Foraminifera From Onotoa Atoll Gilbert Islands

GEOLOGICAL SURVEY PROFESSIONAL PAPER 354-H

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By RUTH TODD

SHORTER CONTRIBUTIONS TO GENERAL GEOLOGY

GEOLOGICAL SURVEY PROFESSIONAL PAPER 354-H

Ecologic study of Recent assemblages from beaches, reefs, and shallow lagoon floor

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1961

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington 25, D.C.

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FORAMINIFERA FROM ONOTOA ATOLL, GILBERT ISLANDS

By Ruth Todd

ABSTRACT

The distribution of 168 species and varieties of smaller Foraminifera is recorded within the lagoon and on the reefs and beaches of Onotoa Atoll as represented by 33 surface samples and 23 pit samples. Nearly all the species are well known in shallow-water sediments of the tropical Pacific; 7 are indeterminate; none are described as new. The lagoon collecting localities were all but one from depths no greater than 20 feet, and mostly from areas protected from the open ocean. Preservation in alcohol of 24 samples permitted a staining process to be used and an estimate to be made of the very small live-dead ratio, and determination of the living places of certain of the species.

Recognition of two major distinctive habitats—(a) reef surfaces and their adjacent slopes and (b) limesand bottom of the lagoon—is based in part on the relative abundance of species and in part on the presence of live (stained) specimens.

Four species—*Calcarina spengleri*, *Baculogypsina sphaerulata*, *Amphistegina madagascariensis*, and *Marginopora vertebralis*—make up quantitatively most of the foraminiferal material in the reef sediments. Major foraminiferal constituents of the lagoon sediments are, in quantitative order: *Amphistegina madagascariensis*, *Heterostegina suborbicularis*, *Marginopora vertebralis*, and *Elphidium striato-punctatum*. Quantitatively insignificant because of their smaller size, but common or abundant in most samples, are many species of miliolids and several species in each of the following families: Textulariidae, Peneroplidae, Buliminidae, Discorbidae, Cymbaloporidae, Anomalinidae, and Planorbulinidae. Globigerinids are present, but only rarely, and appear to have come in from the open ocean through breaks in the reef. Seventeen other families are represented mostly by rare or scattered occurrences.

Stomach and gut contents of 22 fish were found to contain Foraminifera tests nearly as varied as the naturally occurring fauna. The fact that most of the individual fish did not contain as great a variety as the composite of all the fish suggests a rather localized feeding area for each fish.

Seven pits provide short sections—a maximum of 10 feet—into the sediments that make up the northern main island. These sediments are interpreted as beach sands overlying and transitional to reef flat deposits.

INTRODUCTION

Onotoa Atoll is a "dry" atoll (referring to its rainfall [Cloud, 1952, p. 10–15]) in the southern part of the Gilbert Islands. It is elongate northwest-southeast and bordered nearly continuously on the northeast (windward) and south sides by narrow islands but either open to the ocean or protected by discontinuous living coral reefs on the southwest side (fig. 40). Its dimensions are roughly 12 miles long and 4 to 5 miles wide. Latitude and longitude at its northwestern end are 1°46′ S. and 175°30′ E. Its physical description may be found in a preliminary report by Preston E. Cloud, Jr. (1952), who in 1951 made the collections upon which this study is based.

Acknowledgments.—I am indebted to Preston E. Cloud, Jr., for making available the well-documented material and to John E. Randall for the identifications of the fishes studied. For helpful suggestions and discussions I am grateful to Preston E. Cloud, Jr., and to Richard Cifelli. Invaluable help in preparation of material and tabulation of results was received from Doris Low. The illustrations of the individual specimens of Foraminifera were made by Elinor Stromberg.

MATERIAL STUDIED

Samples were studied from the following areas of Onotoa Atoll:

(1) Area open to ocean on west (leeward) side of atoll (7 samples from depths between 3 and 18 feet);
(2) Lagoon:
  (a) Southern part (8 samples from depths between 6 and 17 feet, with 1 exception, f11683 [GOC–55] collected from 48 feet)
  (b) Central and northern part (7 samples from depths down to 20 feet);
(3) Reef areas (3 samples from leeward side of atoll and 2 from windward);
(4) Southern part of atoll (4 samples of fine sediment and incipient beachrock);
(5) Islands along the east (windward) side of atoll
  (a) Beach sands (4 samples)
  (b) Material from pits having depths from 20 inches to 11½ feet. The pits start in beach sands, in which many of the specimens are severely corroded (13 samples), and penetrate through progressively richer transitional sediments (7 samples) into sediments of a reef-flat horizon (3 samples).

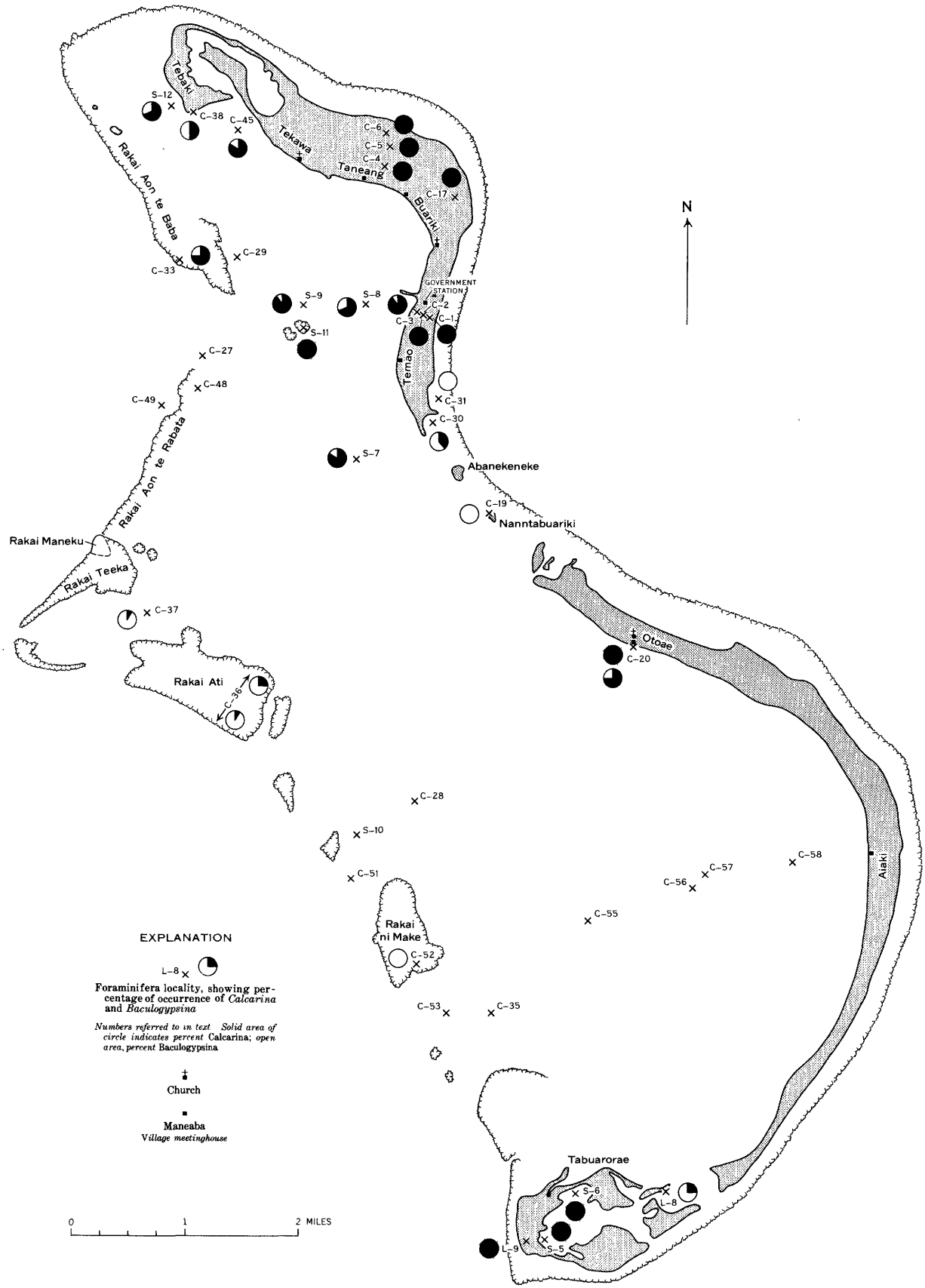

FIGURE 40.—Map of Onotoa showing locations of samples studied and major occurrences and relative abundance of *Calcarina* and *Baculogypsina*.

LOCALITY DATA

The following locality and sample descriptions, taken from P. E. Cloud's field notes, are arranged in order of their U.S. Geological Survey Foraminifera locality numbers. They include pertinent details of the various environments from which the Foraminifera from Onotoa Atoll, Gilbert Islands, were derived.

U.S.G.S. loc. No.	*Field localities and descriptions*
f11639–f11643.	GOC–1. Southern part of northern main island, about 1,100 ft S. 41° E. from east (inshore) end of lagoon-side jetty at Government Station and 325 ft inshore from sea beach along line bearing S. 87° W. at Pacific Science Board campsite. Pit in which water level fluctuated with tide. Pit section in descending order, with unit thicknesses, is:
f11639.	GOC–1A. 99+ percent medium-grained *Calcarina* sand, dark brownish gray from organic matter. Roots very abundant, up to seven-eighths of an inch in diameter. Foraminifera worn or eroded by organic acids. Subaerial accumulation?. Top 9–10 in.
f11640.	GOC–1B. 99+ percent medium-grained dark-tan *Calcarina* sand, abruptly gradational to f11639 (GOC–1A). Sample f11640 differs only in organic content, abundance of roots, and good preservation of *Calcarina*, suggesting only slight transportation. Roots moderately abundant, as much as one-half of an inch in diameter, cutting off abruptly at base. Subaerial accumulation?. Thickness, 16–17 in.
f11641.	GOC–1C. Similar to f11642 (GOC–1D), which follows, but has alternating layers of semi-indurated to indurated material. Basal 1–4 in. indurated. Roots rarely extend into unit C. Probably deposited along beach near reef flat. Thickness, 7–10 in.
f11642.	GOC–1D. Weakly indurated to nonindurated medium-grained limesand, 80± percent well-preserved *Calcarina* and 20± percent other Foraminifera and detrital $CaCO_3$, much of it quite fine grained. Other Foraminifera include *Marginopora*. Color is light tan to flesh. Thickens where f11641 (GOC–1C) thins and unit C apparently represents incipient beachrock at top of unit D. No roots. Probably deposited along beach near reef flat. Thickness, 14–17 in.
f11643.	GOC–1E. Zone of *Heliopora*. About 70 percent blue coral of which much may be but none is certainly in position of growth; 30± percent interstitial limesands are coarse to fine grained, light tan to flesh, of detrital $CaCO_3$ and Foraminifera. *Marginopora* abundant; *Calcarina* common; echinoid spines occasional. Interpreted as reef-flat horizon, built up to about low tide level and then overrun by beach of f11642 (GOC–1D). No roots. 16 in. above watermark. Thickness, 25 in.
f11644–f11649.	GOC–2. Southern part of northern main island, about 940 ft S. 25° E. from east (inshore) end of lagoon-side jetty at Government Station and 660 ft inshore from sea beach along line bearing S. 87° W. at Pacific Science Board campsite. Pit similar to GOC–1. Pit section in descending order, with unit thicknesses, is:
f11644.	GOC–2A. Medium- to fine-grained limesand, dark brownish gray from organic matter. Worn *Calcarina* about 60 percent; remainder of detrital fines. Roots uncommon. Some stones as much as three-fourths of an inch in diameter. Top 5 in.
f11645.	GOC–2B. Medium-grained limesand. Worn *Calcarina* about 70 percent with occasional pebbles as much as three-eighths of an inch in upper 7 in. Up to 95+ percent worn *Calcarina* below. Remainder is detrital $CaCO_3$. Tan to flesh colored; darker above than below. Roots abundant, as much as three-eighths of an inch in diameter. Thickness, 19 in.
f11646.	GOC–2C. Loose $CaCO_3$ gravel composed of 50 percent $CaCO_3$ pebbles as much as 2½ in. long and 50 percent worn *Calcarina* and detrital $CaCO_3$. Roots abundant, as much as one-fourth of an inch in diameter. Thickness, 11 in.
f11647.	GOC–2D. Strongly indurated flesh-colored granule sandstone, of varied detrital $CaCO_3$. One loose sand layer 2–4 in. from base. Roots very rare. Thickness, 15 in.
f11648.	GOC–2E. Very fine grained flesh-colored detrital limesand. No roots. Thickness, 6 in.
f11649.	GOC–2F. Zone of *Heliopora*. Essentially same as f11643 (GOC–1E). No roots. Reef flat horizon? Thickness, 51 in.
f11650–f11653.	GOC–3. Southern part of northern main island, about 870 ft S. 3° E. (true) from east (inshore) end of lagoon-side jetty at Government Station and 340 ft inshore from lagoon beach along line bearing N. 87° E. through Pacific Science Board campsite strip. Pit similar to GOC–1 and GOC–2. Pit section in descending order, with unit thicknesses, is:
f11650.	GOC–3A. Dark-brownish-gray organically enriched limesand similar to f11644 (GOC–2A). Roots common. Top 8 in.
f11651.	GOC–3B. Similar to f11650 (GOC–3A) but with less organic matter and only dark-tan to light-brown color. Roots abundant as much as one-half of an inch in diameter. Subsoil. Thickness, 6 in.
None.	GOC–3C. Medium-grained flesh-colored (pinkish-tan) limesand with occasional granules and small pebbles (to one-half of an inch in diameter). Mostly 90 percent worn and smooth *Calcarina* but with occasional Foraminifera of other sorts, echinoid spines, algal fragments, small mollusks, and detrital $CaCO_3$. Many roots, upper part. Thickness, 38 in.

