomly distributed over test. Neck long.

Occurrence: 885 to 3,200 m.

Uvigerina excellens Todd

Plate 2, figures 13a, b

Uvigerina excellens Todd, *in* Cushman and McCulloch, 1948, Allan Hancock Pacific Exped. Repts., v. 6, no. 5, p. 258, pl. 33, fig. 2.

Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2053.

?*Uvigerina striata* d'Orbigny. Coryell and Mossman, 1942, Jour. Paleontology, v. 16, p. 245, pl. 36, figs. 53, 54.

Elegant species, with numerous distinct uniform costae over all of test except occasionally the last chamber.

Uchio (1960, pl. 7, fig. 14) illustrates this species but does not describe its occurrence.

Occurrence: 435 to 885 m.

Illustrated specimen: length 0.90 mm, width 0.43 mm, from sample C–14.

Uvigerina incilis Todd

Plate 2, figure 14

Uvigerina incilis Todd, *in* Cushman and McCulloch, 1948, Allan Hancock Pacific Exped. Repts., v. 6, no. 5, p. 260, pl. 33, fig. 4.

Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2053.

Some specimens with overhang at base of chambers, giving sharp costae appearance of short basal spines.

Occurrence: 50 to 144 m.

Illustrated specimen: length 0.40 mm, width 0.20 mm, from sample C–6.

Uvigerina peregrina Cushman

Plate 2, figures 15, 16

Uvigerina peregrina Cushman, 1923, U.S. Natl. Mus. Bull. 104, pt. 4, p. 166, pl. 42, figs. 7–10.

Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 217.

Crouch, 1952, Am. Assoc. Petroleum Geologists Bull., v. 36, p. 832, pl. 3, fig. 14.

Uvigerina hispido-costata Cushman and Todd, 1945, Cushman Lab. Foram. Research Spec. Pub. 15, p. 51, pl. 7, figs. 27, 31.

Uvigerina peregrina var. *dirupta* Todd, *in* Cushman and McCulloch, 1948, Allan Hancock Pacific Exped. Repts., v. 6, no. 5, p. 267, pl. 34, fig. 3.

Crouch, 1952, Am. Assoc. Petroleum Geologists Bull., v. 36, p. 832, pl. 3, figs. 15, 16.

Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2053.

Uvigerina curticosta Cushman. Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, p. 65, pl. 7, figs. 12, 13.
?*Uvigerina gallowayi* Coryell and Mossman, 1942, Jour. Paleontology, v. 16, p. 244, pl. 36, fig. 50.

Complete gradation from forms with costae over entire length (fig. 16) to those with spines on all or part of test (*U. peregrina dirupta*) (fig. 15). Former type most abundant in deeper samples (C–10, C–13), the latter more abundant in C–9, C–14. As these forms cannot be separated morphologically or geographically, they are all included in the species *Uvigerina peregrina*.

Occurrence: 800 to 1,700 m.
Illustrated specimens: Fig. 15, length 1.03 mm, width 0.50 mm, from sample C–14; fig. 16, length 0.82 mm, width 0.38 mm, from sample C–10.

Genus ANGULOGERINA Cushman

Cushman, 1927, Cushman Lab. Foram. Research Contr., v. 3, p. 69.

Type species:—*Uvigerina angulosa* Williamson, 1858, Recent British Foraminifera, Ray Soc., London, p. 67, pl. 5, fig. 140.

Angulogerina agrestis Todd

Angulogerina agrestis Todd, *in* Cushman and McCulloch, 1948, Allan Hancock Pacific Exped. Repts., v. 6, no. 5, p. 288, pl. 36, fig. 6.
Occurrence: 50 m off El Salvador. Reported by Cushman and McCulloch at depths of 30 to 85 m.

Angulogerina carinata Cushman

Plate 3, figures 1, 2

Angulogerina carinata Cushman, 1927, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 1, p. 159, pl. 4, fig. 3.
Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 185.
Cushman and McCulloch, 1948, Allan Hancock Pacific Exped. Repts., v. 6, no. 5, p. 281, 286, pl. 35, figs. 8, 11.
Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2050.
Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, p. 66, pl. 7, fig. 19.
Angulogerina carinata var. *bradyana* Cushman, 1932, Cushman Lab. Foram. Research Contr., v. 8, p. 45, pl. 6, figs. 9, 10.
Cushman and McCulloch, 1948, Allan Hancock Pacific Exped. Repts., v. 6, no. 5, p. 287, pl. 35, fig. 9.

Specimens in C–7 and C–16 (pl. 3, figs. 1a, b) with thin translucent walls and well-developed carinae might be assigned to *A. carinata bradyana*. Those from the deeper samples exhibit the thick opaque walls characteristic of *A. carinata* and generally lack well-developed carinae (pl. 3, figs. 2a, b).

Occurrence: A. carinata s. s., 435 to 1,700 m. Reported by Cushman and McCulloch at depths of 12 to 1,100 m. *A. carinata bradyana*, 140 to 144 m. Reported by Cushman and McCulloch from 6 to 455 m.
Illustrated specimens: Fig. 1, length 0.85 mm, width 0.35 mm, from sample C–7; fig. 2, length 0.98 mm, width 0.33 mm, from sample C-9.

Angulogerina semitrigona (Galloway and Wissler)

Uvigerina semitrigona Galloway and Wissler, 1927, Jour. Paleontology, v. 1, p. 77, pl. 11, fig. 21.
Angulogerina semitrigona (Galloway and Wissler). Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 71.
Cushman and McCulloch, 1948, Allan Hancock Pacific Exped. Repts., v. 6, no. 5, p. 292, 293, pl. 36, fig. 5.

Specimens small and thin walled with angularity developed only on later chambers.

Occurrence: 140 to 144 m. Reported by Cushman and McCulloch from the Gulf of California to the Galapagos, at depths of 0 to 300 m.

Family BOLIVINIDAE

Genus BOLIVINA d'Orbigny

d'Orbigny, 1839, Voyage dans l'Amérique Méridionale, v. 5, pt. 5, Foraminifères, p. 61.

Type species.—Bolivina plicata d'Orbigny, ibid., p. 62, pl. 8, figs. 4–7.

Bolivina acuminata Natland

Bolivina sp., Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 171.
Bolivina subadvena Cushman var. *serrata* Natland [not Chapman, 1892], 1938, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 4, no. 5, p. 145, 146, pl. 5, figs. 8, 9.
Cushman and McCulloch, 1942, Allan Hancock Pacific Exped. Repts., v. 6, no. 4, p. 213, pl. 26, fig. 14, pl. 27, figs. 1, 2.
Bolivina subadvena Cushman var. *acuminata* Natland. Cushman and Gray, 1946, Cushman Lab. Foram. Research Spec. Pub. 19, p. 34, pl. 5, fig. 46.
Bolivina acuminata Natland, 1950, Geol. Soc. America Mem. 43, pt. 4, p. 22, pl. 5, figs. 21a, b.
Walton, 1955, Jour. Paleontology, v. 29, p. 1001, pl. 102, fig. 5.
Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2050.
Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, pl. 6, fig. 20.
Smith, 1963, U.S. Geol. Survey Prof. Paper 429–A, p. A21, A22, pl. 30, figs. 20, 21.

