Benthonic Foraminiferal Ecology in Port Castries Bay, St. Lucia: A Preliminary Report*

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Introduction

The island of St. Lucia, located in the east central Caribbean Sea (Fig. 1), was selected as the site for an investigation of the ecology of shallow-water, tropical benthonic Foraminifera. The island, one of the larger members of the West Indies chain, lies about half-way between Martinique and St. Vincent and is separated from them by channels which are about 1400 and 600 m. deep, respectively. St. Lucia is roughly lenticular in shape and measures approximately 233 sq. miles in area (Jesse, 1964). The coastline is well indented, giving rise to many small bays and inlets. For the present study, three bays, Choc, Port Castries, and Marigot, were surveyed on the leeward or western side of the island; the field work was conducted in February and March, 1968. This preliminary report deals with only one of the bays, namely, Port Castries, and the data discussed here include hydrography, bottom sediments and distribution of benthonic Foraminifera. The overall purpose of this continuing study is to compare the benthonic foraminiferal populations present in diverse nearshore environments of this part of the Caribbean and unravel the possible relationships between the distributions of the foraminiferal species and important physical and chemical parameters. This investigation is part of a major environmental study program of the Atlantic Oceanographic Laboratory dealing with benthonic Foraminifera from various latitudes from the Arctic to the tropics.

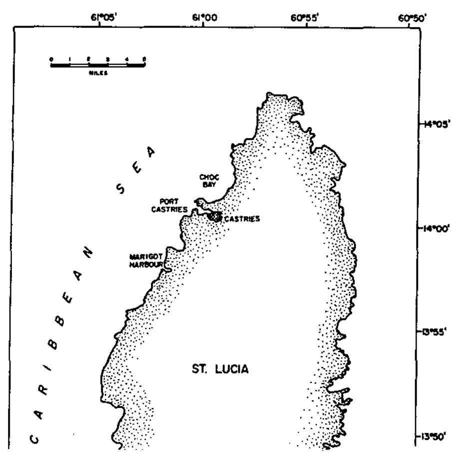

Figure 1 Location of study areas on the lee-ward side of St. Lucia.

Sampling procedure and laboratory techniques

The following procedure was employed to obtain undisturbed sediment samples of a constant volume. At each station four plastic coring tubes having a 3.5 cm inside diameter were taken by a SCUBA diver to the bottom and forced into the sediment to a depth of about 10 cm at four points from 0.3 to 0.5 m apart. The diver attempted to choose sampling points at which the bottom topography and the texture and colour of the substrate appeared to be representative of the area about the sampling station (Schafer, 1967). The plastic tubes were then capped and transported to the surface in vertical orientation. The upper one cm of sediment (the portion containing most of the living Foraminifera) was extruded by a plunger; this portion of the sample was transferred to a jar and stored in a solution of Rose Bengal stain in water mixed with isopropyl alcohol.

The second cm of at least one of the cores was also sampled and preserved similarly. Bottom water samples were also collected.

Bottom water temperature and salinity were recorded *in situ* using an Industrial Instruments Salinometer. A Metrohm model E280A pH meter was used for pH measurements. A part of each water sample was immediately transported to the laboratory and analyzed for nitrogen (ppm N_2 present as NO_2 and NO_3) and total phosphates (ppm P, present as ortho and metaphosphate) using a Hach water testing kit.

Manuscript received October 30, 1968; B.I. Contribution No. 139.

Samples selected for foraminiferal population studies were processed as follows. The wet sample was washed through a No. 230 (0.063 mm) sieve and dried. The Foraminifera in the dried samples were concentrated and separated by flotation in carbon tetrachloride for initial examination. In order to recover the maximum possible number of tests present in the sample the portion that sank in carbon tetrachloride was refloated in a 10:4 mixture of bromoform and acetone (Gibson and Walker, 1967). It was observed that this second treatment generally resulted in about 99 percent recovery. Both the floats were used for foraminiferal counts. The relative proportions of species and total numbers of tests (living plus dead) were determined by counting the tests in a known fraction of the foraminiferal concentrate; this fraction which had at least 300 specimens was obtained using an Otto microsplitter. The total number of living tests, however, was counted for the entire sample.

The grain size distribution of the sediments was investigated by means of standard sieving and pipette techniques.

Hydrography

Port Castries is an elongate bay situated between two mountain spurs. Its major axis is about 6000 ft. long and essentially perpendicular to the leeward coast of St. Lucia. The city of Castries which borders the bay is the largest urban centre on the island. The average water depth of Port Castries is about 11 m ; a maximum depth of about 18 m occurs in the central part of the bay (Fig. 2). In its northern part the Vieille Ville shoal extends bayward from Serafin Point on the shore giving rise to environmental conditions that are markedly different from those found in the adjacent parts of the bay. Fresh water enters the bay primarily via the Castries River on its southeastern shore.