U.S.G.S. loc. No.	*Field localities and descriptions*
f11652.	GOC–3D. Similar to GOC–3C but has fairly numerous pebbles (one-half of an inch maximum diameter) and granules; small gastropods relatively common, and *Marginopora* common. Thickness, 20 in.
None.	GOC–3E. Pinkish-gray granule gravel of fragmentary ramose calcareous algae with interstitial *Calcarina* sand (worn smooth). Thickness, 10 in.
f11653.	GOC–3F. Similar to f11652 (GOC–3D). Thickness, 40 in.
None.	GOC–3G. Zone of large head-forming crustose corallines and occasional astraeiform corals and interstitial sand like f11652 (GOC–3D) and f11653 (GOC–3F). Only algae and corals sampled. Thickness, 8 in.
None.	GOC–3H. Similar to f11652 (GOC–3D) and f11653 (GOC–3F). (Field observation, no sample taken.) Thickness, 8 in.
f11654–f11655.	GOC–4. North-central part of northern main island, about 1,000 ft east-northeast from Taneang-Tekawa Maneaba. Section in area of fine clastic limesand that makes fine-grained loamy soil—at this place dry. Pit section in descending order, with unit thicknesses, is:
f11654.	GOC–4A. Very fine grained brownish-gray (from organic matter) limesand; grades down to f11655 (GOC–4B). Roots common, as much as five-eighths of an inch in diameter. Top 10 in.
f11655.	GOC–4B. Pinkish-yellow clastic limesand—mostly fine grained, with <10 percent *Calcarina* but local patches contain abundant *Calcarina*. Only occasional roots in upper part. Thickness, 26 in.
f11656.	GOC–5. North-central part of northern main island, about 1,700 ft northeast from Taneang-Tekawa Maneaba. Area of pebble coral gravel with interstitial limesands. Stony and hard to dig. Dug down only 20 in., of which top 10 in. is organic-rich, brownish-gray soil with plentiful roots. Lower 10 in. pinkish yellow.
f11657–f11659.	GOC–6. North-central part of northern main island, about 2,400 ft north-northeast from Taneang-Tekawa Maneaba. Section in area of fine clastic limesands locally with thin gravel veneer at surface and locally of old dune sand material near shore. Pit section in descending order, with unit thicknesses, is:
f11657.	GOC–6A. Organic-rich, dark-gray-brown limesand, 20± percent worn *Calcarina*, few small pebbles (as much as one-half of an inch in diameter), many small roots. Top 6 in.
f11658.	GOC–6B. Dark-tan limesand, 30–40 percent worn *Calcarina*, many roots as much as one-half of an inch in diameter; no pebbles. Thickness, 10 in.
f11659.	GOC–6C. Flesh-colored medium-grained limesand, 10–25 percent badly worn *Calcarina*. Thickness, 14 in.
f11660–f11661.	GOC–17. Central part of northern main island, about 2,100–2,200 ft due east from Buariki Maneaba. Area of fine clastic limesilt on which water lies close to surface, hardpan tends to form, ground water is brackish, and soil is generally poor. Pit section in descending order, with unit thicknesses, is:
f11660.	GOC–17A. Fine medium-grayish-tan limesand and limesilt. Many roots as much as three-eighths of an inch in diameter. Few *Calcarina*. Top 9 in.
f11661.	GOC–17B. Light-tan medium-grained limesand, 10–15 percent *Calcarina*. Roots mainly in top inch or two but some to bottom. Thickness, 15 in.
f11662.	GOC–19. Beach sand on the northwest shore of islet of Nanntabuariki. Excellently preserved *Baculogypsina* and *Marginopora* washed in from adjacent reef flats to north and east.
f11663–f11664.	GOC–20. Southern main island, section above beach just south of Otoae village Maneaba, lagoon shore. Section in descending order, with unit thicknesses, is:
f11663.	GOC–20A. Limesand, 20± percent *Calcarina*, scattered pebbles as much as 2 in long. Top 24 in.
f11664.	GOC–20B. Shell bed, limesand (50 percent *Calcarina*) matrix—small *Cardium* most abundant. Goes laterally to a pebble gravel. Thickness, 6 in.
None.	GOC–20C. Limesand, 40–50 percent *Calcarina*, occasional pebbles as much as 2 in long. Thickness, 15 in.
f11665.	GOC–27. About 9,200 ft S. 72° W. from offshore end of Government Station jetty (on southern part of northern main island) just south of main passage out of lagoon (Rawa ni Karoro) where coral shoals known as Aon te Rabata begin to deepen. Collection from area where reef knolls and patches rise above the limesand bottom at 16 ft depth. Most specimens from a low coral patch about 14 ft below the surface.
f11666.	GOC–28. Slightly less than 4 miles N. 85° W. from Aiaki Maneaba in outer lagoon. Reef patches and knolls rising above limesand bottom (at 14 ft) to within 6 ft of water surface. Fish taken from on and near reef knolls and sediment taken from bottom.
f11667.	GOC–29. About 1 mile S. 32° W. from Tekawa church at lagoon margin of south end of reef stretch known as Aon te Baba. Collection from reef patches rising above limesand bottom (at a depth of 9 ft reduced to mean low tide) to within 1 ft of surface. Much *Halimeda*, many sheetlike crustose corallines red on under sides. Limesand very fine to limesilt at centers of open areas.
f11668.	GOC–30. *Heliopora* flat at south end of the northern main island. At +1 ft low tide, tops of living *Heliopora* and few *Porites lobata* seen were just flush with water surface.

U.S.G.S. loc. No.	Field localities and descriptions
f11669.	GOC–31. Southeast end of northern main island. Scrapings from green algal crust on inner flat of windward reef about midway out (east) on reef flat from center of cove at southeast end of island. Sediment-binding green algae are matted with *Baculogypsina, Marginopora,* and other Foraminifera.
f11670.	GOC–33. About 7,100 ft S. 50° W. from Tekawa church at seaward edge of Aon te Baba reef north of main boat passage. Reef area is broad and irregular, fronted seaward by area of limesand 18 ft deep at midtide or about 15 ft reduced to mean low tide. (At collecting locality reef itself at general depth of 3 ft at mean low tide, with holes to depth of 8 ft at mean low tide.) Medium-grained limesand with ripple marks parallel to reef front. Slopes gradually seaward with off-lying reef patches.
f11671–f11672.	GOC–35. About 8,600 ft N. 18° W. from Tabuarorae Maneaba in 17 ft of water at mean low tide.
f11671.	GOC–35a. South bottom sample.
f11672.	GOC–35b. North bottom sample. Area of many coral patches on limesand-gravel bottom. Anchored for first sample (f11671 GOC–35a) of limesand-gravel over an area richly floored with red bushy crustose corallines, but dragged anchor and drifted northwest about 100 yd where collected second bottom sample (f11672, GOC–35b) of relatively pure limesand.
f11673–f11674.	GOC–36. Southeast end of reef area known as Rakai Ati (south side of big westward point of reef near center of atoll). A flourishing reef; collection from reef flat northeastward in shoal waters, from strip about one-half of a mile long running clear across the reef.
f11673.	GOC–36a. Seaward or southwestward ±500 ft is area of much coral in small and large patches with interspersed coarse limesand having a considerable gravel fraction of granule and pebble size.
f11674.	GOC–36b. Lagoonward or northeastward ±500 ft is mostly sand with scattered coral patches.
f11675.	GOC–37. About one-third of the distance between the north point of the reef area known as Rakai Ati and the east end of Rakai Maneku, at inner part of point of reef that projects westward from near the center of Onotoa Atoll. Sediment sample taken from hole about 10–12 ft deep.
f11676.	GOC–38. Lower beach at southwest corner of Tebaki, north end of northern main island. Sandy lagoon beach.
f11677.	GOC–45. Area of *Thalassia* patches on coarse limesand bottom off northwest end of outer rib of elevated beachrock at north Tekawa, northwest Onotoa Atoll.
f11678.	GOC–48. About 10,000 ft S. 62° W. from lagoon end of Government Station jetty at north end of reefy shoal area known as Aon te Rabata. Coral patches rising to within 5 ft of surface from lesser (30–50 percent of area) intervening areas of limesand bottom, 12 ft.
f11679.	GOC–49. About 12,000 ft S. 63° W. from lagoon end of Government Station jetty, on the seaward side of the north end of a reefy shoal area known as Aon te Rabata, in patch reefs rising to within 6 ft of surface Limesand bottom at 18 ft deep.
f11680.	GOC–51. About 3¼ miles N. 31° W. from Tabuarorae Maneaba near center of Te Rawa ni Bao, a pass in south part of leeward reef. Collected from thickly set coral masses rising from 15 ft (sounded at low tide) of water to within about 8–10 ft of surface locally. Bottom of coral-algal rock and living corals and algae with minor pockets of very coarse limesand and calcareous gravel. Sediment sample taken in shoal area lagoonward in about 3 ft of water from hole containing coarse limesand and gravel.
f11681.	GOC–52. About 12,000 ft N. 30° W. from Tabuarorae Maneaba at south end of Rakai ni Make, a reef area in southern part of leeward reef. Collected corals, algae, mollusks, and sample of coarse limesand and gravel, the latter from a hole in about 3 ft of water.
f11682.	GOC–53. About 9,300 ft N. 30° W. from Tabuarorae Maneaba in southern part of Te Rawa Tekatobibi, a pass through south end of leeward reef. Collected from coral patches and knolls rising to occasional maximum of within 4 ft of surface from a bottom sounded at 18 ft.
f11683	GOC–55. About 13,400 ft S. 75° W. from Aiaki Maneaba in deep central part of the lagoon. Impalpably fine limemud from bottom of low scattered dead and living coral patches on intervening limemud and limesand about 30–40 percent sediments and 60–70 percent coral.
f11684.	GOC–56. About 8,300 ft S. 76° W. from Aiaki Maneaba on reef patch in the central lagoon. Complex mass of living coral with patches of limesand and fine gravel on surface, perhaps 150–200 yd in diameter, rising from surrounding bottom of ±18 ft. Depths on knoll 4–10 ft at mean low tide, with coral heads rising to within 1 ft of surface. Sediment sample from mean low tide depth of ±6 ft.
f11685.	GOC–57. About 7,500 ft S. 80° W. from Aiaki Maneaba on reef patch in central lagoon. Habitat, bottom types, and depth range similar to f11684 (GOC–56), but much more limesand and less coral. Depth of sediment sample at ±6 ft at mean low tide datum.

U.S.G.S. loc. No.	Field locations and descriptions
f11686.	GOC–58. About 3,600 ft S. 80° W. from Aiaki Maneaba on reef patch in central lagoon. Generally similar to f11684 (GOC–56) and f11685 (GOC–57) but smaller and deeper and contains even less coral than f11685 (GOC–57). Bottom at ±10 ft at mean low tide datum, with patchy coral. Collected bottom sample at 15 ft mean low tide datum from limesand slope leading off to slightly deeper water.
f11687.	51–L–8. Southeast end of Tabuarorae islet corresponding to Aontebeke land area. Weakly bonded limesand along beach.
f11688.	51–L–9. Southwest end of Mangaia land area, Tabuaurorae islet. Low, narrow north-trending ridge in area of lush vegetation, apparently most easterly of a set of older dunesand ridges—±500 ft long, about 60 ft across from intertrough to intertrough. Only one of set that seems phosphatic.
f11689.	51–S–5. Central Tabuarorae islet. West end of tidal flats encircled by islet.
f11690.	51–S–6. Tabuarorae islet. Near center of north arm of tidal flats encircled by islet.
f11691.	51–S–7. About 4,400 ft N. 86° W. from northwest corner of Abanekeneke, sediment taken in about 14 ft of water at mean low tide datum.
f11692.	51–S–8. About 1,400 ft S. 60° W. from lagoon end of Government Station jetty. Drag sample of limesand bottom between sparse dead and living coral, taken in about 9 ft of water at mean low tide datum.
f11693.	51–S–9. About 4,200 ft S. 79° W. from lagoon end of Government Station jetty. Fine limesand bottom at 20 ft depth at mean low tide datum. Patches of growing coral mostly to about 10–15 ft in diameter and only 1–2 ft above bottom.
f11694.	51–S–10. About 3½ miles N. 30° W. from Tabuarorae Maneaba. From coarse- to medium-grained limesand bottom about 10 ft deep with coral pinnacles rising to within 6 ft of surface.
f11695.	51–S–11. About 4,600 ft S. 65° W. from lagoon end of Government Station jetty. Limesand bottom of reentrant or depression in large lagoon reef patch.
f11696.	51–S–12. West side of Tebaki, northwest Onotoa Atoll. Center of clean limesand area between southwestward extending limesand spits.

FAUNA

A total of 168 species and varieties have been found in the Onotoa samples. In table 1 the samples are grouped, according to similarity of environment, in the following categories:

1. Area open to ocean on west (leeward side)
2. Lagoon
3. Reef areas
4. Islands along east side of atoll.

In the last category are included both modern beach sands and material from a series of dug pits inshore from the sea beach. Samples from the pits are grouped according to similarity of composition and in order of increasing variety of species. With this arrangement, the samples fall into three subdivisions: those interpreted as beach sands, those interpreted as reef flat sediments, and those transitional between these two types of deposits.

As the Onotoa species are nearly all well known and well illustrated (Cushman, Todd, and Post, 1954; Todd, 1957; Todd and Low, 1960), complete formal descriptions are not included in this report and only a selected few are illustrated. In a later section, certain species that are not found in these three Professional Papers are discussed and selected references included for them.