For quantitative analysis of the species off El Salvador, see Smith (1963).

Occurrence: 47 to 450 m. Reported by Cushman and McCulloch from southern California to Mexico, in 20 to 334 m.

Bolivina argentea Cushman

Bolivina argentea Cushman, 1926, Cushman Lab. Foram. Research Contr., v. 2, pt. 2, p. 42, pl. 6, fig. 5.
Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 200.
Cushman, 1937, Cushman Lab. Foram. Research Spec. Pub. 9, p. 140, pl. 19, figs. 7–11.

Crouch, 1952, Am. Assoc. Petroleum Geologists Bull., v. 36, p. 828, pl. 3, fig. 1.
Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2050.
Walton, 1955, Jour. Paleontology, v. 29, p. 1001, pl. 101, figs. 26, 27.
Smith, 1963, U.S. Geol. Survey Prof. Paper 429–A, p. A17, pl. 29, figs. 14, 17.
?*Bolivina dottiana* Coryell and Mossman, 1942, Jour, Paleontology, v. 16, p. 239, pl. 36, fig. 33.
Bolivina subargentea Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, p. 64, pl. 6, figs. 21, 22.

Species large, strongly dimorphic. For quantitative analysis of this species off El Salvador, see Smith (1963).

Uchio (1960) erected the new species *B. subargentea* for those forms with a keeled periphery and basal spine. Cushman stated in his original description of specimens from off Panama that the species is sometimes keeled. In Special Publication 9, he illustrated specimens from off California with a distinct keel and spine. In the samples off El Salvador, both types are found. Therefore, in the author's opinion, the erection of a new species is not warranted.

Occurrence: 435 to 1,700 m.

Bolivina bradyi Asano

Bolivina beyrichi Reuss. Cushman, 1911, U.S. Natl. Mus. Bull. 71, pt. 2, p. 34, 35, fig. 56.
Bolivina bradyi Asano, 1938, Geol. Soc. Japan Jour., v. 45, no. 538, p. 603, pl. 16, fig. 2.
Smith, 1963, U.S. Geol. Survey Prof. Paper 429–A, p. A23, pl. 31, figs. 1, 2.
Loxostomum bradyi (Asano). Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, p. 64, pl. 7, fig. 9.
?*Loxostoma instabile* Cushman and McCulloch, 1942, Allan Hancock Pacific Exped. Repts., v. 6, no. 4, p. 221–222, pl. 28, figs. 6, 7 [not pl. 27, figs. 15–17, pl. 28, figs. 1–5].

For quantitative analysis of the species off El Salvador, see Smith (1963).

Occurrence: 80 to 450 m.

Bolivina humilis Cushman and McCulloch

Bolivina seminuda Cushman var. *humilis* Cushman and McCulloch, 1942, Allan Hancock Pacific Exped. Repts., v. 6, no. 4, p. 211, pl. 26, figs. 1–6.
Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2050.
Bolivina humilis Cushman and McCulloch. Smith, 1963, U.S. Geol. Survey Prof. Paper 429–A, p. A16, pl. 29, figs. 10–13.

For quantitative analysis of this species off El Salvador, see Smith (1963).

Occurrence: 140 to 1,700 m.

Bolivina inflata Heron-Allen and Earland

Bolivina inflata Heron-Allen and Earland, 1913, Royal Irish Acad. Proc., v. 31, pt. 64, p. 68, pl. 4, figs. 16–19.
Cushman, 1937, Cushman Lab. Foram. Research Spec. Pub. 9, p. 166, pl. 18, fig. 16.
Smith, 1963, U.S. Geol. Survey Prof. Paper 429–A, p. A22, pl. 30, figs. 22, 23.

For quantitative discussion of this species off El Salvador, see Smith (1963).

Occurrence: 47 to 450 m.

Bolivina interjuncta bicostata Cushman

Bolivina costata d'Orbigny var. *bicostata* Cushman, 1926, Cushman Lab. Foram. Research Contr., v. 2, pt. 2, p. 42.
Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2050.
Bolivina interjuncta Cushman. Natland, 1950, Geol. Soc. America Mem. 43, pt. 4, p. 20–21, pl. 5, fig. 16.
Bolivina interjuncta Cushman var. *bicostata* Cushman, 1939, Cushman Lab. Foram. Research Spec. Pub. 9, p. 116, pl. 22, fig. 23.
Cushman and McCulloch, 1942, Allan Hancock Pacific Exped. Repts., v. 6, no. 4, p. 195, pl. 23, figs. 9–11.
Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, pl. 6, fig. 23.
Smith, 1963, U.S. Geol. Survey Prof. Paper 429–A, p. A17, A18, pl. 30, figs. 1–4.

For a discussion of quantitative morphologic variations of this species off El Salvador, see Smith (1963).

Occurrence: 50 to 885 m. Reported by Cushman and McCulloch from California to Colombia, at depths of 18 to 400 m.

Bolivina minuta Natland

Bolivina sp. Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 231.
Bolivina minuta Natland, 1938, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 4, no. 5, p. 146, pl. 5, fig. 10.
Crouch, 1952, Am. Assoc. Petroleum Geologists Bull., v. 36, p. 830, pl. 3, fig. 3.
Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, pl. 7, fig. 1.
Smith, 1963, U.S. Geol. Survey Prof. Paper 429–A, p. A19, A20, pl. 30, figs. 11, 12.
?*Bolivina minuta* Natland. Cushman and McCulloch, 1942, Allan Hancock Pacific Exped. Repts., v. 6, pt. 4, p. 201, pl. 24, figs. 4–7.
?*Loxostomum truncatum* Phleger and Parker, 1951, Geol. Soc. America Mem. 46, pt. 2, p. 17, pl. 7, figs. 17, 18.
Bolivinita minuta (Natland). Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2050.

For a discussion of quantitative morphology of the species off El Salvador, see Smith (1963).

Occurrence: 800 to 1,600 m.

Bolivina pacifica Cushman and McCulloch

Bolivina punctata d'Orbigny. Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 75.
Bolivina seminuda Cushman (part), 1937, Cushman Lab. Foram. Research Spec. Pub. 9, pl. 18, fig. 15 [not figs. 13, 14].