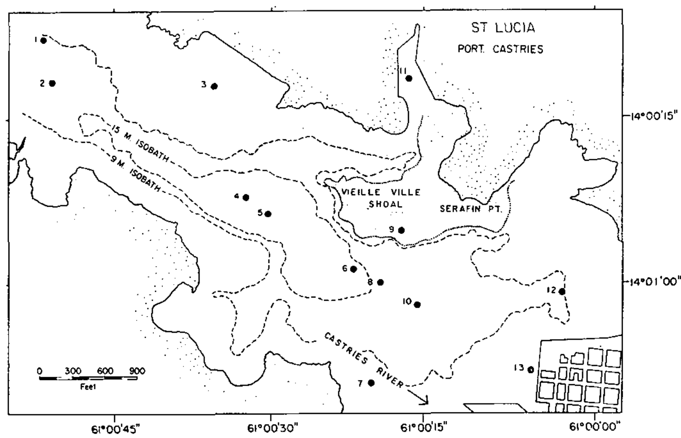

Figure 2 Bathymetry and station locations, Port Castries Bay. Stations 2, 5, 8, 10 and 13 were used only for current meter observations.

TABLE 1

PHYSICAL AND CHEMICAL CHARACTERISTICS OF WATER AND SEDIMENTS IN PORT CASTRIES BAY

STATION	BOTTOM WATER						SURFACE WATER		SEDIMENTS
	TEMP. (°C)	SALINITY (°/oo)	O_2 (ppm)	pH	P (ppm)	N_2 (ppm)	TEMP. (°C)	SALINITY (°/oo)	pH
1	26.2	35.50	7	7.8	0.30	0.06	26.5	34.88	6.5
3	26.0	33.96	7	7.8	0.17	0.05	26.1	33.96	7.5
4	26.2	35.11	6	8.1	0.20	0.09	26.4	34.80	7.2
6	26.1	34.87	7	7.3	0.27	0.06	26.3	34.27	7.0
7	27.7	34.42	7	8.2	0.18	0.06	27.8	34.03	7.4
9	26.6	34.65	9	8.1	0.34	0.06	26.9	34.56	7.7
11	26.4	34.72	6	8.1	0.10	0.05	27.0	34.50	7.5
12	26.1	34.73	7	7.7	0.24	0.06	26.4	34.22	7.1

Bottom water temperatures measured in Port Castries in March, 1968, ranged from 26.0°C to 27.7°C. Temperatures were fairly constant (26.0 to 26.3°C) in water depths greater than 6 m. Salinity of bottom water ranged from 34.0 to 35.5°/oo. At the eastern end of the bay salinities decreased by about 1°/oo. This slight decrease may be attributed to natural runoff and sewage discharged into this end of the port. A maximum difference of about 0.5°/oo was observed between surface and bottom waters. Dissolved oxygen in the bottom water averaged about 7 ppm; no major regional differences were observed. A somewhat higher O_2 value measured at station 9 may be ascribed to an increase in the algal population in this relatively shallow part of the bay. The pH of the bottom water was usually higher than that of the corresponding bottom sediment; the values ranged from 7.3 to 8.2. The phosphate concentration in bottom waters (P, present as ortho and metaphosphate) ranged from 0.10 to 0.34 ppm. The relatively higher values were obtained from samples recovered from the deeper central parts of the bay. Nitrogen concentration in bottom waters (N_2 present as NO_2 and NO_3) ranged from 0.018 to 0.090 ppm. The higher values were associated with the deeper offshore areas. The data on these physical and chemical parameters are given in Table 1.

Nature of substrate

The size distribution of bottom sediments in Port Castries Bay is controlled primarily by water depth and proximity to the shore, the mouth of the bay and the mouth of the Castries River. The phi median diameters of bottom sediment samples range from 1.16 to 8.03. The sediments deposited adjacent to the mouth of the Castries River are characterized by increased amounts of silt- and clay-sized particles (Fig. 3). At station 9 the sediments are considerably coarser than in the surrounding areas because of the shallow nature of this part of the bay. The phi median value of bottom sediments decreases near the mouth of the bay, probably because of the increased velocity of bottom currents and intensity of wave-generated turbulence.

Bottom sediments in Port Castries are generally poorly to very poorly sorted (Folk and Ward, 1957). Sediments at the mouth and in the southern half of the bay show a relatively greater degree of sorting (Table 2). In the southern half of the bay this increased sorting may be attributed to the limited size range of the suspended sediment particles carried by the Castries River into the bay.