Major constituents of the Onotoa fauna are:

Amphistegina madagascariensis d'Orbigny
Baculogypsina sphaerulata (Parker and Jones)
Calcarina spengleri (Gmelin)
Elphidium striato-punctatum (Fichtel and Moll)
Homotrema rubrum (Lamarck)
Heterostegina suborbicularis d'Orbigny
Marginopora vertebralis Blainville

Besides these, the following species, although they make up negligible amounts of the population, are found in most of the samples except the beach sand:

Acervulina inhaerens Schultze
Cibicidella variabilis (d'Orbigny)
Cornuspira planorbis Schultze
Cymbaloporetta bradyi (Cushman)
C. squammosa (d'Orbigny)
Elphidium advenum var. *dispar* Cushman
E. crispum (Linné)
Gaudryina (Siphogaudryina) rugulosa Cushman
Haddonia torresiensis Chapman
Neoconorbina patelliformis (Brady)
Planorbulina acervalis Brady
Pyropilus rotundatus Cushman
Quinqueloculina polygona d'Orbigny
Reussella simplex (Cushman)
Rosalina candeiana d'Orbigny
Schlumbergerina alveoliniformis (Brady)
Siphogenerina raphana (Parker and Jones)
Spirolina arietina (Batsch)
Spiroloculina angulata Cushman
Tretomphalus concinnus (Brady)
T. planus Cushman
Triloculina irregularis (d'Orbigny)
T. oblonga (Montagu)

The remaining 138 species and varieties are rare for the most part, and their occurrences are scattered or single occurrences. Among them, however, are a few species whose distribution shows a restricted, and possibly significant pattern.

TABLE 1.—*Distribution of Recent Foraminifera of Onotoa Atoll*

[A indicates abundant; C, common; R, rare. Symbol printed in boldface indicates presence of live specimens]

	Area open to ocean on west (leeward side)							Lagoon															Reef areas					Southern part of atoll				From islands along east side of atoll																										
								Southern								Central and northern							Leeward			Windward						Beach sands				Pits inshore from sea beach (see text fig. 1)																						
																																				Interpreted as beach sands													Transitional sediments							Interpreted as reef flats		
	GOC-33	GOC-27	GOC-48	GOC-49	GOC-37	GOC-51	GOC-53	GOC-35a	GOC-35b	GOC-55	GOC-56	GOC-57	GOC-58	GOC-28	51-S-10	51-S-7	51-S-8	51-S-9	51-S-11	GOC-29	GOC-45	51-S-12	GOC-52	GOC-36a	GOC-36b	GOC-30	GOC-31	51-L-8	51-L-9	51-S-5	51-S-6	GOC-38	GOC-19	GOC-20A	GOC-20B	GOC-1A	GOC-2A	GOC-3A	GOC-3B	GOC-3D	GOC-3F	GOC-4A	GOC-5	GOC-6A	GOC-6B	GOC-6C	GOC-1B	GOC-2B	GOC-4B	GOC-17A	GOC-17B	GOC-1C	GOC-2C	GOC-1D	GOC-2D	GOC-1E	GOC-2E	GOC-2F
Hyperamminidae:																																																										
Sagenina frondescens (Brady)	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lituolidae:																																																										
Ammobaculites sp. (pl. 22, fig. 1)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Textulariidae:																																																										
Textularia agglutinans d'Orbigny	R	R	--	R	--	--	R	--	--	R	R	**R**	--	--	R	--	--	**R**	--	R	--	--	R	--	--	--	R	--	--	--	--	--	R	--	R	--	--	--	--	R	--	--	--	--	--	R	R	R	--	--	--	R	--	R	--	R	R	R
alveata Todd	--	--	--	R	--	--	--	--	R	R	--	R	R	--	--	--	--	?	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
candeiana d'Orbigny	--	R	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	?	--	--	--	--	--	R	--	R	R	R
dupla Todd	R	?	--	--	--	--	**C**	--	R	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	R
foliacea Heron-Allen and Earland	--	--	--	--	--	--	--	--	--	--	--	**R**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
foliacea var. *oceanica* Cushman	--	--	--	--	--	--	--	--	--	**C**	--	**R**	**R**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Verneuilinidae:																																																										
Gaudryina cf. *G. pauperata* Earland	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**R**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(*Siphogaudryina*) *rugulosa* Cushman (pl. 25, fig. 5b)	R	C	C	R	C	**C**	A	--	--	R	**R**	**C**	R	R	C	--	--	--	R	--	--	--	**C**	--	--	R	--	--	--	--	--	R	--	--	--	--	--	--	--	C	R	--	--	--	--	--	R	--	--	--	R	--	--	R	--	--	R	R
(*Siphogaudryina*) *siphonifera* (Brady)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**R**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Valvulinidae:																																																										
Valvulina davidiana Chapman	R	R	R	R	--	--	--	--	--	R	**R**	**R**	--	R	--	--	--	--	--	R	--	R	--	--	--	--	--	--	--	--	--	R	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Clavulina angularis d'Orbigny	R	R	R	**C**	R	--	--	--	--	R	--	**R**	--	--	--	--	--	**R**	R	C	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	R	R
Miliolidae:																																																										
Quinqueloculina agglutinans d'Orbigny	--	--	R	--	--	--	--	--	--	--	--	R	--	R	--	--	--	R	--	R	--	--	?	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
anguina Terquem var. *arenata* Said	--	--	R	R	R	--	--	--	--	R	--	**R**	--	R	--	**R**	R	**C**	**R**	C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
berthelotiana d'Orbigny	--	--	--	--	--	--	R	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
bidentata d'Orbigny (pl. 22, fig. 2)	R	**R**	R	R	--	--	--	--	--	R	R	**R**	R	R	R	R	R	**R**	--	R	**R**	--	--	--	?	--	--	--	--	--	--	?	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	R	C	R	R
distorqueata Cushman	R	--	--	--	R	--	--	--	--	--	--	--	--	--	R	--	--	--	R	R	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
cf. *Q. ferussaci* d'Orbigny	--	--	--	R	--	--	--	--	R	--	R	--	--	R	--	--	--	--	--	R	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	?	--	--	C	--	--	--	--	R	--	--
neostriatula Thalmann	R	R	--	--	--	--	--	--	--	R	**R**	R	--	--	--	R	R	**R**	--	R	R	R	R	--	**R**	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--
polygona d'Orbigny (pl. 22, fig. 5)	--	--	R	R	--	--	--	--	--	R	--	**R**	**C**	--	R	R	--	R	--	R	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	C	R	R	R	A	A	C
sulcata d'Orbigny	R	--	R	R	R	--	R	--	--	R	--	**R**	**R**	--	--	R	--	R	--	C	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R
tubus Todd	R	R	R	--	R	--	--	--	--	--	**R**	**C**	R	R	--	R	--	R	--	R	--	--	R	--	R	R	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	R	R	R	R	R	R	R	R	R	R
Triloculina bicarinata d'Orbigny	**R**	--	--	R	--	R	**R**	--	R	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	?	--	--	--	--	--	--	--
cuneata Karrer	**R**	C	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	**R**	--	R	**R**	C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	C	--	--	--	R	A	--	A	--	R	A	R
earlandi Cushman	--	--	R	R	--	--	--	--	--	R	--	--	--	--	**R**	R	--	R	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--
incisura Todd	--	--	--	--	R	--	**R**	--	--	--	--	**R**	R	--	**R**	**R**	--	--	--	**R**	--	R	R	--	R	C	**R**	--	--	R	R	R	R	--	--	--	--	--	--	--	--	--	--	--	--	--	C	C	R	R	C	C	A	C	C	A	C	C
irregularis (d'Orbigny)	**C**	R	R	**C**	R	**R**	R	R	--	R	R	**R**	R	R	R	--	R	**R**	--	R	**R**	C	R	--	R	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	R	R	R	R	R	R	R	R	--	R	R
kerimbatica (Heron-Allen and Earland)	R	R	R	--	--	--	--	--	--	--	--	R	R	--	--	R	--	--	--	R	--	R	**C**	--	R	R	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	C	--	R	--	R	R	C	R	A	C	C
marshallana Todd	--	R	--	--	--	--	R	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	C	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	?	--	--	R	--	--	--	R	R	--	--
oblonga (Montagu)	--	--	R	R	R	--	R	--	--	R	R	R	R	--	--	--	R	R	R	**A**	**R**	R	R	--	**R**	R	--	--	--	R	R	R	--	--	R	R	--	--	--	R	R	--	--	--	--	--	C	R	--	--	R	C	A	A	C	C	C	C
spinata Cushman	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	?	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
subplanciana Cushman	R	--	--	--	R	--	--	--	--	R	--	?	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	R
transversestriata (Brady)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	R
tricarinata d'Orbigny	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trigonula (Lamarck)	R	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**R**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--
Spiroloculina angulata Cushman	R	R	R	R	R	**R**	--	R	--	R	--	**R**	--	--	--	R	R	R	--	C	R	--	**C**	--	R	?	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	R	R	--	R	R	R	R	C	C	R	C
clara Cushman	R	--	--	R	--	--	--	--	--	--	--	--	R	--	R	--	C	R	--	R	--	C	R	--	R	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
clara var. *lirata* Cushman	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
communis Cushman and Todd	?	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	**R**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
corrugata Cushman and Todd	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	R	R	--	R	R	R
eximia Cushman	--	--	R	--	R	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
rugosa Cushman and Todd	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
venusta Cushman and Todd	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R
Massilina planata Cushman	--	R	--	--	R	--	--	--	--	R	--	--	--	R	--	--	--	--	R	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

TABLE 1.—*Distribution of Recent Foraminifera of Onotoa Atoll*—Continued

[A indicates abundant; C, common; R, rare. Symbol printed in boldface indicates presence of live specimens]

	Area open to ocean on west (leeward side)							Lagoon: Southern								Lagoon: Central and northern							Reef areas: Leeward			Reef areas: Windward	
	GOC-33	GOC-27	GOC-48	GOC-49	GOC-37	GOC-51	GOC-53	GOC-35a	GOC-35b	GOC-55	GOC-56	GOC-57	GOC-58	GOC-28	51-S-10	51-S-7	51-S-8	51-S-9	51-S-11	GOC-29	GOC-45	51-S-12	GOC-52	GOC-36a	GOC-36b	GOC-30	GOC-31
Miliolidae—Continued																											
Hauerina diversa Cushman				R							**R**	R						R		R			R				
involuta Cushman	R	R	R	R	R								R				R	R		R					R		
milletti Cushman				R			?				**R**	R	R			R		**R**		R			**R**				
pacifica Cushman	**R**	R		R			R													R	**R**			?	**R**		
serrata Cushman	R									R	?									R							
speciosa (Karrer)					R											R				R							
Schlumbergerina alveoliniformis (Brady)	R	**C**	R	C	R		R		R	**R**	**R**	**C**	**R**	R	**R**	R	C	**C**	R	C	**C**	**R**	**R**		**R**		
Ammomassilina alveoliniformis (Millett)		R																R									
Articulina elongata Cushman																				R							
pacifica Cushman			R					R		R				R						R							
Nubeculina divaricata (Brady)		?	C	R	R									R	R				R	R			R				
Miliolinella australis (Parr)	R					**R**												R		R		R	R				
labiosa (d'Orbigny)	R	R	R	R			R				**R**	**R**			**R**					C		R	R		**R**	R	
oceanica (Cushman)	R																	**R**		C			R		R	R	R
Pyrgo denticulata (Brady)									**R**																		
Ophthalmidiidae:																											
Cornuspira planorbis Schultze			R	R	R				R	R	**R**	**R**	R	R		**R**		**R**		**R**	R	R	C		**R**	R	R
Planispirinella exigua (Brady)												R				R		R		R							
Wiesnerella auriculata (Egger)																				R							
Parrina bradyi (Millett)	R				R											**R**		**R**		R			**R**		**R**	R	
Fischerinidae:																											
Fischerina pellucida Millett (pl. 22, fig. 6)												**R**								R							
Placopsilinidae:																											
Placopsilina bradyi Cushman and McCulloch																							R				
? sp. (pl. 22, figs. 3, 4; pl. 25, fig. 5d)			**R**		R					R				R				**R**	R								
Haddonia torresiensis Chapman		C		R	R	R		R			R	**R**	R	R	R		R		R				**R**			C	
Bdelloidina aggregata Carter																											
Polymorphinidae:																											
Sigmomorphina terquemiana (Fornasini)																							R				
Camerinidae:																											
Heterostegina suborbicularis d'Orbigny (pl. 25, fig. 5a)	**A**	**A**	C	C	A	A	A	**A**	A	**A**	A	**A**	**C**	A	A	C	C	**A**	A	A	**C**	C	**A**	**C**	C	R	
Peneroplidae:																											
Peneroplis ellipticus d'Orbigny		R		R					R	R	**R**	**R**		R	**R**	**R**	R	**R**		R	R	R			**R**		
proteus d'Orbigny (pl. 22, fig. 7)			R													R	R			R							
Spirolina acicularis (Batsch)																R		R		R							
arietina (Batsch)	R	C	R	**R**	R	**R**		R	R	R		R	R	R	R		R	**R**		R	**C**	C	**R**	**R**	R	R	**R**
Monalysidium politum Chapman			R												?		R			R	R	R					
Sorites marginalis (Lamarck)		C	R	R								R	R	R		**C**	R			R		R					
Marginopora vertebralis Blainville	**C**	**C**	C	**A**	A	**R**	R	C	C	C	**A**	**A**	**A**	C	C	C	**A**	**A**	R	C	**C**	A	**C**	**R**	A	A	**A**
Alveolinellidae:																											
Borelis pulchrus (d'Orbigny)		**R**		R		R	R							R	R		R	**R**									
Heterohelicidae:																											
Bolivinella folium (Parker and Jones)												R		R		R		R		R							
Buliminidae:																											
Buliminella milletti Cushman							R					R				R											R
Buliminoides williamsonianus (Brady)				R			**C**									**R**				R							
Fissurina lacunata (Burrows and Holland)																				R							
lagenoides (Williamson)			R																								
milletti Todd							R																				