Bolivina acerosa Cushman var. *pacifica* Cushman and McCulloch, 1942, Allan Hancock Pacific Exped. Repts., v. 6, no. 4, p. 185–186, pl. 21, figs. 2, 3.

Bolivina pacifica Cushman and McCulloch. Crouch, 1952, Am. Assoc. Petroleum Geologists Bull., v. 36, p. 830, pl. 3, fig. 4.

Walton, 1955, Jour. Paleontology, v. 29, p. 1002, pl. 102, fig. 4.

Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, pl. 7, fig. 2.

Smith, 1963, U.S. Geol. Survey Prof. Paper 429–A, p. A16, A17, pl. 29, figs. 8, 9.

For a discussion of quantitative morphology of this species off El Salvador, see Smith (1963).

Occurrence: 47 to 3,100 m. Reported by Cushman and McCulloch off Alaska at a depth of 4 m, and from the Gulf of California to Colombia at depths of 90 to 225 m.

Bolivina plicatella Cushman

Bolivina plicatella Cushman, 1930, Florida Geol. Survey Bull. 4, p. 46, pl. 8, fig. 10.

Bolivina sp. Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 24.

Occurrence: 37 to 140 m.

Bolivina pseudobeyrichi Cushman

Bolivina beyrichi Reuss var. *alata* Cushman [not Seguenza], 1911, U.S. Natl. Mus. Bull. 71, pt. 2, p. 35, fig. 57.

Bolivina pseudobeyrichi Cushman, 1926, Cushman Lab. Foram. Research Contr., v. 2, p. 45.

Cushman, 1927, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 1, no. 10, p. 156, pl. 3, fig. 7.

Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 214.

Cushman, 1937, Cushman Lab. Foram. Research Spec. Pub. 9, p. 139–140, pl. 19, figs. 4, 5.

Smith, 1963, U.S. Geol. Survey Prof. Paper 429–A, p. A22, A23, pl. 31, figs. 3–8.

Loxostomum pseudobeyrichi (Cushman). Crouch, 1952, Am. Assoc. Petroleum Geologists Bull., v. 36, p. 832, pl. 3, fig. 13.

Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2052.

Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, pl. 7, fig. 10.

Loxostoma pseudobeyrichi (Cushman). Walton, 1955, Jour. Paleontology, v. 29, p. 1010, pl. 102, fig. 20.

For a discussion of the quantitative morphology of this species off El Salvador, see Smith (1963).

Occurrence: 435 to 1,700 m.

Bolivina seminuda Cushman

Bolivina seminuda Cushman, 1911, U.S. Natl. Mus. Bull. 71, pt. 2, p. 34, fig. 55.

Cushman, 1927, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 1, no. 10, p. 157, pl. 3, fig. 6.

Cushman, 1937, Cushman Lab. Foram. Research Spec. Pub. 9, p. 142, pl. 18, fig. 14 [not figs. 13, 15].

Cushman and McCulloch, 1942, Allan Hancock Pacific Exped. Repts., v. 6, no. 4, p. 210, pl. 25, fig. 14.

Crouch, 1952, Am. Assoc. Petroleum Geologists Bull., v. 36, p. 830, pl. 3, fig. 6.

Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2050.

Smith, 1963, U.S. Geol. Survey Prof. Paper 429–A, p. A15, A16, pl. 29, figs. 1–7.

Bolivina seminuda Cushman var. *foraminata* R. E. and K. C. Stewart, 1930, Jour. Paleontology, v. 4, p. 66, pl. 8, figs. 5a, b.

Bolivina foraminata R. E. and K. C. Stewart. Coryell and Mossman, 1942, Jour. Paleontology, v. 16, p. 239, 241, pl. 36, fig. 34.

[not] *Bolivina seminuda* Cushman, 1942, U.S. Natl. Mus. Bull. 161, pt. 3, p. 26, pl. 7, fig. 6.

For a discussion of the quantitative morphology of this species off El Salvador, see Smith (1963).

Occurrence: 435 to 3,200 m.

Bolivina semiperforata Lewis Martin

Bolivina spissa Cushman. Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 193 [in part].

Crouch, 1952, Am. Assoc. Petroleum Geologists Bull., v. 36, p. 830, pl. 3, fig. 7.

Walton, 1955, Jour. Paleontology, v. 29, p. 1002, pl. 101, figs. 24, 25.

Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2050.

Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, pl. 7, figs. 7, 8.

Bolivina semiperforata Lewis Martin, 1952, Cushman Found. Foram. Research Contr., v. 3, p. 129, pl. 21, figs. 10, 11.

Smith, 1963, U.S. Geol. Survey Prof. Paper 429–A, p. A18, A19, pl. 30, figs. 5–8.

For a discussion of the quantitative morphology of this species off El Salvador, see Smith (1963).

Occurrence: 800 to 1,700 m.

Bolivina spinea Cushman

Bolivina spinea Cushman, 1942 Cushman Lab. Foram. Research Spec. Pub. 6, p. 58, pl. 8, fig. 11.

Occurrence: 1,700 m.

Bolivina striatula Cushman

Bolivina striatula Cushman, 1922, Carnegie Inst. Washington Pub. 311, p. 27, pl. 3, fig. 10.

Smith, 1963, U.S. Geol. Survey Prof. Paper 429–A, p. A19, pl. 30, figs. 9, 10.

Bolivina cf. *B. karreriana* H. B. Brady var. *carinata* Millett. Cushman and Wickenden, 1929, U.S. Natl. Mus. Proc., v. 75, art. 9, p. 10, pl. 4, fig. 5.

Bolivina advena Cushman var. *striatella* Cushman. Cushman and Moyer, 1930, Cushman Lab. Foram. Research Contr., v. 6, p. 58, pl. 8, fig. 6.

Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 27.

Cushman and McCulloch, 1942, Allan Hancock Pacific Exped. Repts., v. 6, no. 4, p. 187, pl. 21, figs. 7-11.

Bolivina striatula Cushman var. *spinata* Cushman, 1936, Cushman. Lab. Foram. Research Spec. Pub. 6, p. 59, pl. 8, figs. 9a, b.

Cassidulina oblonga Reuss

Plate 3, figure 12

Cassidulina oblonga Reuss, 1850, K. Akad. Wiss. Wien, Math.–nat. Kl., Denkschr., Wien, v. 1, p. 376, pl. 48, fig. 5, 6.
Natland, 1950, Geol. Soc. America Mem. 43, pt. 4, p. 34, pl. 9, figs. 6a, b.
Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41. p. 2050.
Cassidulina kattoi Takayanagi, 1953, Tohoku Univ., Inst. Geology and Paleontology, Short Papers 5, p. 34, pl. 4, figs. 10a, b.

Types of Reuss' species were not examined, but comparison with original illustrations indicate that these specimens are assignable to it.