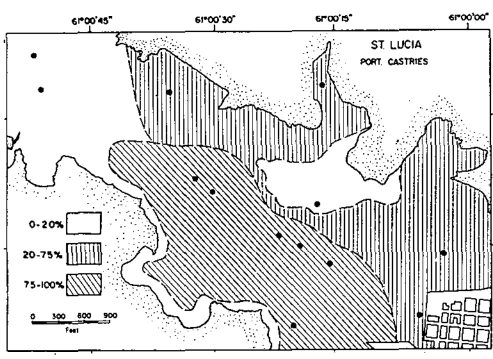

Figure 3 Distribution of silt and clay percentage in bottom sediment samples, Port Castries.

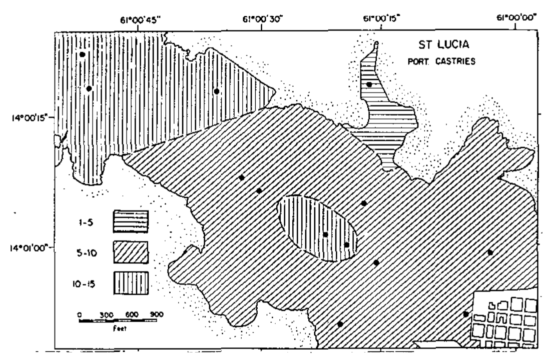

Figure 4 Population density of living Foraminifera in Port Castries, expressed in terms of number of tests per c.c. of wet sediment in the top one-cm layer.

Benthonic Foraminifera: standing crop

The abundance of living Foraminifera in Port Castries Bay is considerably less than that observed in temperate nearshore waters (e.g. Schafer, 1964; 1968). The relatively low concentration of nitrogen (as nitrate and nitrite; Table 1) may be partially responsible for this small standing crop by decreasing the phytoplankton which is the principal food for Foraminifera (Lee et al, 1966). This agrees well with the fact that relatively larger numbers of living specimens are found at station 6 and at the seaward end of the bay (Fig. 4). The relationship of this geographical distribution to environmental conditions in the bay cannot be defined at this time.

TABLE 2

GRAIN SIZE CHARACTERISTICS OF SEDIMENTS IN PORT CASTRIES BAY

STATION	DEPTH (m)	PHI MEDIAN DIAMETER	PHI DEVIATION	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)
1	15	1.70	1.28	0.34	91.02	5.53	3.09
3	6	4.57	2.64	1.72	32.89	48.21	17.17
4	17	7.07	1.91	0.00	2.45	57.48	40.06
6	17	7.39	1.68	0.00	1.92	63.73	34.34
7	4	8.03	1.85	0.00	12.39	36.71	50.89
9	3	1.16	2.24	10.01	77.82	7.98	4.17
11	3	4.97	2.55	1.11	24.90	51.89	22.09
12	12	5.54	2.58	0.00	27.56	47.31	25.12

A preliminary analysis of subsamples obtained at each station indicates a patchy or uneven distribution of living foraminiferal population at most stations in the bay. This inequality (in the number of living Foraminifera per c. c. in the top one cm layer) is especially evident in the relatively denser populations. The living/total ratio in the benthonic foraminiferal assemblage generally varies between 4 and 13 percent. There is apparently no meaningful pattern in this variation, and the calculation of sedimentation rates on the basis of living/total ratios (Uchio, 1960) is not possible. There is, however, one unusually high value of 31 percent at station 7 which may reflect a comparatively rapid deposition of fluviomarine sediments.

A number of authors, including Richter (1961), Phleger (1964), Buzas (1965), Boltovskoy (1966), and Brooks (1967), have reported instances in which Foraminifera have been found living in sediments at depths greater than one cm below the sediment-water interface. In order to test this relationship, the second cm. of sediment obtained from Port Castries cores was analyzed for its content of living Foraminifera. In most cases the number of living Foraminifera in the second cm subsample amounted to less than 20 percent of the number found living in the top cm subsample from the same core. This small value may represent specimens that were mixed with deeper sediments during the coring operation and need not be indicative of the normal habitat of the species. One exception to this generalization has been observed at station 1 located at the mouth of the bay. Here the percentages of living Foraminifera in two second cm subsamples are considerably higher (about 42 percent of the first cm value) than at other locations. The size distribution of sediment at this station differs from that found in most of the inshore parts of the bay; the sediment is composed of relatively coarser particles (91 percent sand, phi median 1.70) that are almost continually subject to wave-generated turbulence during the winter months. This turbulence causes appreciable sediment transport and mixing of detrital particles at the sediment-water interface. The shifting of the substrate results in the burial of some living specimens to depths greater than one cm ; however, since the sediment is coarse, loosely packed, and highly permeable, the buried benthonic Foraminifera are apparently able to survive for some length of time.