	Southern part of atoll				From islands along east side of atoll: Beach sands				Pits inshore from sea beach (see text fig. 1): Interpreted as beach sands													Transitional sediments							Interpreted as reef flats		
	51-L-8	51-L-9	51-S-5	51-S-6	GOC-38	GOC-19	GOC-20A	GOC-20B	GOC-1A	GOC-2A	GOC-3A	GOC-3B	GOC-3D	GOC-3F	GOC-4A	GOC-5	GOC-6A	GOC-6B	GOC-6C	GOC-1B	GOC-2B	GOC-4B	GOC-17A	GOC-17B	GOC-1C	GOC-2C	GOC-1D	GOC-2D	GOC-1E	GOC-2E	GOC-2F
Miliolidae—Continued																															
Hauerina diversa Cushman																								R							
involuta Cushman																															
milletti Cushman																															
pacifica Cushman																					R										
serrata Cushman																															
speciosa (Karrer)																															
Schlumbergerina alveoliniformis (Brady)					R																		R	R						R	R
Ammomassilina alveoliniformis (Millett)																															
Articulina elongata Cushman																															
pacifica Cushman																															
Nubeculina divaricata (Brady)																															
Miliolinella australis (Parr)																															
labiosa (d'Orbigny)					R									R								R	R	R		R	R	R	R	C	R
oceanica (Cushman)					R																R				R	R		R			R
Pyrgo denticulata (Brady)																														R	R
Ophthalmidiidae:																															
Cornuspira planorbis Schultze			R											R						R	R		R		R	R	C	C	R	R	R
Planispirinella exigua (Brady)					R																										
Wiesnerella auriculata (Egger)																															
Parrina bradyi (Millett)																						**R**	**R**	**R**					R	R	R
Fischerinidae:																															
Fischerina pellucida Millett (pl. 22, fig. 6)																															
Placopsilinidae:																															
Placopsilina bradyi Cushman and McCulloch																															
? sp. (pl. 22, figs. 3, 4; pl. 25, fig. 5d)																															
Haddonia torresiensis Chapman					R	C		R	R	R			R							C			R	R	R		A	R	R	A	R
Bdelloidina aggregata Carter																															R
Polymorphinidae:																															
Sigmomorphina terquemiana (Fornasini)																															
Camerinidae:																															
Heterostegina suborbicularis d'Orbigny (pl. 25, fig. 5a)	R	C	C	R	C	R	R	C	R		R	C	A	C	C	C	R	C	C		R	R	C	C	R	C	C	R		R	C
Peneroplidae:																															
Peneroplis ellipticus d'Orbigny	R																														
proteus d'Orbigny (pl. 22, fig. 7)																								R							
Spirolina acicularis (Batsch)																															R
arietina (Batsch)			R		R			R							R				R		R	R	R	R	R			R			R
Monalysidium politum Chapman																															
Sorites marginalis (Lamarck)			R																				R		R	R			R		R
Marginopora vertebralis Blainville	A		R	R	A	A	C	C	C	C		R	A	R	C	R				C	C	C	C	C	C	R	A	C	A	A	A
Alveolinellidae:																															
Borelis pulchrus (d'Orbigny)					R																										
Heterohelicidae:																															
Bolivinella folium (Parker and Jones)																															
Buliminidae:																															
Buliminella milletti Cushman																											R	R	R	R	R
Buliminoides williamsonianus (Brady)																															
Fissurina lacunata (Burrows and Holland)																															
lagenoides (Williamson)																															
milletti Todd																											?				

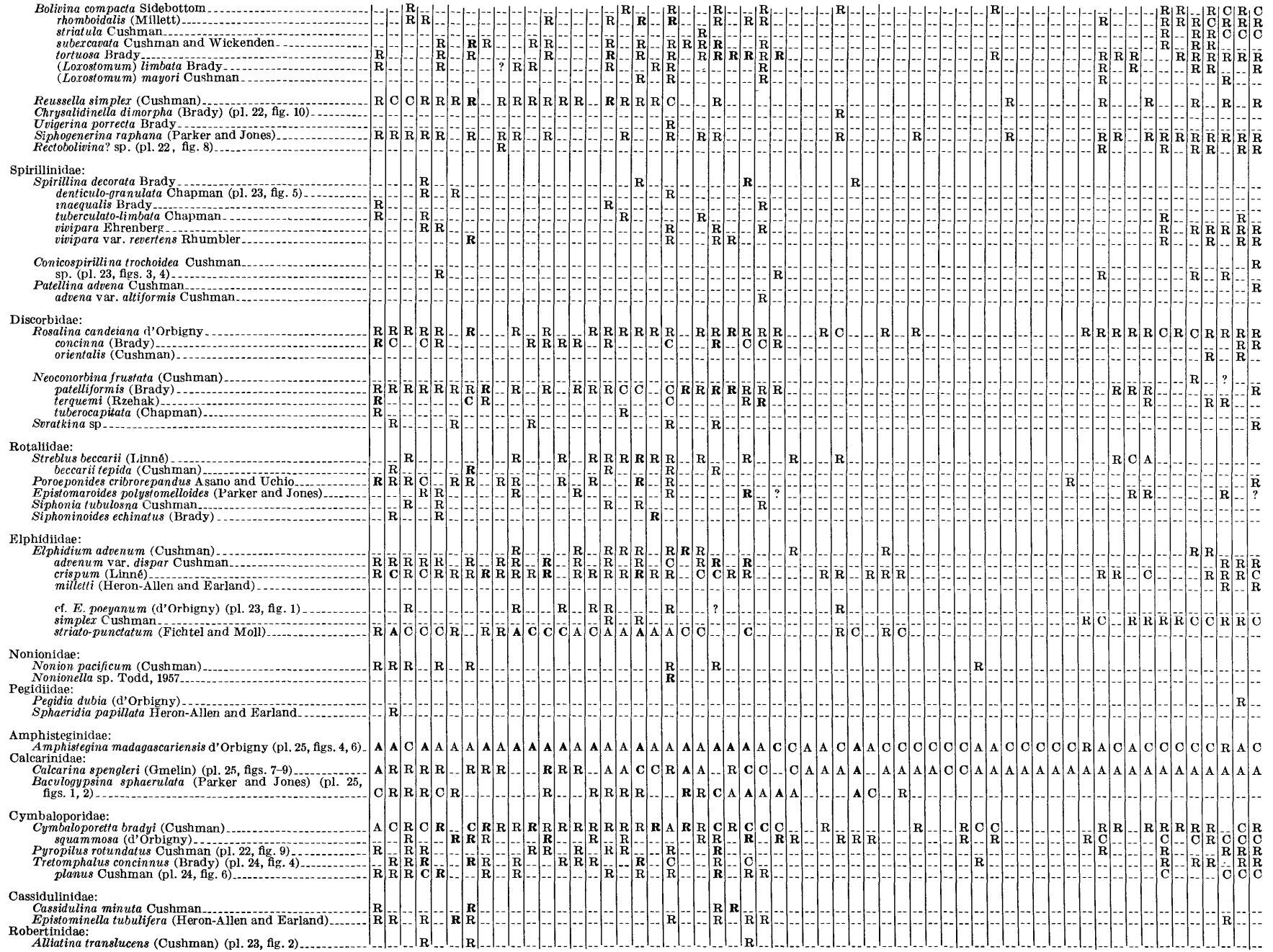
Bolivina compacta Sidebottom
rhomboidalis (Millett)
striatula Cushman
subexcavata Cushman and Wickenden
tortuosa Brady
(*Loxostomum*) *limbata* Brady
(*Loxostomum*) *mayori* Cushman
Reussella simplex (Cushman)
Chrysalidinella dimorpha (Brady) (pl. 22, fig. 10)
Uvigerina porrecta Brady
Siphogenerina raphana (Parker and Jones)
Rectobolivina? sp. (pl. 22, fig. 8)
Spirillinidae:
Spirillina decorata Brady
denticulo-granulata Chapman (pl. 23, fig. 5)
inaequalis Brady
tuberculato-limbata Chapman
vivipara Ehrenberg
vivipara var. *revertens* Rhumbler
Conicospirillina trochoidea Cushman
sp. (pl. 23, figs. 3, 4)
Patellina advena Cushman
advena var. *altiformis* Cushman
Discorbidae:
Rosalina candeiana d'Orbigny
concinna (Brady)
orientalis (Cushman)
Neoconorbina frustata (Cushman)
patelliformis (Brady)
terquemi (Rzehak)
tuberocapitata (Chapman)
Svratkina sp
Rotaliidae:
Streblus beccarii (Linné)
beccarii tepida (Cushman)
Poroeponides cribrorepandus Asano and Uchio
Epistomaroides polystomelloides (Parker and Jones)
Siphonia tubulosa Cushman
Siphoninoides echinatus (Brady)
Elphidiidae:
Elphidium advenum (Cushman)
advenum var. *dispar* Cushman
crispum (Linné)
milletti (Heron-Allen and Earland)
cf. *E. poeyanum* (d'Orbigny) (pl. 23, fig. 1)
simplex Cushman
striato-punctatum (Fichtel and Moll)
Nonionidae:
Nonion pacificum (Cushman)
Nonionella sp. Todd, 1957
Pegidiidae:
Pegidia dubia (d'Orbigny)
Sphaeridia papillata Heron-Allen and Earland
Amphisteginidae:
Amphistegina madagascariensis d'Orbigny (pl. 25, figs. 4, 6)
Calcarinidae:
Calcarina spengleri (Gmelin) (pl. 25, figs. 7–9)
Baculogypsina sphaerulata (Parker and Jones) (pl. 25, figs. 1, 2)
Cymbaloporidae:
Cymbaloporetta bradyi (Cushman)
squammosa (d'Orbigny)
Pyropilus rotundatus Cushman (pl. 22, fig. 9)
Tretomphalus concinnus (Brady) (pl. 24, fig. 4)
planus Cushman (pl. 24, fig. 6)
Cassidulinidae:
Cassidulina minuta Cushman
Epistominella tubulifera (Heron-Allen and Earland)
Robertinidae:
Alliatina translucens (Cushman) (pl. 23, fig. 2)

TABLE 1.—*Distribution of Recent Foraminifera of Onotoa Atoll*—Continued

[A indicates abundant; C, common; R, rare. Symbol printed in boldface indicates presence of live specimens]

	Area open to ocean on west (leeward side)							Lagoon: Southern								Lagoon: Central and northern							Reef areas: Leeward			Reef areas: Windward		Southern part of atoll				From islands along east side of atoll: Beach sands				Pits inshore from sea beach (see text fig. 1): Interpreted as beach sands													Transitional sediments							Interpreted as reef flats		
	GOC-33	GOC-27	GOC-48	GOC-49	GOC-37	GOC-51	GOC-53	GOC-35a	GOC-35b	GOC-55	GOC-56	GOC-57	GOC-58	GOC-28	51-S-10	51-S-7	51-S-8	51-S-9	51-S-11	GOC-29	GOC-45	51-S-12	GOC-52	GOC-36a	GOC-36b	GOC-30	GOC-31	51-L-8	51-L-9	51-S-5	51-S-6	GOC-38	GOC-19	GOC-20A	GOC-20B	GOC-1A	GOC-2A	GOC-3A	GOC-3B	GOC-3D	GOC-3F	GOC-4A	GOC-5	GOC-6A	GOC-6B	GOC-6C	GOC-1B	GOC-2B	GOC-4B	GOC-17A	GOC-17B	GOC-1C	GOC-2C	GOC-1D	GOC-2D	GOC-1E	GOC-2E	GOC-2F
Globigerinidae:																																																										
Globigerina bulloides d'Orbigny	--	--	--	--	--	--	**R**	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--
eggeri Rhumbler (pl. 24, fig. 5)	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
cf. *G. inflata* d'Orbigny (pl. 24, fig. 1)	R	R	--	R	--	**R**	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--
Globigerinata glutinata (Egger) (pl. 24, fig. 3)	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--
Globigerinoides conglobatus (Brady)	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ruber (d'Orbigny)	R	--	--	--	--	--	R	--	R	--	--	--	--	--	--	--	--	R	--	C	--	--	R	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
sacculifer (Brady)	R	R	--	C	--	R	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	R	--	--	R	--	--	R	R	R	R
Globigerinella aequilateralis (Brady)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R
Orbulina universa d'Orbigny? (pl. 24, fig. 2)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--
Pulleniatina obliquiloculata (Parker and Jones) (pl. 24, fig. 7)	--	--	--	R	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Anomalinidae:																																																										
Anomalina glabrata Cushman	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	R
Cibicides cicatricosus (Schwager)	--	R	--	--	R	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	?	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	R	--
lobatulus (Walker and Jacob)	--	?	--	R	--	--	R	--	--	--	--	**R**	--	--	--	--	R	R	--	--	--	R	**R**	--	--	R	--	R	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	R	--	--	--	R	--	R	R
mayori (Cushman)	--	R	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R
cf. *C. pseudoumgerianus* (Cushman)	R	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cibicidella variabilis (d'Orbigny)	**R**	--	--	R	--	**R**	R	--	--	--	R	R	R	R	R	--	--	R	R	C	R	--	**R**	R	**R**	**R**	R	--	--	--	R	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	R	R	R	R
Planorbulinidae:																																																										
Planorbulina acervalis Brady	C	R	R	C	R	--	R	--	--	R	R	R	--	--	R	R	R	**R**	--	C	--	R	**R**	R	R	--	--	--	--	--	--	R	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	R	R	R	R
? *rubra* d'Orbigny	--	--	--	R	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--
Planorbulinoides retinaculatus (Parker and Jones)	--	R	R	R	R	--	R	--	R	R	--	--	--	R	--	--	--	--	--	--	--	--	C	--	--	--	R	--	--	--	--	--	C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--
Acervulina inhaerens Schultze	C	R	C	R	C	--	R	R	R	R	R	R	--	R	--	R	--	**R**	R	R	--	--	**A**	--	R	--	--	--	--	--	--	R	R	R	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--
sp. Todd, 1957	--	R	--	R	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Gypsina globula (Reuss)	R	C	R	R	R	**R**	R	--	--	R	**R**	--	--	R	R	--	--	--	R	R	--	--	--	--	--	--	--	--	--	--	--	R	--	--	R	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	R	--	--	R	R	R	R	--
plana (Carter)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
vesicularis (Parker and Jones)	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Homotremidae:																																																										
Homotrema rubrum (Lamarck)	C	A	R	A	R	C	A	--	R	R	--	R	--	C	R	--	R	R	--	--	--	R	C	R	R	--	--	R	--	--	--	C	C	--	R	--	--	--	R	C	R	--	--	--	--	C	R	R	--	--	R	C	R	C	C	--	R	C