Occurrence: 80 to 800 m.
Illustrated specimen: length 0.23 mm, width 0.17 mm, from sample C–6

Cassidulina tumida Natland

Plate 3, figures 7, 11

Cassidulina tumida Natland, 1938, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 4, no. 5, p. 148, 159, pl. 6, figs. 2, 3.
Crouch, 1952, Am, Assoc. Petroleum Geologists Bull., v. 36, p. 838, pl. 6, fig. 14.
Cassidulina pulchella d'Orbigny. Coryell and Mossman, 1942, Jour. Paleontology, v. 16, p. 244, pl. 36, fig. 49.
Cassidulina sp. Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2050.

Large variation in acuteness of periphery: some specimens with broadly rounded peripheries (pl. 3, figs. 7a, b), others with acute peripheries. In samples C–9 and C–4, some specimens with broad spinose keel (pl. 3, fig. 11). This is the form referred to *C. pulchella* by Coryell and Mossman and to *Cassidulina* sp. by Bandy and Arnal. It should perhaps be designated as a subspecies because of ecologic isolation.

Occurrence: 435 to 885 m.
Illustrated specimens: Fig. 7, length 0.75 mm, width 0.67 mm, from sample C–8; fig. 11, length 0.87 mm, width 0.68 mm. from sample C–14.

Genus CASSIDULINOIDES Cushman

Cushman, 1927, Cushman Lab. Foram. Research Contr., v. 3, p. 84.

Type species.—Cassidulina parkeriana H. B. Brady, 1881, Micros. Soc. Quart. Jour., p. 59. (Brady, 1884, *Challenger* Rept., Zoology, v. 9, p. 432, pl. 54, figs. 11–16.)

Cassidulinoides aff. C. mexicanus (Cushman)

Fatter and with initial end not so produced as in typical *C. mexicana* (Cushman) (1922b, p. 131, pl. 24, fig. 5).

Occurrence: 1,700 m.

Cassidulinoides simplex Cushman and Todd

Cassidulinoides sp. Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 204.
Cassidulinoides simplex Cushman and Todd, 1945, Cushman Lab. Foram. Research Spec. Pub. 15, p. 63, pl. 10, fig. 15.
Occurrence: 140 to 144 m.

Cassidulinoides tenuis Phleger and Parker

Cassidulinoides tenuis Phleger and Parker, 1951, Geol. Soc. America Mem. 46, pt. 2, p. 27, pl. 14, figs. 14–17.
Occurrence: 450 m.

Genus EHRENBERGINA Reuss

Reuss, 1850, K. Akad. Wiss. Wien, Denkschr., v. 1, p. 377.

Type species.—Ehrenbergina serrata Reuss, 1850, pl. 48, fig. 7.

Ehrenbergina cf. E. undulata Parker

Less numerous chambers than the typical *E. undulata* Parker (Phleger and others, 1953, p. 46, 47, pl. 10, figs. 14–16), with spines less regular than those of the typical form and a granular surface. Very rare and so no positive comparison possible.

Occurrence: 1,600 m.

Family CHILOSTOMELLIDAE

Genus CHILOSTOMELLA Reuss

Reuss, 1850, K. Akad. Wiss. Wien, Denkschr., v. 1, p. 379.

Type species.—Chilostomella ovoidea Reuss, 1850, p. 380, pl. 48, fig. 12.

Chilostomella cushmani Chapman

Chilostomella cushmani Chapman, 1941, Royal Soc. South Australia Trans., Adelaide, v. 65, pt. 2, p. 177, pl. 8, fig. 9, pl. 9, fig. 6.
Chilostomella czizeki Reuss. Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2050.

Genus PULLENIA Parker and Jones

Parker and Jones, 1862, *in* Carpenter, Introduction to the study of Foraminifera, Ray Soc., London, p. 184.

Type species.—Pullenia sphaeroides (d'Orbigny) =*Nonionina bulloides* d'Orbigny, 1846 =*Nonionina sphaeroides* d'Orbigny, 1826, Annals des Sci. Naturelles, ser. 1, v. 7, p. 293, no. 1.

Pullenia bulloides (d'Orbigny)

Nonionina bulloides d'Orbigny, 1826, Annals des Sci. Naturelles, v. 7, p. 293, model no. 2.
Pullenia bulloides (d'Orbigny). Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, chart, line 272.
Phleger and Parker, 1951, Geol. Soc. America Mem. 46, pt. 2, p. 29, pl. 15, fig. 11.
Crouch, 1952, Am. Assoc. Petroleum Geologists Bull., v. 36, p. 841, pl. 7, figs. 2, 3.
Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2052.
Occurrence: 1,600 to 3,100 m.

Pullenia aff. P. elegans Cushman and Todd

Pullenia elegans Cushman and Todd. Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2052.

Less acute periphery and more inflated last chamber than typical *P. elegans* (Cushman and Todd, 1943, p. 23, pl. 4, fig. 11). More chambers than *P. pedroana* Kleinpell (1938, p. 341, pl. 22, fig. 14, 15) and sigmoid sutures.

Occurrence: 885 m.

Pullenia salisburyi R. E. and K. C. Stewart

Plate 3, figures 10a, b

Pullenia salisburyi R. E. and K. C. Stewart, 1930, Jour. Paleontology, v. 4, p. 72, pl. 8, fig. 2.
Crouch, 1952, Am. Assoc. Petroleum Geologists Bull., v. 36, p. 841, 842, pl. 7, fig. 5.
Walton, 1955, Jour. Paleontology, v. 29, p. 1012, pl. 104, fig. 20.
Resig, 1958, Micropaleontology, v. 4, p. 307.
Occurrence: 140 to 450 m.
Ilustrated specimen: length 0.52 mm, width 0.42 mm, from sample C–7.

Pullenia subcarinata (d'Orbigny)

Plate 3, figures 13a, b

Nonionina subcarinata d'Orbigny, 1839, Voyage dans l'Amérique Méridionale, v. 5, pt. 5, Foraminifères, p. 28, pl. 5, figs. 23, 24.
Pullenia subcarinata (d'Orbigny). Heron-Allen and Earland, 1932, *Discovery* Repts., Foraminifera, pt. I, v. 4, p. 403, pl. 13, figs. 14–18.

Possibly equivalent to *P. salisburyi* R. E. and K. C. Stewart but thicker, with more broadly rounded periphery and deeper umbilicus.

Occurrence: 800 m.
Illustrated specimen: length 0.74 mm, width 0.67 mm, from sample C–9.

Family EPISTOMINIDAE

Genus HOEGLUNDINA Brotzen

Brotzen, 1948, Sveriges Geol. Undersökning, Avh., Stockholm, ser. C, no. 493 (Arsb. 42, no. 2), p. 92.