The species *Textularia foliacea* Heron-Allen and Earland, with its variety *oceanica*, appears to be restricted to the central deeper part of the lagoon where the bottom is covered by fine to coarse limesand between patches of coral. *Streblus beccarii* (Linné) is a large robust form unknown in typical form in the Marshall Islands but is found fairly commonly around Saipan Island. At Onotoa Atoll it is present in some of the lagoonal sediments. It probably is not a reef dweller. The rare occurrences of *Bolivinella folium* (Parker and Jones) are all from limesand bottom in the central part of the lagoon.

Examples of the Foraminifera typical of the limesand bottom of the lagoon are illustrated on plate 25, figures 4–6.

In general, the Onotoa fauna shows rather close correspondence in species composition to the faunas of other areas of the central Pacific. Comparisons with shallow-water faunas around Saipan, Mariana Islands, (Todd, 1957), and inside the lagoons of four atolls (Bikini, Eniwetok, Rongelap, and Rongerik) in the northern Marshall Islands (Cushman, Todd, and Post, 1954) are of interest. At Saipan the material was collected from depths mostly not greater than 38 feet—depths comparable to those at Onotoa which were mostly shallower than 20 feet. In the Marshall Islands most of the samples came from depths greater than 60 feet. No striking differences in fauna were observed between Saipan and Onotoa when the rarer occurrences from each area are left out of consideration. In the Marshall Islands, on the other hand, where the material came from significantly greater depths than did the Onotoa material, three species that are unknown at Onotoa are present with more than scattered occurrences. Their absence at Onotoa may signify an upper depth limitation for them, somewhere between 20 and 60 feet. The species are *Operculina ammonoides* (Gronovius), *Calcarina hispida* Brady, and *Anomalinella rostrata* (Brady).

WET SAMPLES

Twenty-four of the Onotoa samples were treated with alcohol when collected in 1951 and preserved wet in order that distinction between living specimens and empty tests would be possible. By this means an estimate of which species actually lived in various locations and which species may have been deposited there as empty tests could be made.

In the spring of 1957, after approximately 6 years, the samples were processed by staining in rose bengal solution as described by Walton (1952, p. 58), Relatively few specimens (such as of the order of 1 percent) gave a positive reaction to the stain. It is unknown whether or not a 6-year interval between collection and processing may affect the apparent live-dead ratio. To me it seems doubtful that it had an appreciable effect on the Onotoa samples, as the stained specimens observed were mostly very clearly and unmistakable stained.

On table 1, the record of live specimens is indicated by the abundance symbol being printed in bold face. An A or C printed in bold face does not of course mean that the live specimens were abundant or common, but merely that among the abundant or common specimens were some live (stained) ones.

With the stained individuals forming so small a percentage of the total specimens present, it is not unreasonable to assume that evidence for these live specimens would be frequently missed. This assumption may be the explanation for the "lack" of stained specimens of a particular species in certain samples where unstained specimens of that species are common to abundant. The following common to abundant species are those of which living specimens probably occurred but were missed in the samples studied.

Amphistegina madagascariensis d'Orbigny
Baculogypsina sphaerulata (Parker and Jones)
Calcarina spengleri (Gmelin)
Cymbaloporeita bradyi (Cushman)
C. squammosa (d'Orbigny)
Elphidium striato-punctatum (Fichtel and Moll)
Heterostegina suborbicularis d'Orbigny
Marginopora vertebralis Blainville
Schlumbergerina alveoliniformis (Brady)
Spirolina arietina (Batsch)

The assumption that specimens of the foregoing species lived where they occur commonly to abundantly seems, therefore, a safe one.

The two major distinctive habitats that are recognizable at Onotoa on the basis of the relative abundance of species in the sediments are the surfaces and slopes of reefs and the limesand bottom of the lagoon. Presence and absence of stained specimens (that is, collected as living individuals) of certain species in samples from these two areas confirms the distinction between these two habitats. The major inhabitants of reef surfaces and the slopes adjacent to reefs seem to be (in order of abundance):

Calcarina spengleri (Gmelin)
Baculogypsina sphaerulata (Parker and Jones)
Amphistegina madagascariensis d'Orbigny
Marginopora vertebralis Blainville
Cymbaloporetta bradyi (Cushman)
C. squammosa (d'Orbigny)

The major inhabitants of the limesand bottom of the lagoon seem to be (in order of abundance):

Amphistegina madagascariensis d'Orbigny
Heterostegina suborbicularis d'Orbigny
Marginopora vertebralis Blainville
Spirolina arietina (Batsch)

Cymbaloporetta bradyi (Cushman)
C. squamosa (d'Orbigny)
Elphidium striato-punctatum (Fichtel and Moll)
Schlumbergerina alveoliniformis (Brady)

Minor inhabitants of the limesand floor include four large arenaceous species, *Valvulina davidiana* Chapman, *Haddonia torresiensis* Chapman, and the two large species of *Gaudryina (Siphogaudryina)*; a variety of miliolids; the peneroplids *Peneroplis ellipticus* d'Orbigny and *Sorites marginalis* (Lamarck); several buliminids including *Reussella simplex* (Cushman) and a few species of *Bolivina;* a few discorbids including several species of *Rosalina* and *Neoconorbina;* several species of *Elphidium;* a few forms belonging in the Cymbaloporidae (*Pyropilus rotundatus* Cushman and two species of *Tretomphalus*); and several species of the families Anomalinidae and Planorbulinidae that are usually attached forms.

In addition, the following species are present as live specimens in the lagoon but seem to be locally restricted, their local restriction being obvious from the limited distribution of their empty tests as well as of stained specimens:

Buliminoides williamsonianus (Brady)
Cassidulina minuta Cushman
Epistomaroides polystomelloides (Parker and Jones)
Epistominella tubulifera (Heron-Allen and Earland)
Placopsilina? sp.
Poroeponides cribrorepandus Asano and Uchio
Siphoninoides echinatus (Brady)
Spirillina (several species)
Streblus beccarii (Linné)
Textularia dupla Todd
T. foliacea Heron-Allen and Earland
T. foliacea var. *oceanica* Cushman

As for the remaining 76 species present in the 24 wet samples, for which no evidence of living specimens was found, with but two exceptions the species are rare with scattered occurrences. One interpretation of these 76 may be that the specimens did not live precisely where found and the empty tests were deposited there after having been washed in from another, probably nearby, location. However, the possibility of missing stained specimens, in assemblages where the species in question occurs rarely, is very great. Thus a second interpretation is that evidence of live specimens was missed in many of these rare occurrences.

The two exceptions where species were not rare are *Spiroloculina clara* Cushman and *Homotrema rubrum* (Lamarck). Specimens of *Spiroloculina clara* were probably washed into their collecting localities as empty tests. In *Homotrema rubrum* the red original color of the test would preclude recognition of any red stain if present. Furthermore, it is unlikely that broken-off fragments of such permanently attached forms as *Homotrema* would retain their protoplasm for long. However, in other less firmly or less permanently attached forms, such as *Planorbulina* and *Acervulina*, staining proved that at least some of the detached specimens were still alive when collected.

EXAMINATION OF FISH CONTENTS

Stomach and gut contents of 22 fishes were examined for their Foraminifera, and many species were found in several of them (table 2). The fishes fall into five groups as follows:

Trigger fishes:
Nos. 2–4. *Rhinecanthus aculeatus* (Linnaeus)
8. *R. rectangulus* (Bloch and Schneider)
5–7. *Balistapus undulatus* (Park)
20. *Melichthys bunvia* (Günther)
Surgeon fishes:
Nos. 16. *Acanthurus gahhm* (Forskål)
17. *Ctenochaetus striatus* (Quoy and Gaimard)
18. *C. cyanoguttatus* Randall
Parrot fishes:
Nos. 9–15. *Scarus* sp.
File fish:
No. 21. *Cantherines sandwichensis* (Quoy and Gaimard)
Puffers:
Nos. 22, 24. *Arothron nigropunctatus* (Bloch)

From Cloud's observations in the field (written communication July 24, 1959), the feeding habits of these groups of fish are as follows: Trigger fishes and surgeon fishes browse mostly on algae and coral, but they also eat small echinoids and take in considerable amounts of the bottom sediment. The parrot fishes browse on algae, coral, and coral-algal rock, occasionally breaking off large chunks. The file fishes and puffers seem to eat mainly coral.

It can be seen from the occurrence table that a greater variety of Foraminifera species is found in the trigger and surgeon fishes (in which the habit of taking in bottom sediment is present) than in those fishes that ordinarily browse only on the various plants and animals that grow up from the lagoon floor.

In general, a larger proportion of attached forms are found in the stomach and gut contents than are found in the bottom sediments. In only one sample, however, was any foraminiferal material obviously bitten off by a fish: a large fragment of *Planorbulinoides retinaculatus* (Parker and Jones) found in one of the trigger fishes. Probably most of the specimens were taken in as a part of the bottom sediment incidental to the obtaining of other food. In some samples a large proportion of the specimens of *Amphistegina* still retain their light-green color and fresh appearance, suggesting they were living when taken in by the fish.

The composite fauna from the several fish examined is one characteristic of shallow conditions. The most abundant species is *Amphistegina madagascariensis* d'Orbigny, which is the dominant species in most

TABLE 2.—*Occurrence of Foraminifera in stomach and gut contents of fish from the lagoon at Onotoa Atoll*

	Trigger fishes									Surgeon fishes			Parrot fishes							File fish	Puffers	
	Rhinecanthus aculeatus (Linnaeus)			*Rhinecanthus rectangulus* (Bloch and Schneider)	*Balistapus undulatus* (Park)				*Melichthys buniva* (Günther)	*Acanthurus gahhm* (Forskål)	*Ctenochaetus striatus* (Quoy and Gaimard)	*C. cyanoguttatus* Randall	*Scarus* sp.							*Cantherines sandwichensis* (Quoy and Gaimard)	*Arothron nigropunctatus* (Bloch)	
	2	3	4	8	5	5a	6	7	20	16	17	18	9	10	11	12	13	14	15	21	22	24
Textulariidae:																						
Textularia candeiana d'Orbigny										×												
Verneuilinidae:																						
Gaudryina cf. *G. pauperata* Earland	×				×																	
Valvulinidae:																						
Clavulina angularis d'Orbigny					×		×															
multicamerata Chapman	×																					
Miliolidae:																						
Quinqueloculina bidentata d'Orbigny										×												
neostriatula Thalmann	×											×										
sulcata d'Orbigny	×							×														
Triloculina cuneata Karrer	×				×																	
incisura Todd																					×	
irregularis (d'Orbigny)	×		×	×	×	×		×		×												
kerimbatica (Heron-Allen and Earland)			×																			
oblonga (Montagu)	×				×		×	×		×		×										
subplanciana Cushman			×									×										
terquemiana (Brady)		×																				
trigonula (Lamarck)										×												
Spiroloculina angulata Cushman	×				×							×										
clara Cushman	×																					
Hauerina involuta Cushman												×										
milletti Cushman	×																					
pacifica Cushman												×									×	
Schlumbergerina alveoliniformis (Brady)			×																			
Miliolinella australis (Parr)										×												×
labiosa (d'Orbigny)																					×	
Ophthalmidiidae:																						
Cornuspira planorbis Schultze	×																					
Parrina bradyi (Millett)	×																				×	
Camerinidae:																						
Heterostegina suborbicularis d'Orbigny	×	×	×		×		×	×		×	×	×					×		×			×
Peneroplidae:																						
Peneroplis ellipticus d'Orbigny			×																			
proteus d'Orbigny	×																					
Spirolina arietina (Batsch)	×	×										×										
Marginopora vertebralis Blainville	×	×	×	×	×	×	×	×		×	×	×										
Buliminidae:																						
Bolivina striatula Cushman	×																					
Reussella simplex (Cushman)					×					×		×										
Siphogenerina raphana (Parker and Jones)					×																	
Rectobolivina? sp										×												
Spirillinidae:																						
Spirillina vivipara Ehrenberg								×														
Conicospirillina sp							×															
Discorbidae:																						
Rosalina candeiana d'Orbigny					×			×		×	×	×									×	
concinna (Brady)	×						×															
rugosa d'Orbigny	×																					
Neoconorbina patelliformis (Brady)								×		×		×										
Svratkina sp							×	×														
Rotaliidae:																						
Streblus beccarii (Linné)			×																			
Poroeponides cribrorepandus Asano and Uchio								×		×												
Elphidiidae:																						
Elphidium advenum (Cushman) var. *dispar* Cushman	×																					
crispum (Linné)					×	×				×	×	×										
simplex Cushman	×							×														
striato-punctatum (Fichtel and Moll)	×																					
Amphisteginidae:																						
Amphistegina madagascariensis d'Orbigny	×	×	×	×	×	×	×	×	×	×	×	×			×	×	×	×	×		×	×
Calcarinidae:																						
Calcarina spengleri (Gmelin)	×	×	×	×				×		×	×								×			
Baculogypsina sphaerulata (Parker and Jones)		×			×	×		×		×	×					×						
Cymbaloporidae:																						
Cymbaloporetta bradyi (Cushman)	×		×		×		×	×	×		×	×									×	
squammosa (d'Orbigny)	×	×			×	×	×	×	×	×		×									×	
Tretomphalus concinnus (Brady)					×		×	×	×		×									×	×	
planus Cushman	×			×				×														
Globigerinidae:																						
Globigerinoides ruber (d'Orbigny)								×														
sacculifer (Brady)							×															
Anomalinidae:																						
Cibicides lobatulus (Walker and Jacob)					×															×		
Cibicidella variabilis (d'Orbigny)							×	×	×	×											×	×
Planorbulinidae:																						
Planorbulina acervalis Brady					×			×														
Planorbulinoides retinaculatus (Parker and Jones)		×		×	×																×	
Acervulina inhaerens Schultze	×				×			×	×													
Homotremidae:																						
Homotrema rubrum (Lamarck)		×		×		×	×	×	×	×		×	×	×					×		×	×

shallow waters of the tropical Pacific. The next most abundant species is *Heterostegina suborbicularis* d'Orbigny. Abundance of these two forms is known to vary greatly from place to place, possibly for reasons related to gregarious habit of Foraminifera. Likewise, their abundance varies greatly in the stomach and gut contents. Fish No. 15, for example, contained more specimens of *Heterostegina* than of any other genus of Foraminifera.

Miliolids are much more abundant than buliminids in the samples under discussion. Peneroplids (except for *Marginopora vertebralis* Blainville, a species that appears to live more abundantly on the reef flats than on the bottom of the lagoon) are rare, and arenaceous forms are almost completely missing. Globigerinids are also very rare in the stomach and gut contents. Quite a large proportion of the specimens found in the stomach and gut contents are attached forms, such as *Neoconorbina*, *Rosalina*, *Cymbaloporetta*, *Cibicides*, *Cibicidella*, *Acervulina*, *Planorbulina*, *Planorbulinoides*, and *Homotrema*.

In the bottom sediments, specimens of *Tretomphalus* are found in fair abundance; those with float chambers accompanied by rather large numbers of the *Rosalina*-stages without float chambers. The morphogenetic relationship between these two forms was demonstrated and clearly illustrated by Myers (1943, pl. 3), who also presented other observations regarding the biology and ecology of the genus *Tretomphalus*. Myers concluded (1943, p. 21) that the planktonic stage of *Tretomphalus* was very brief and lasted usually no more than 18 hours unless the specimen became encrusted with minute algae or other organisms, in which case it would remain afloat indefinitely. If not thus supported, a planktonic specimen would promptly sink to the bottom after the escape of the gametes through the large pores in the spherical float chamber. Thus in a tropical environment where there is no marked seasonal temperature fluctuation and where the water temperature of about 29° C is well above the 18° C observed to be the minimum temperature for development of the floating stages of *Tretomphalus* (Myers, 1943, p. 22), a steady supply of the fragile specimens with float chambers might be expected to be constantly added to the bottom sediments.

The *Rosalina* stages of *Tretomphalus*, however, presumably did not live in the bottom sands or muds but attached to algae or any sort of stemmed structure and thus could have been obtained by the fish as it browsed. Nevertheless, most of both forms of this genus were probably taken in as a part of the bottom sediment rather than in the process of browsing on algae or coral (Cloud, 1952, p. 26; 1959, p. 398–399, pls. 130, 131).

The trigger and surgeon fishes, most of which contain a large proportion of reef-dwelling Foraminifera, such as *Baculogypsina*, *Calcarina*, and *Marginopora*, may be interpreted as being frequenters of reef flats and reef fronts. Other fishes, whose stomachs are free or nearly free of those large genera, probably fed mostly in patch reefs and sandy areas. The observation that certain fish had consumed large proportions of one or the other, but usually not both, of the two major genera (*Calcarina* and *Baculogypsina*) that inhabit the reef flats suggests that individual fish may be quite restricted in their food-gathering travels.

Study of stomach and gut contents of sedentary animals might throw additional light on the probable dwelling places of various species of Foraminifera, whether on algae of various kinds, or on coral, or in the sands or muds of the lagoon bottom.

Table 2 gives the species of Foraminifera found in the 22 samples of fish stomach and gut contents. In only three samples were species found in the fish that were not also found in the bottom sediments:

1. *Clavulina multicamerata* Chapman in fish No. 2. It differs from *C. angularis* d'Orbigny in a rounded cross section toward the apertural end instead of a triangular section throughout.
2. *Triloculina terquemiana* (Brady) in fish No. 3.
3. *Rosalina rugosa* d'Orbigny in fish No. 2. It differs from *R. candeiana* d'Orbigny in having very coarse perforations, which may prove to be not a specific distinction.

FORAMINIFERA FROM PITS

Samples were examined from seven pit sections well away from the beach. All the pits were shallow, three in the southern part and four in the central part of the northern main island. (See USGS locs. f11639–f11661.) None of the four pits (GOC–4, GOC–5, GOC–6, and GOC–17) in the central part of the island exceeded 3 feet in depth. The other three pits (GOC–1, GOC–2, and GOC–3) were deeper: about 6 feet, 9 feet, and 11 feet, the deepest sample studied from the last hole, however, being at 10 feet.

Omitting the pit at GOC–17, all the excavations started in soil composed of nearly pure *Calcarina* sand, much darkened by organic matter, and in which roots were common. Some, but not all, of the specimens of *Calcarina* were much worn, presumably by abrasion before final deposition. The specimens also show the effects of corrosion by organic acids in the soil, in that many of the shells are porous with openings into the chamber cavities (pl. 25, fig. 7). The dark stain and porosity of the shells was not observed in material obtained from below a depth of about 1 foot.

The uppermost sections of the pits at GOC–1, GOC–2, and GOC–4 and the entire section of the pits

at GOC–3, GOC–5, and GOC–6 are interpreted as beach sands. (See fig. 41.) These sands are composed of *Calcarina* with lesser amounts of *Amphistegina*, *Marginopora*, and *Heterostegina*. Minor elements, such as miliolids and species of *Bolivina* and *Cymbaloporetta*, increase with depth in pits GOC–3 and GOC–6. In the lower sections of these pits the orange color of the sand and good preservation of specimens is similar to that of modern beach sands, and there is only slight evidence of abrasion. Presumably the species in these pits lived not far from where they were deposited.

In pits GOC–1, GOC–2, and GOC–4 the beach sands are gradually transitional into sediments with a much smaller proportion of *Calcarina* and a greater variety of other Foraminifera. Nevertheless, even with the change, *Calcarina* remains the predominant element to the bottom of all the pits. (See pl. 25, figs. 8, 9.) These richer and more varied sediments are interpreted as a reef-flat horizon which was built up to become progressively shallower and finally to be overrun by the sediments of an adjacent beach—sediments that now overlie it in the pits. The transition between beach sands and reef-flat sediment, however, occurs at different depths in the various pits. For example, the pit at GOC–3, although sampled to a greater depth than any other pit, did not—even at a depth of 10 feet—reach the rich fauna of the reef flat horizon (fig. 41).

The pit at GOC–17 was dug through limesand and limesilt throughout, and the entire 2-foot section is in sediments transitional between those of a reef-flat horizon and beach sands. No beach sands overlie the surface at GOC–17.

In addition to the pits on the northern main island, a small section is exposed above the beach on the lagoon side of the southern main island at GOC–20. Material in the 3¾-foot section is beach sand (pl. 25, fig. 3), slightly richer and less well worn than that occurring in the area of the pits on the northern main island.

A few of the species found in the pits were not found in the lagoon sediments. None of them occur more than very rarely and all are known as Recent species:

Bdelloidina aggregata Carter
Conicospirillina trochoidea Cushman
Elphidium milletti (Heron-Allen and Earland)
Neoconorbina frustata (Cushman)
Patellina advena Cushman
Pegidia dubia (d'Orbigny)
Rosalina orientalis (Cushman)
Spiroloculina corrugata Cushman and Todd

Among the species found rather consistently in the lagoon and reef sediments, the following are conspicuous by their absence from the pits:

Baculogypsina sphaerulata (Parker and Jones)
Elphidium striato-punctatum (Fichtel and Moll)
Hauerina involuta Cushman
Spiroloculina clara Cushman
Valvulina davidiana Chapman

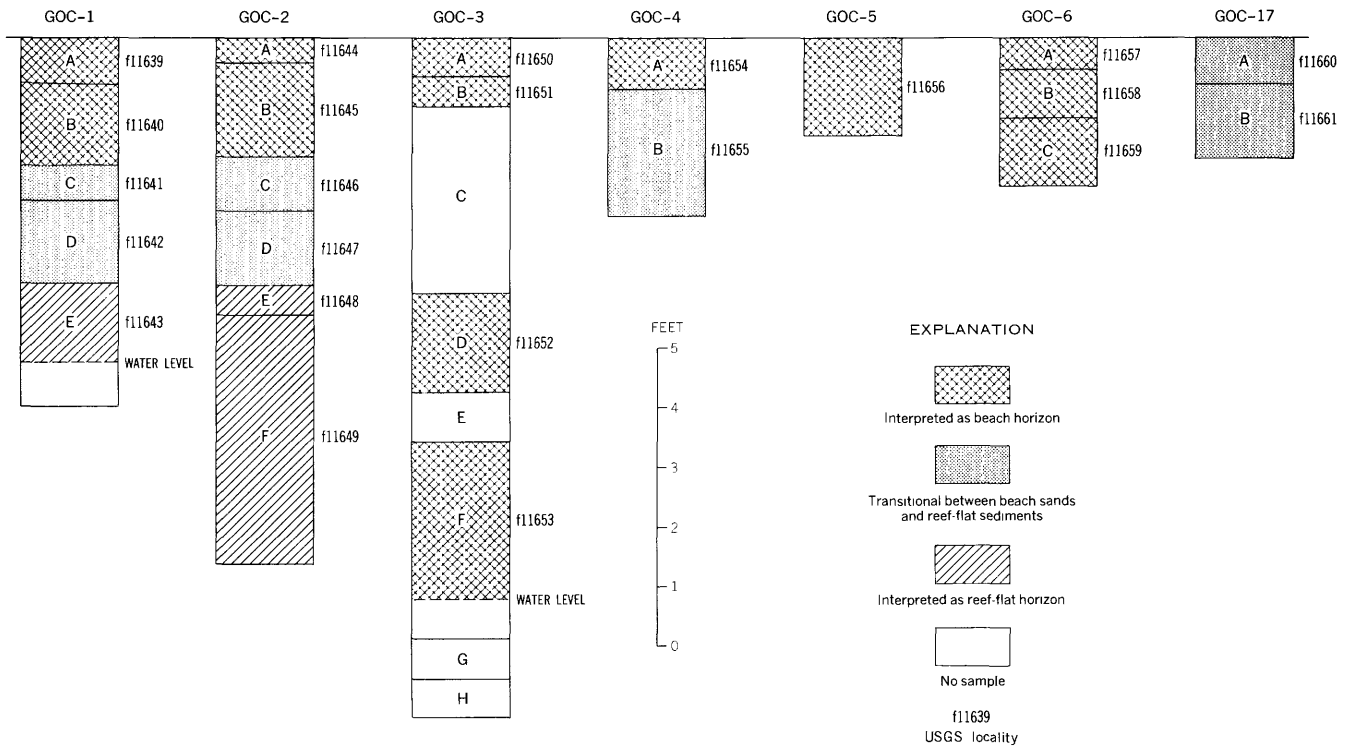

FIGURE 41.—Diagrammatic sections of seven dug pits on the northern main island of Onotoa Atoll. For detailed illustrations of Foraminifera sands of GOC-1D see pl. 25, fig. 9; of GOC-2F, pl. 25, fig. 8; GOC-6A, pl. 25, fig. 7.

For the last four species listed it is probable that a shallow reef-flat horizon is not the preferred habitat (see occurrence of these species in table 1), and hence their absence is not unexpected. For *Baculogypsina sphaerulata*, on the other hand, its absence in an environment known to be its preferred habitat is surprising and suggests the existence of some prohibitive factor, as discussed in the following section.

LOCAL DISTRIBUTION OF *CALCARINA* AND *BACULOGYPSINA*

With but two exceptions, the more abundant species at Onotoa seem to be distributed more or less uniformly, though in varying proportions depending upon the facies. The two exceptions are *Calcarina spengleri* (Gmelin) and *Baculogypsina sphaerulata* (Parker and Jones). Both of these two species are believed to be mainly reef dwellers although some live specimens were also found in the bottom sediments adjacent to reefs and in some beach sands (f11676, GOC–38) and coarse shallow sediments (f11677, GOC–45) of the lagoon.