Type species.—Rotalia elegans d'Orbigny, 1826, Annals des Sci. Naturelles, ser. 1, v. 7, p. 276 (not figured). (Parker, Jones, and Brady, 1871, Annals and Mag. Nat. History, London, ser. 4. v. 8, pl. 12, fig. 142).

Hoeglundina elegans (d'Orbigny)

Rotalia elegans d'Orbigny, 1826, Annals des Sci. Naturelles, v. 7, p. 276, model no. 6.
Epistomina elegans (d'Orbigny). Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 182.
Höglundina elegans (d'Orbigny). Crouch, 1952, Am. Assoc. Petroleum Geologists Bull., v. 36, p. 836, pl. 5, figs. 14, 15.
Bandy, 1953, Jour. Paleontology, v. 27, p. 177, pl. 23, fig. 9.
Walton, 1955, Jour. Paleontology, v. 29, p. 1009, pl. 103, figs. 5, 14.
Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2051.
Hoeglundina elegans (d'Orbigny). Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, pl. 9, figs. 4, 5.
Occurrence: 800 to 1,700 m.

Family ROBERTINIDAE

Genus CUSHMANELLA Palmer and Bermudez

Palmer and Bermudez, 1936, Soc. Cubana Hist. Nat. Mem., v. 9, no. 4, p. 252.

Type species.—Nonionina brownii d'Orbigny, 1839, *in* De la Sagra, Histoire Physique Politique Naturelle de l'Île de Cuba, Foraminifères p. 45, pl. 7, figs. 22, 23.

Cushmanella primitiva Cushman and McCulloch

Plate 3, figures 9a, b

Cushmanella primitiva Cushman and McCulloch, 1940, Allan Hancock Pacific Exped. Repts., v. 6, no. 3, p. 163, 168, pl. 18, figs. 6–8, 10.
Occurrence: 37 to 140 m.
Illustrated specimen: length 0.35 mm, width 0.20 mm, from sample C–4.

Family NONIONIDAE

Genus NONION Montfort

Montfort, 1808, Conchyliologie systématique et classification méthodique des Coquilles, Paris, F. Schoell, v. 1, p. 211.

Type species.—Nautilus incrassatus Fichtel and Moll, 1798, Testacea Microscopica, p. 38, pl. 4, figs. a–c.

Nonion affine (Reuss)

Plate 4, figures 1a, b

Nonionina affinis Reuss, 1851, Deutsche geol. Gesell. Zeitschr., v. 3, p. 72, pl. 5, fig. 32.
Nonion (barleanus) umbilicatula var. *pacifica* Cushman. Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 253.
Nonion barleeanum (Williamson). Cushman, 1939, U.S. Geol. Survey Prof. Paper 191, p. 23, pl. 6, fig. 11.
Crouch, 1952, Am. Assoc. Petroleum Geologists Bull., v. 36, p. 826, pl. 1, fig. 12.
Phleger, Parker, and Pierson, 1953, Swedish Deep-Sea Exped. Repts., v. 7, no. 1, p. 30, pl. 6, fig. 4.
Nonion barleeanus (Williamson). Bandy, 1953, Jour. Paleontology, v. 27, p. 177, pl. 21, fig. 8.
Nonion sp. cf. *N. barleeanus* (Williamson). Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2052.
Nonion affine (Reuss). Boltovskoy, 1958, Micropaleontology, v. 4, p. 193–200.
Nonion parkerae Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, p. 60, 61, pl. 4, figs. 9, 10.
Occurrence: 1,600 to 3,100 m.
Illustrated specimen: length 0.37 mm, width 0.28 mm, from sample C–10.

Nonion grateloupi (d'Orbigny)

Nonionina grateloupi d'Orbigny, 1826, Annals des Sci. Naturelles, v. 7, p. 294, model no. 19.
d'Orbigny, 1839, *in* De la Sagra, Histoire Physique Politique Naturelle de l'Île de Cuba, Foraminifères, p. 46, pl. 6, figs. 6, 7.
Occurrence: 37 to 140 m.

Genus NONIONELLA Cushman

Cushman, 1926, Cushman Lab. Foram. Research Contr., v. 2, p. 64.

Type species.—*Nonionella miocenica* Cushman, 1926, Cushman Lab. Foram. Research Contr., v. 1, p. 91, pl. 13, figs. 4a–c. =*Nonionina auris* Cushman [not d'Orbigny], 1926, Cushman Lab. Foram Research Contr., v. 2, p. 64.

Nonionella basispinata (Cushman and Moyer)

Plate 4, figures 7a, b

Nonion pizarrense W. Berry var. *basispinata* Cushman and Moyer, 1930, Cushman Lab. Foram. Research Contr., v. 6, p. 54, pl. 7, fig. 18.
Nonion pizarrense W. Berry var. *basispinatum* Cushman and Moyer. Cushman and McCulloch, 1940, Allan Hancock Pacific Exped. Repts., v. 6, no. 3, p. 158, pl. 17, figs. 8, 9, pl. 18, figs. 4, 5.
Nonionella basispinata (Cushman and Moyer). Bandy, 1953, Jour. Paleontology, v. 27, p. 177, pl. 21, fig. 13.
Walton, 1955, Jour. Paleontology, v. 29, p. 1010, pl. 101, fig. 16.
Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, p. 61, pl. 4, figs. 13, 14.
Occurrence: 20 to 140 m.
Illustrated specimen: length 0.50 mm, width 0.37 mm, from sample C–2.

Nonionella miocenica Cushman

Nonionella miocenica Cushman, 1926, Cushman Lab. Foram. Research Contr., v. 2, p. 64.
Cushman and McCulloch, 1940, Allan Hancock Pacific Exped. Repts., v. 6, no. 3, p. 161, pl. 18, fig. 1.
Occurrence: 37 to 450 m.

Family ALABAMINIDAE?

Genus GYROIDINA d'Orbigny

d'Orbigny, 1826, Annals des Sci. Naturelles, ser. 1, v. 7, p. 278.

Type species (by subsequent designation).—*Gyroidina orbicularis* d'Orbigny, ibid., model no. 13. (Parker, Jones and Brady, 1865, Annals and Mag. Nat. History, London, v. 16, ser. 3, pl. 3, fig. 85.)

Gyroidina altiformis R. E. and K. C. Stewart

Gyroidina soldanii var. *altiformis* R. E. and K. C. Stewart, 1930, Jour. Paleontology, v. 4, p. 67, pl. 9, figs. 2a–c.
Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 218.
Gyroidina altiformis R. E. and K. C. Stewart. Crouch, 1952, Am. Assoc. Petroleum Geologists Bull., v. 36, p. 834, pl. 4, figs. 10, 11.
Walton, 1955, Jour. Paleontology, v. 29, p. 1009, pl. 103, figs. 10, 11.
Resig, 1958, Micropaleontology, v. 4, p. 306.
Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, pl. 8, figs. 13–15.