Figure 40 shows the 27 localities where either one or both of these species was found to constitute a significant part of the Foraminifera population. Symbols indicate the approximate relative abundance of these species to each other (not to the total fauna). In table 1 it will be observed that either or both are present in many other samples, but less abundantly.

It may be seen that in the overall picture *Calcarina* dominates. It is present to the exclusion of *Baculogypsina* in 11 of the localities. In only 3 localities is *Baculogypsina* present alone, while in the remaining 13 localities the 2 genera are found together, though possibly not living together. Even though live specimens were found in the same sample, easy transport over short distances by means of surf or currents leaves the possibility open that the two genera do not occupy precisely the same ecological niche. In general the samples where *Baculogypsina* is predominant are from localities in or near breaks in the reef and away from land areas (pl. 25, figs. 1, 2).

I have no theories as to the reason for the separate geographic occurrence, here and elsewhere, of these two genera. I believe it is more than a chance distribution, and more than a result of incomplete collection of or examination of samples. In each of the seven pits (f11639–f11661, GOC–1 to GOC–17) only *Calcarina* was found. As two of these pits (GOC–2 and GOC–3) afford sections of about 9 and 10 feet, respectively, the sediments penetrated probably represent deposition over a considerable period of time. The fact that only *Calcarina* was found in all the pit samples suggests that *Baculogypsina* may have been a comparatively late comer to this atoll. However *Baculogypsina* is not a late comer in the general area of the western Pacific as is evidenced by the fact that at Bikini and Eniwetok atolls it is found in the shallow drillings but is not present in the Recent fauna.

NOTES ON SELECTED SPECIES

Chrysalidinella dimorpha (Brady)

Plate 22, figure 10

Chrysalidinella dimorpha (Brady). Cushman, 1945, Cushman Lab. Foram. Research Contr., v. 21, p. 52, pl. 8, figs. 21, 22.

This species is characterized by its elongate and straight-sided form. Only a single specimen was found.

Elphidium cf. E. poeyanum (d'Orbigny)

Plate 23, figure 1

Rare specimens found in several of the lagoon samples are distinctive in having a nearly transparent wall, uninflated test, and very short retral processes. In these characteristics they are similar to *Elphidium poeyanum* (d'Orbigny) (Cushman, 1939, p. 54, pl. 14, figs. 25, 26), a common species of the West Indian region. They are easily distinguishable from *E. simplex* Cushman, which has an umbilical plug, a milky wall, and a tendency toward inflation of the later chambers. I have not observed this very transparent species elsewhere in the western Pacific.

Globigerina cf. G. inflata d'Orbigny

Plate 24, figure 1

Rare specimens in the lagoon samples, mostly in those samples from areas open to the ocean on the southwest, seem related to *Globigerina inflata* d'Orbigny (Cushman, 1946, p. 16, pl. 3, fig. 3; pl. 4, figs. 1–4). They are close coiled with four chambers making up the final whorl and have a large, arched and rimmed aperture that opens into the umbilicus.

Globigerina inflata was not found in the *Globigerina* oozes around the Marshall Islands, nor was it observed among the rare globigerinids found in the shallow sediments around Saipan. Its nearest reported occurrence seems to be the Mid-Pacific seamounts (Hamilton, 1953, p. 222).

Globigerinita glutinata (Egger)

Plate 24, figure 3

Globigerinita glutinata (Egger). Phleger, Parker, and Peirson, 1953, Swedish Deep-Sea Exped. Repts., v. 7, Sediment cores from the North Atlantic Ocean, no. 1, p. 16, pl. 2, figs. 12–15.

Rare specimens of this small globigerinid occur in the lagoon and in the area open to the ocean. One

occurrence was from sediments interpreted as a reef-flat horizon from the bottom of one of the pits.

Neoconorbina terquemi (Rzehak)

Rosalina orbicularis Terquem, 1876, Essai Classement Animaux Plage Environs Dunkerque, Paris, fasc. 2, p. 75, pl. 9, fig. 4.
Rosalina terquemi Rzehak, 1888, Austria Geol. Reichsanst., Verh., p. 228.
Conorbina orbicularis (Terquem). Parker, 1954, Harvard Coll. Mus. Comp. Zoology Bull., v. 111, no. 10, p. 522, pl. 8, figs. 13, 14.

This species is type of the genus *Neoconorbina;* the name *terquemi* was proposed to differentiate Terquem's species from one described earlier under the name by d'Orbigny.

The species occurs in a few of the lagoon and reef-flat samples, in some samples fairly commonly. Their low, flat, scalelike shape suggests they were attached in life.

Nubeculina divaricata (Brady)

Nubeculina divaricata (Brady). Cushman, 1932, U.S. Natl. Mus. Bull. 161, pt. 1, p. 48, pl. 11, figs. 5, 6.

This miliolid with arenaceous coating is generally recognizable only when its uncoated tubular neck is preserved. It was found in a few of the lagoon and reef samples.

Placopsilina bradyi Cushman and McCulloch

Placopsilina bradyi Cushman and McCulloch, 1939, Allan Hancock Pacific Exped., v. 6, no. 1, p. 112, pl. 12, figs. 14, 15.
Placopsilina cenomana Brady [not d'Orbigny] 1884 [part], *Challenger* Rept., Zoology, v. 9, p. 315, pl. 36, fig. 1 [not figs. 2?, 3].

Several specimens of this permanently attached form were found on the surfaces of shells and algae from the reef edge (f11681, GOC–52). They consist of a series of coarsely agglutinated chambers, initially coiled, then in a uniserial arrangement and an irregularly winding course.

The first mention of this species (see second reference in synonymy) included two and possibly three types of forms under the name *Placopsilina cenomana:* figure 1, coarsely arenaceous, white, and with transverse measurements of 0.30–0.45 mm; figure 3, arenaceous, orange, and with transverse measurements of 0.04–0.08 mm; and figure 2 possibly differing in being either finely arenaceous or not agglutinated. The distinction between the very small orange one and the larger white one was recognized by the erection in 1920 of *P. confusa* Cushman (1920, p. 71, pl. 14, fig. 6) for the former, leaving the latter in *P. cenomana* d'Orbigny. The original description of *P. bradyi*, however, included all three of Brady's figures in synonymy, probably by oversight, as no mention of *P. confusa* is made, and the description, figures, and a paratype in the U.S. National Museum collection (USNM 35815) all indicate that a form equivalent to Brady's figure 1 (not fig. 3) is meant to carry the name of *P. bradyi.*

As comparison of type material of the two species, *P. confusa* and *P. bradyi*, indicates possible if not probable specific differences between the two, the name *P. bradyi* is retained for the Onotoa specimens.

Placopsilina? sp.

Plate 22, figures 3, 4; plate 25, figure 5d

Rare fragments of irregularly curving cylindrical agglutinated tubes, consisting of uniserial chambers varying in height but usually quite low and uneven in shape, were found in three lagoon samples. One unbroken end shows a smooth, round, and unrimmed apertural opening in the depressed center of the final chamber. These fragments may be the upward-growing parts of attached specimens of *Placopsilina.*

Quinqueloculina polygona d'Orbigny

Plate 22, figure 5

Quinqueloculina polygona d'Orbigny, 1839, *in* De la Sagra, Histoire physique, politique et naturelle de l'Île de Cuba, Foraminifères, p. 198, pl. 12, figs. 21–23.
Cushman, 1932 [part], U.S. Natl. Mus. Bull. 161, pt. 1, p. 25, pl. 6, fig. 6 [not fig. 5].

Typical specimens of this angular miliolid that was described from shore sands of Cuba are present, sometimes abundantly, in the Onotoa samples.

Rectobolivina? sp.

Plate 22, figure 8

Rectobolivina sp. Todd, 1957, U.S. Geol. Survey Prof. Paper 280–H, p. 290–291 (table)

In the Onotoa material, particularly that from the reef-flat horizons in pits GOC–1 and GOC–2, are rare specimens that are questionably referred to this genus. They are identical with some from Tanapag lagoon, Saipan. They are always in association with *Siphogenerina raphana* (Parker and Jones) from which they are distinguishable by their much smaller size (0.35–0.55 mm long), slenderer form (0.10–0.20 mm wide), more translucent wall, proportionally longer multiserial stage (becoming biserial but twisted in the present material), and the slightly indented sutures and hence slightly lobulated outline. They may prove to be related to *Siphogenerina raphana*, possibly being included in the same species.

Rosalina candeiana d'Orbigny

Rosalina candeiana d'Orbigny, 1839, *in* De la Sagra, Histoire physique, politique et naturelle de l'Île de Cuba, Foraminifères, p. 97, pl. 4, figs. 2–4.
Discorbis opima Cushman, 1933, Cushman Lab. Foram. Research Contr., v. 9, p. 88, pl. 9, fig. 3.

This is the commonest of the discorbids found at Onotoa, occurring in nearly all the lagoon samples and on the reef flats. It is too fragile to persist in the beach sands. As is typical of the family Discorbidae, specimens were probably loosely attached by their ventral surfaces during life, but not cemented, so that as empty tests they were easily washed down into the bottom sediments.

Rosalina concinna (Brady)

Discorbina concinna Brady, 1884, *Challenger* Rept., Zoology, v 9, p. 646, pl. 90, figs. 7, 8.
Discorbis micens Cushman, 1933, Cushman Lab. Foram. Research Contr., v. 9, p. 89, pl. 9, fig. 5.

This small circular scalelike species was also attached during life. It is almost surely the early stage of the species of *Tretomphalus* that is called *T. concinnus* (Brady), referring to the same Brady reference as above. Thus the separation of these two forms is wholly artificial and a matter of convenience. In most samples where either is common, the two forms occur together.

Rosalina orientalis (Cushman)

Discorbis orientalis Cushman, 1926, B. P. Bishop Mus. Bull. 27, p. 130 [imprint date 1925].
Todd, 1957, U.S. Geol. Survey Prof. Paper 280–H, p. 290–291 (table), pl. 90, fig. 13.

Comparison with the types indicates that this species is merely a high-spired form of *Rosalina candeiana*.

Spiroloculina rugosa Cushman and Todd

Spiroloculina rugosa Cushman and Todd, 1944, Cushman Lab. Foram. Research Spec. Pub. 11, p. 66, pl. 9, figs. 9–13.

A single specimen of this species with its distinctively rugose wall was observed in f11667, GOC–29.

Spiroloculina venusta Cushman and Todd

Spiroloculina venusta Cushman and Todd, 1944, Cushman Lab. Foram. Research Spec. Pub. 11, p. 60, pl. 8, figs. 16, 17.

This species was found rarely in the lagoon samples.

Svratkina sp.

Epistominella sp. D, Todd, 1957, U.S. Geol. Survey Prof. Paper 280–H, p. 292–293 (table), pl. 92, fig. 2.
Svratkina sp. A, Todd and Low, 1960, U.S. Geol. Survey Prof. Paper 260–X, p. 840.

The genus *Svratkina* was erected (Pokorný, 1956, p. 257) for specimens that had been previously reported under various other names from Australia, Europe, and America and from the Eocene (if not older) to the Recent. This compact and close-coiled genus is distinguished by large pores, particularly on the dorsal side, the pores sometimes surrounded by tubular necks, and by the aperture being a long, narrow opening extending from the umbilicus along the base of the apertural face to a depression beneath the periphery where it widens and extends upward into the apertural face.

The first reference cited above is to specimens of this genus from Recent lagoon sediments of Saipan; the second to specimens from the upper part of the Eniwetok drill holes in the Marshall Islands. Identical specimens are found rarely at Onotoa. They seem very close to the type of the genus, *Discorbis tuberculata* (Balkwill and Wright) var. *australiensis* Chapman, Parr, and Collins, but may prove to be distinct when sufficient material becomes available.

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[Italic numbers indicate descriptions]

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PLATES 22–25

PLATE 22

FIGURE 1. *Ammobaculites* sp. (p. 177 tab.)
USNM 626873, × 56; USGS f11667, GOC–29.

2. *Quinqueloculina bidentata* d'Orbigny. (p. 177 tab.)
USNM 626883, × 44; USGS f11679, GOC–49; *a*, side view; *b*, apertural view.

3, 4. *Placopsilina*? sp. (p. 187)

3. USNM 626879, × 27; USGS f11678, GOC–48; *a*, *b*, opposite sides; *b*, attached surface; *c*, edge view showing terminal aperture.