Dorsal sutures curved, limbate; dorsal side nearly flat. Ventral sutures straight, faintly limbate, ventral side strongly convex. Rare.

Occurrence: 1,600 to 1,700 m.

Gyroidina rotundimargo R. E. and K. C. Stewart

Gyroidina soldanii var. *rotundimargo* R. E. and K. C. Stewart, 1930, Jour, Paleontology, v. 4, p. 68, pl. 9, fig. 3.
Occurrence: 800 to 885 m.

Gyroidina multilocula Coryell and Mossman

Plate 4, figures 4a–c

Gyroidina soldanii var. *multilocula* Coryell and Mossman, 1942, Jour. Paleontology, v. 16, p. 237, pl. 36, fig. 20.
Gyroidina soldanii var. *rotundimargo* R. E. and K. C. Stewart. Natland, 1950, Geol. Soc. America Mem. 43, pt. 4, p. 29, pl. 7, figs. 7a–c.

Specimens with numerous uninflated chambers; sutures flush, on dorsal side straight, radial, on ventral side curved; umbilicus large and deep.

Occurrence: 435 to 450 m.
Illustrated specimen: length 0.49 mm, width 0.40 mm, from sample C–15.

Gyroidina nitidula (Schwager)

Plate 4, figures 2a–c

Rotalia nitidula Schwager, 1866, *Novara* Exped., Geol. Theil, v. 2, p. 263, pl. 7, fig. 110.
Gyroidina soldanii var. *nitidula* (Schwager). Cushman, 1931, U.S. Natl. Mus. Bull. 104, pt. 8, p. 40, pl. 8, fig. 9.

Test small; dorsal side flat to slightly convex; sutures flush, oblique to periphery; whorls inflated; ventral side roundly convex, sutures curved; umbilical depression small; aperture with a lip.

Occurrence: 435 to 800 m.
Illustrated specimen: length 0.35 mm, width 0.32 mm, from sample C–15.

Family EPONIDIDAE

Genus BUCCELLA Anderson

Anderson, 1952, Washington Acad. Sci. Jour., v. 42, no. 5, p. 143–151.

Type species.—*Eponides hannai* Phleger and Parker, 1951, Geol. Soc. America Mem. 46, pt. 2 p. 21, pl. 10, figs. 11–14.

Buccella hannai (Phleger and Parker)

Eponides hannai Phleger and Parker, 1951, Geol. Soc. America Mem. 46, pt. 2, p. 21, pl. 10, figs. 11–14.

Buccella hannai (Phleger and Parker). Anderson, 1952, Washington Acad. Sci. Jour., v. 42, no. 5, p. 144, figs. 3a–c.

Occurrence: 50 m. Reported by Phleger and Parker to depths of 100 m in the Gulf of Mexico.

Genus EPONIDES Montfort

Montfort, 1808, Conchyliologie systématique et classification méthodique des Coquilles, Paris, F. Schoell, v. 1, p. 127. (Cushman, 1931, U.S. Natl. Mus. Bull. 104, pt. 8, p. 42.)

Type species.—Nautilus repandus Fichtel and Moll, 1798, Testacea Microscopica, p. 35, pl. 3, figs. a–d.

Eponides antillarum (d'Orbigny)

Plate 4, figures 3a–c

Rotalina antillarum d'Orbigny, 1839, *in* De la Sagra, Histoire Physique Politique Naturelle de l'Île de Cuba, Foraminifères, p. 75, pl. 5, figs. 4–6.

Eponides antillarum (d'Orbigny). Phleger and Parker, 1951, Geol. Soc. America Mem. 46, pt. 2, p. 20, pl. 10, figs. 9. 10.

Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2051.

Occurrence: 47 to 64 m.

Illustrated specimen: length 0.66 mm, width 0.60 mm, from sample C–4.

Eponides repandus (Fichtel and Moll)

Nautilus repandus Fichtel and Moll, 1803, Testacea Microscopica, p. 35, pl. 3, figs. a–d.

Eponides repanda (Fichtel and Moll). Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 109.

Eponides repandus (Fichtel and Moll). Phleger and Parker, 1951, Geol. Soc. America Mem. 46, pt. 2, p. 21, pl. 11, figs. 5, 6.

Occurrence: 50 to 64 m.

Eponides turgidus Phleger and Parker

Eponides turgidus Phleger and Parker, 1951, Geol. Soc. America Mem. 46, pt. 2, p. 22, pl. 11, figs. 9a, b.

Occurrence: 800 to 885 m. Reported by Phleger and Parker to depths of 3,400 m in the Gulf of Mexico but characteristic of depths of 100 to 500 m.

Genus PSEUDOEPONIDES Uchio

Uchio, 1950, Assoc. Petroleum Technologists Jour., v. 15, no. 4, p. 190.

Uchio, 1951, Paleont. Soc. Japan Trans., Proc., Tokyo, new ser, no. 2, p. 38.

Type species.—Pseudoeponides japonica Uchio, 1950, op. cit., p. 190, text fig. 16. (Also Uchio, 1951, op. cit., pl. 3, fig. 1.)

Pseudoeponides umbonatus (Reuss)

Plate 4, figures 8a–c

Rotalina umbonata Reuss, 1851, Deutsche geol. Gesell. Zeitschr., v. 3, p. 75, pl. 5, figs. 35a–c.

Truncatulina tenera Brady, 1884, *Challenger* Rept., Zoology, v. 9, p. 665, pl. 95, fig. 11.

Eponides umbonata (Reuss). Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 243.

Eponides umbonatus (Reuss). Crouch, 1952, Am. Assoc. Petroleum Geologists Bull., v. 36, p. 836, pl. 5, figs. 8, 9.

Phleger, Parker, and Pierson, 1953, Swedish Deep-Sea Exped. Repts., v. 7, pt. 1, p. 42, pl. 9, figs. 9, 10.

Eponides tener (Brady). Bandy, 1953, Jour. Paleontology, v. 27, p. 177, pl. 23, fig. 3.

Occurrence: 885 to 1,700 m.

Illustrated specimen: length 0.40 mm, width 0.35 mm, from sample C–10.

Genus EPISTOMINELLA Husezima andMaruhasi

Husezima and Maruhasi, 1944, Jour. Research Inst. Nat. Resources, Japan, v. 1, p. 397.

Type species.—Epistominella pulchella Husezima and Maruhasi, ibid., pl. 34, figs. 10a–c.

Epistominella bradyana (Cushman)

Plate 4, figures 5a, b

Pulvinulinella bradyana Cushman, 1927, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 1, no. 10, p. 165, pl. 5, figs. 11–13.