4. USNM 626880, × 27; USGS f11678, GOC–48. Fragment of a terminal part that grew outward from initial attached portion.

5. *Quinqueloculina polygona* d'Orbigny. (p. 187)
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7. *Peneroplis proteus* d'Orbigny. (p. 178 tab.)
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10. *Chrysalidinella dimorpha* (Brady). (p. 186)
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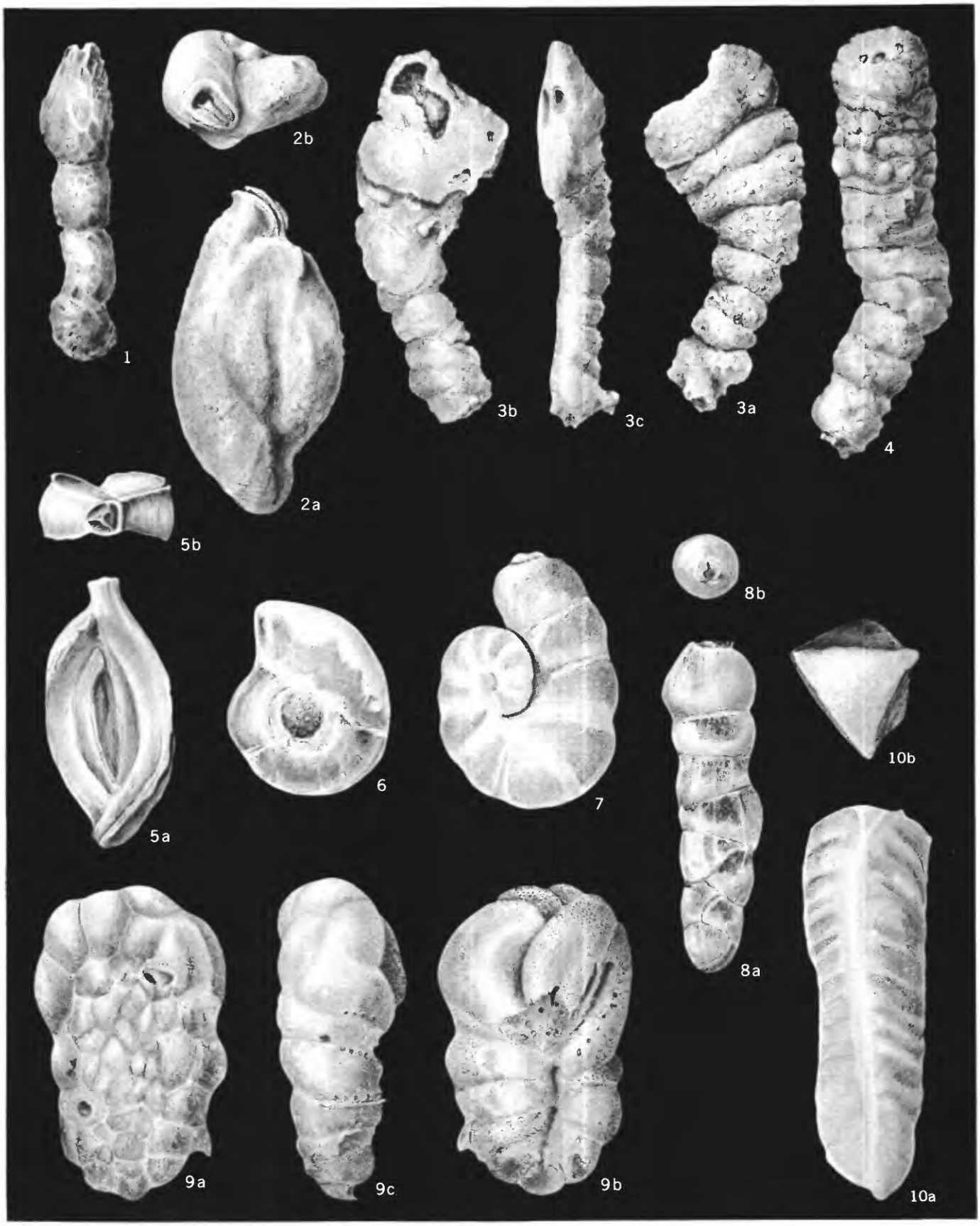

RECENT BENTHONIC FORAMINIFERA FROM ONOTOA ATOLL

PLATE 23

[*a*, Dorsal view; *b*, ventral view; *c*, peripheral view, except as indicated]

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3, 4. *Conicospirillina* sp. (p. 179 tab.)
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5. *Spirillina denticulo-granulata* Chapman. (p. 179 tab.)
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RECENT BENTHONIC FORAMINIFERA FROM ONOTOA ATOLL

PLATE 24

[*a*, Dorsal view; *b*, ventral view; *c*, peripheral view]

FIGURE 1. *Globigerina* cf. *G. inflata* d'Orbigny. (p. 186)
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2. *Orbulina universa* d'Orbigny? (p. 180 tab.)
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3. *Globigerinita glutinata* (Egger). (p. 186)
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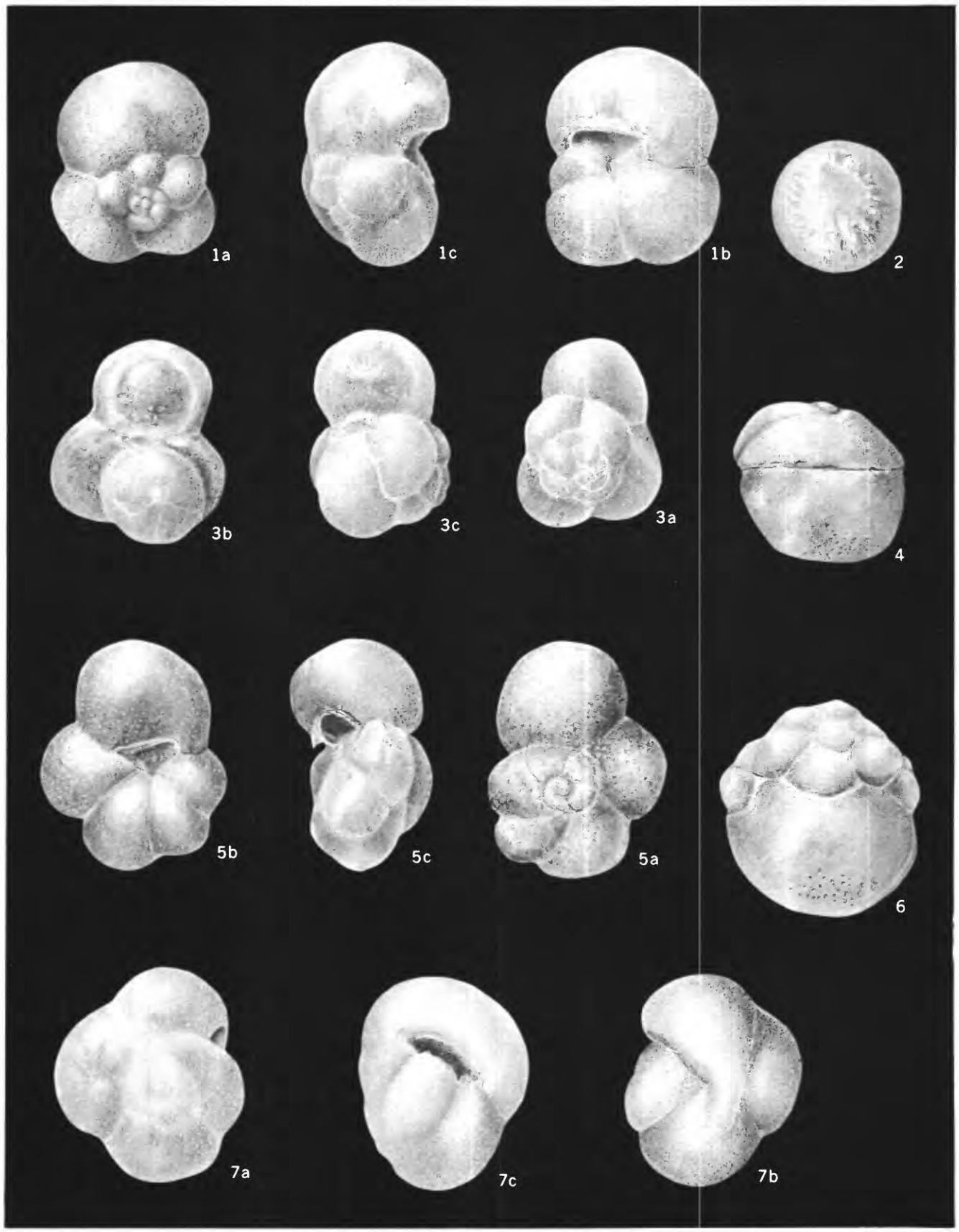


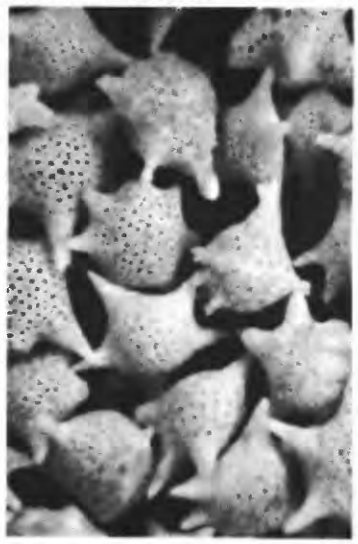
RECENT PLANKTONIC FORAMINIFERA FROM ONOTOA ATOLL

PLATE 25

[All figures × 15]

FIGURE 1. *Baculogypsina* sand from islet of Nanntabuariki on windward (northeast) side of Onotoa Atoll. USGS f11662, GOC–19. Fresh specimens washed onto beach from adjacent reef flat.

2. *Baculogypsina* sand from southeast end of Tabuarorae islet, south end of Onotoa Atoll. USGS f11687, 51–L–8. Well-worn specimens associated with *Amphistegina* and *Calcarina*.
3. *Calcarina*-bearing limesand from upper part of section above lagoon beach just south of Otoae village Maneaba, southern main island of Onotoa Atoll. USGS f11663, GOC–20A. Specimens mostly well preserved.
4. *Amphistegina*-bearing limesand from lagoon floor in northern part of lagoon, about 4,600 ft S. 65° W. from lagoon end of Government Station jetty, Onotoa Atoll. USGS f11695, 51–S–11. From bottom of reentrant or depression in large lagoon reef patch.
5. Miscellaneous Foraminifera from limesand bottom at 14 ft in outer part of lagoon of Onotoa Atoll, slightly less than 4 miles N. 85° W. from Aiaki Maneaba. USGS f11666, GOC–28. Among others, *Heterostegina suborbicularis* d'Orbigny (*a*), *Gaudryina* (*Siphogaudryina*) *rugulosa* Cushman (*b*), *Elphidium striato-punctatum* (Fichtel and Moll) (*c*), *Placopsilina*? sp. (*d*), and *Amphistegina madgascariensis* d'Orbigny (*e*) are recognizable.
6. *Amphistegina*-bearing limesand from seaward edge of Aon te Baba reef, west side of north end of Onotoa Atoll, about 7,100 ft S. 50° W. from Tekawa church. USGS f11670, GOC–33. Worn *Amphistegina* with associated *Heterostegina* and *Marginopora*.
7. Worn *Calcarina* beach sand, stained dark from organic matter and corroded by organic acids. From top 6 in. in pit GOC–6, north-central part of northern main island, about 2,400 ft north-northeast from Taneang-Tekawa Maneaba. USGS f11657, GOC–6A.
8. *Calcarina*-bearing sand interpreted as reef-flat horizon from bottom of 9-ft pit GOC–2, southern part of northern main island, about 940 ft S. 25° E. from east (inshore) end of lagoon-side jetty at Government Station and 660 ft inshore from sea beach along line bearing S. 87° W. at Pacific Science Board campsite. USGS f11649, GOC–2F.
9. *Calcarina* sand, interpreted as transitional between beach and reef flat, from near bottom of 6-ft pit GOC–1, southern part of northern main island, about 1,100 ft S. 41° E. from east (inshore) end of lagoon-side jetty at Government Station and 325 ft inshore from sea beach along line bearing S. 87° W. at Pacific Science Board campsite. USGS f11642, GOC–1D. Both fresh (with spines) and worn specimens.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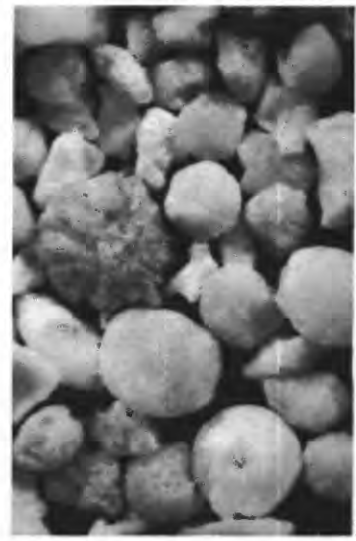
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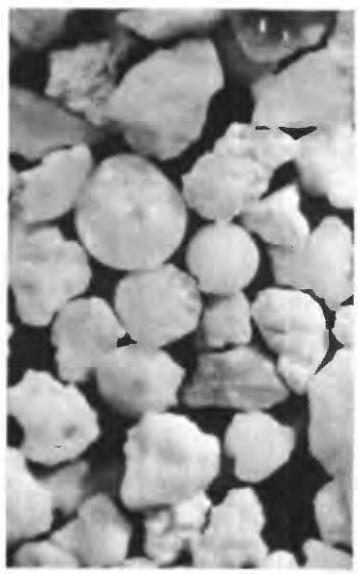
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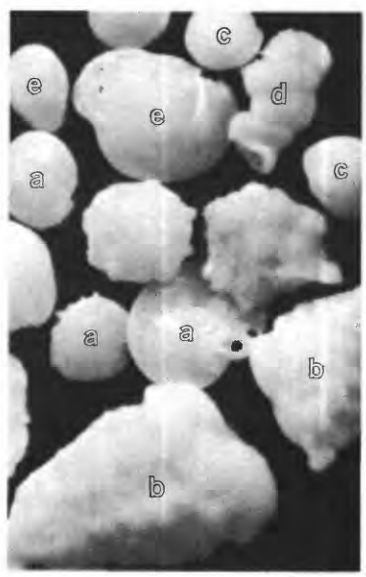

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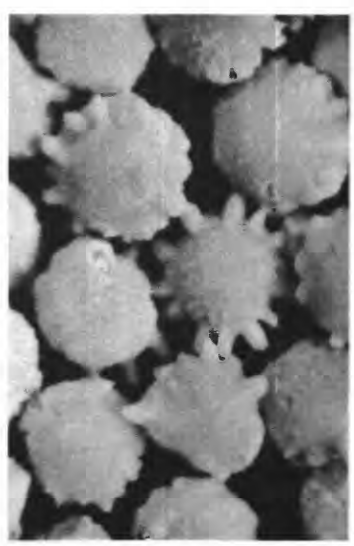
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FORAMINIFERA SANDS FROM ONOTOA ATOLL