Natland, 1933, Scripps Inst. Oceanography, Tech. Ser. Bull., v. 3, no. 10, chart, line 196.

Epistominella bradyana (Cushman). Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2051.

Occurrence: 80 to 1,700 m.

Illustrated specimen: length 0.38 mm, width 0.30 mm, from sample C–8.

Epistominella exigua (Brady)

Plate 4, figures 6a, b

Pulvinulina exigua Brady, 1884, *Challenger* Rept., Zoology, v. 9, p. 696, pl. 103, figs. 13, 14.

Pulvinulinella bradyana Cushman. Natland, 1950, Geol. Soc. America Mem. 43, pt. 4, p. 33, pl. 9, fig. 3.

Pseudoparrella exigua (H. B. Brady). Phleger and Parker, 1951, Geol. Soc. America Mem. 46, pt. 2, p. 28, pl. 15, figs. 6, 7.

Epistominella sandiegonensis Uchio, 1960, Cushman Found. Foram. Research Spec. Pub. 5, p. 68, pl. 9, figs. 6, 7.

Test small, fragile, wall thin, allowing internal structures to be seen. Both dorsal and ventral sides vary in convexity from moderate to flat. Sutures depressed; dorsal sutures oblique; ventral sutures radial.

Occurrence: 37 to 140 m.

Illustrated specimen: length 0.23 mm, width 0.22 mm, from sample C–6.

Epistominella obesa Bandy and Arnal

Epistominella obesa Bandy and Arnal, 1957, Cushman Found. Foram. Research Contr., v. 8, p. 56, pl. 7, figs. 8a–c.

Bandy and Arnal, 1957, Am. Assoc. Petroleum Geologists Bull., v. 41, p. 2051.

Occurrence: 435 to 885 m.

Globigerinoides ruber (d'Orbigny). Banner and Blow, 1960, Cushman Found. Foram. Research Contr., v. 11, p. 19–21, pl. 3, fig. 8.

Possibly included in this species in these samples is *Globigerinita glutinata* (Egger) (Bradshaw, 1959, p. 40, pl. 7, figs. 7, 8).

Globigerinoides sacculifer (Brady)

Globigerina sacculifera Brady, 1877, Geol. Mag., v. 4, p. 535.
Brady, 1884, *Challenger* Rept., Zoology, v. 9, p. 604, pl. 80, figs. 11–17, pl. 82, fig. 4.

Globigerinoides sacculifera (Brady). Phleger, Parker, and Pierson, 1953, Swedish Deep-Sea Exped. Repts., v. 7, no. 1, p. 16, pl. 2, figs. 5, 6.
Bradshaw, 1959, Cushman Found. Foram. Research Contr., v. 10, p. 42, pl. 7, figs. 14, 15, 18.

Globigerinoides quadrilobatus (d'Orbigny) subsp. *sacculifer* (Brady). Banner and Blow, 1960, Cushman Found. Foram. Research Contr., v. 11, p. 21–24, pl. 4, figs. 1, 2.

Genus GLOBIGERINELLA Cushman

Cushman, 1927, Cushman Lab. Foram. Research Contr., v. 3, p. 87.

Type species.—*Globigerina aequilateralis* Brady, 1884, *Challenger* Rept., Zoology, v. 9, p. 605, pl. 80, figs. 18–20.

Globigerinella aequilateralis (Brady)

Globigerina aequilateralis Brady, 1884, *Challenger* Rept., Zoology, v. 9, p. 605, pl. 80, figs. 18–20.

Globigerinella aequilateralis (Brady). Phleger, Parker, and Pierson, 1953, Swedish Deep-Sea Exped. Repts., v. 7, no. 1, p. 16, 17, pl. 2, figs. 9–11.
Bradshaw, 1959, Cushman Found. Foram. Research Contr., v. 10, p. 38, pl. 7, figs. 1, 2.

Genus ORBULINA d'Orbigny

d'Orbigny, 1839, *in* De la Sagra, Histoire Physique Politique Naturelle de l'Île de Cuba, Foraminifères, p. 3.

Type species.—*Orbulina universa* d'Orbigny, ibid., pl. 1, fig. 1.

Orbulina universa d'Orbigny

Orbulina universa d'Orbigny, 1839, *in* De la Sagra, Histoire Physique Politique Naturelle de l'Île de Cuba, Foraminifères, p. 3, pl. 1, fig. 1.
Phleger, Parker, and Pierson, 1953, Swedish Deep-Sea Exped. Repts., v. 7, no. 1, p. 17, pl. 2, fig. 8.
Bradshaw, 1959, Cushman Found. Foram, Research Contr., v. 10, p. 49, pl. 8, figs. 17, 18.

Genus PULLENIATINA Cushman

Cushman, 1927, Cushman Lab.Foram. Research Contr., v. 3, p. 90.

Type species.—*Pullenia obliquiloculata* Parker and Jones, 1865, Philos. Trans., v. 155, p. 368, pl. 19, figs. 4a, b.

Pulleniatina obliquiloculata (Parker and Jones)

Pullenia sphaeroides var. *obliquiloculata* Parker and Jones, 1865, Philos. Trans., v. 155, p. 368, pl. 19, figs. 4a, b.

Pulleniatina obliquiloculata (Parker and Jones). Phleger, Parker, and Pierson, 1953, Swedish Deep-Sea Exped. Repts., v. 7, no. 1, p. 17, 18, pl. 2, figs. 16–18.
Bradshaw, 1959, Cushman Found. Foram. Research Contr., v. 10, p. 49, pl. 8, figs. 19, 20.
Banner and Blow, 1960, Cushman Found. Foram. Research Contr., v. 11, p. 25, pl. 7, figs. 4a–c.

Family GLOBOROTALIIDAE

Genus GLOBOROTALIA Cushman

Cushman, 1927, Cushman Lab. Foram. Research Contr., v. 3, p. 91.

Type species.—*Pulvinulina menardii* var. *tumida* Brady, 1877, Geol. Mag., new ser, dec. 2, v. 4, p. 535.

Globorotalia cultrata d'Orbigny

Rotalina cultrata d'Orbigny, 1839, in De la Sagra, Histoire Physique Politique Naturelle de l'Île de Cuba, Foraminifères, p. 76, pl. 5, figs. 7–9.

Rotalia menardii Parker, Jones, and Brady, 1865, Annals and Mag. Nat. History, v. 16, ser. 3, p. 20, pl. 3, fig. 81.

Globorotalia menardii (d'Orbigny). Phleger, Parker, and Pierson, 1953, Swedish Deep-Sea Exped. Repts., v. 7, no. 1, p. 19, 20, pl. 3, figs. 1, 2, 4, 5.
Bradshaw, 1959, Cushman Found. Foram. Research Contr., v. 10, p. 44, pl. 8, figs. 3, 4.

Globorotalia cultrata (d'Orbigny). Banner and Blow, 1960, Cushman Found. Foram. Reserch Contr., v. 11, p. 34, 35, pl. 6, fig. 1.

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PLATE 1

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Side view, × 37, USNM 628524.

3. *Eggerella pusilla* (Goës) (p. B29).
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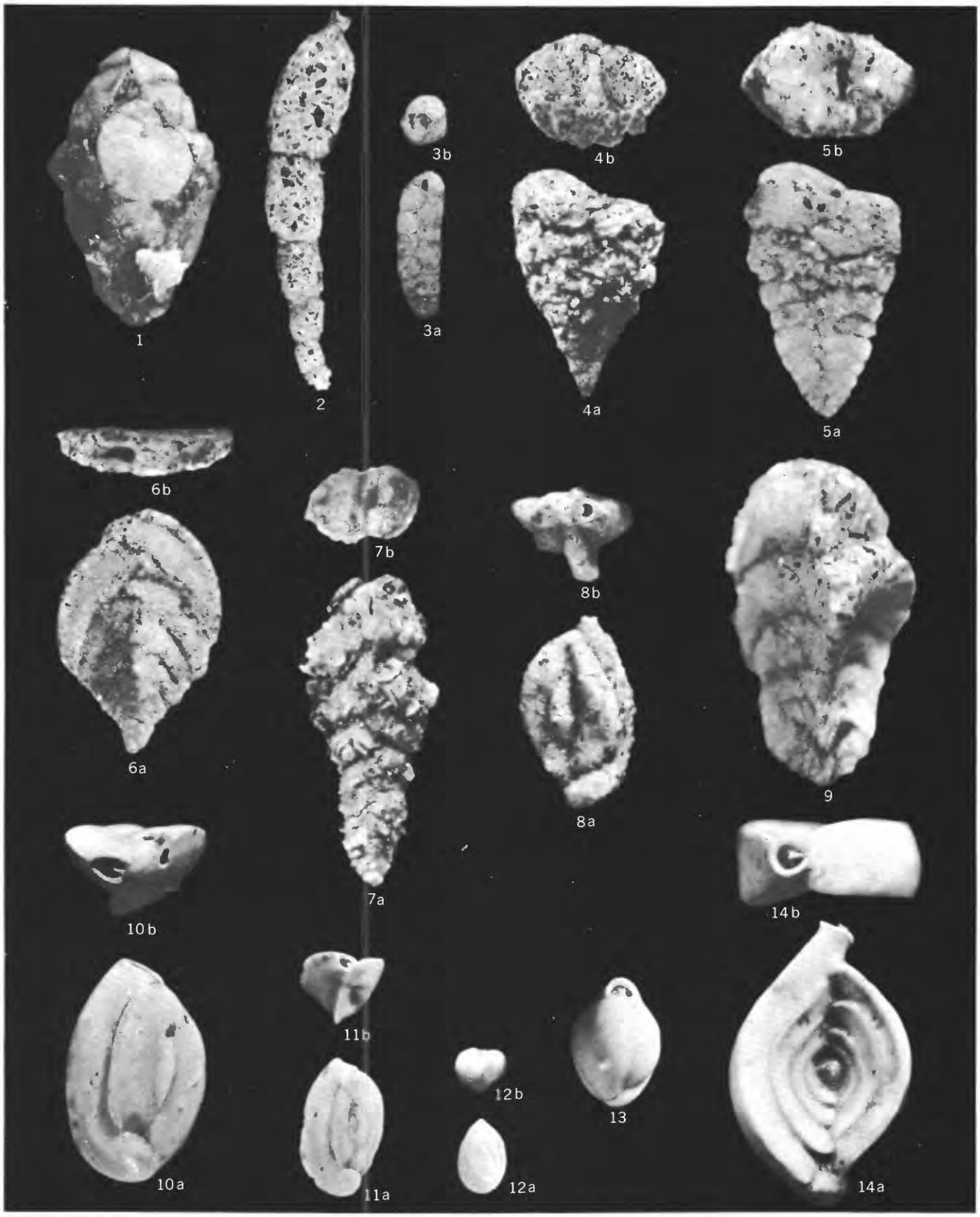
12. *Scutuloris* sp. (p. B29).
12a. Side view; 12b, end view; × 66, USNM 628536.

13. *Miliolinella circularis* (Bornemann) (p. B29).
Side view, × 67, USNM 628537.

14. *Spiroloculina soldanii* Fornasini (p. B30).
14a. Side view; 14b, end view; × 44, USNM 628538.



RECENT FORAMINIFERA OFF EL SALVADOR

PLATE 5

FIGURE 1. *Cancris sagra* (d'Orbigny) (p. B45).
1a. Ventral view; 1b, peripheral view; 1c, dorsal view; × 81, USNM 628579.
2. *Rosalina columbiensis* (Cushman) (p. B44).
2a. Ventral view; 2b, dorsal view, × 109, USNM 628582.
3. *Valvulineria glabra* Cushman (p. B44).
3a. Dorsal view; 3b, ventral view; × 94, USNM 628578.
4. *Valvulineria oblonga* (d'Orbigny) (p. B44).
4a. Dorsal view; 4b, ventral view; × 44, USNM 628577.
5. *Cancris inflatus* (d'Orbigny) (p. B45).
5a. Dorsal view; 5b, peripheral view; 5c, ventral view; × 61, USNM 628580.
6. *Cancris carmenensis* Natland (p. B45).
6a. Ventral view; 6b, peripheral view; 6c, dorsal view; × 59, USNM 628581.

RECENT FORAMINIFERA OFF EL SALVADOR

PLATE 6

FIGURE 1. *Planulina ornata* (d'Orbigny) (p. B46).
1a. Ventral view; 1b, peripheral view; 1c, dorsal view; × 49, USNM 628583.
2. *Hanzawaia concentrica* (Cushman) (p. B44).
2a. Dorsal view; 2b, peripheral view; 2c, ventral view; × 69, USNM 628584.
3. *Planulina limbata* Natland (p. B46).
3a. Dorsal view; 3b, peripheral view; 3c, ventral view; × 45, USNM 628585.
4. *Cibicides mckannai* Galloway and Wissler (p. B47).
4a. Ventral view; 4b, dorsal view; × 95, USNM 628586.
5. *Planulina exorna* Phleger and Parker (p. B46).
5a. Ventral view; 5b, peripheral view; 5c, dorsal view; × 78, USNM 628587.
6. *Cibicides floridanus* (Cushman) (p. B46).
6a. Ventral view; 6b, peripheral view; 6c, dorsal view; × 44, USNM 628528.

RECENT FORAMINIFERA OFF EL SALVADOR