Benthonic Foraminifera: nature of assemblage

The total foraminiferal assemblage found in the sediments of Port Castries Bay is very diverse. This includes most of the species reported by Cushman (1922) from Montego Bay, Jamaica. Hofker (1964) described 74 foraminiferal species from the Caribbean littoral zones but only 39 of these have been found in the Port Castries thanatocoenose. Of the 112 species identified thus far from the present sample, only 46 have been found living. The species are listed at the end of the paper.

In the thanatocoenose, the most varied superfamily is the Miliolacea*, which is represented by 53 species. The percentage of individuals belonging to this group in the total benthonic foraminiferal population ranges from 10 at station 11 to 38 at station 1. Generally, the most dominant species is the cosmopolitan shallow-water rotaliid, Ammonia beccarii (Linné); its percentage attains a maximum of 28.5 in the total population (at station 6) and 38.4 in the living population (at station 3). The second most abundant species is Nonionella atlantica Cushman.

In Port Castries Bay, there is an apparent relationship between the substrate and the nature of the foraminiferal thanatocoenose. This may possibly be interpreted as an agreement between the size grade of the dead tests, which make up the bulk of the assemblage, and that of the terrigenous particles of the bay floor (Reiter, 1959; Boltovskoy, 1963). The foraminiferal species living here include a large proportion of small Rotalicea, Buliminacea and Miliolacea, particularly where the substrate is a mud or sandy mud. The tropical reef assemblages of Soritidae that are characteristic of certain other areas along the coast of St. Lucia (e.g., in the Choc Bay), are extremely rare in Port Castries. An exception is seen at station 1 where a few specimens of Amphisorus, Archaias, Peneroplis and Sorites are present, almost entirely as dead tests. This station has a sandy bottom (sand/mud ratio = 11) and because of its location at the mouth of the bay is subject to a greater degree of wave-induced turbulence than any other station considered in this report; the soritid tests are mostly transported from the reef areas existing north and south of the bay mouth.

The planktonic/benthonic ratio in the total foraminiferal assemblage is very low, with a maximum of 0.036 at station 4 which is one of the deepest (17 m.) of the Port Castries sampling stations.

Summary

Port Castries Bay has an average depth of 11 m. During February and March the bottom water temperatures range between 26 and 28°C and salinities range between 34 and 36°/oo; the pH of the bottom water is usually higher than that of the bottom sediment. No major regional differences in the amount of dissolved oxygen were observed in bottom water samples. Relatively higher concentrations of phosphates, nitrates and nitrites characterize the bottom waters in the deeper central parts of the bay. The size distribution of sediments is apparently controlled by water depth and proximity to the shore, the mouth of the bay and the mouth of the Castries River.

The abundance of living Foraminifera in Port Castries is considerably less than that generally found in more northerly waters. A patchy distribution of living individuals is especially evident in areas inhabited by relatively denser populations. The living Foraminifera observed in the second cm subsamples probably reflect mixing and shifting of the substrate.

The total benthonic foraminiferal assemblage consists of 112 species of which 46 are recorded as living. This living population is dominated by species belonging to the superfamilies Rotalicea, Buliminacea and Miliolacea; Ammonia beccarii (Linné) is the most abundant species. The living/total ratio attains a maximum of 31 percent off the mouth of the Castries River and indicates a relatively rapid sedimentation rate in this part of the bay. The planktonic/benthonic ratio is very low, typical of such shallow-water and nearshore conditions.

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* The superfamily and family names used here are from the classification adopted by Loeblich and Tappan (1964).

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LIST OF BENTHONIC SPECIES, PORT CASTRIES BAY. Species found living have been marked by asterisks.

Acervulina inhaerens Schultze
Adercotryma glomerata (Brady)
* Ammobaculites americanus Cushman
Ammobaculites sp.
Ammomassilina alveoliniformis Millett
* Ammonia beccarii (Linné)
Amphisorus hemprichii Ehrenberg
* Amphistegina gibbosa d'Orbigny
* A. madagascariensis d'Orbigny
Archaias angulatus (Fichtell and Moll)
A. compressus (d'Orbigny)
Articulina antillarum Cushman
A. sagra d'Orbigny
Asterigerina carinata d'Orbigny
* Bolivina earlandi Parr
* B. porrecta Brady
* B. pulchella (d'Orbigny)
* B. spathulata (Williamson)
* B. striatula Cushman
* B. truncata (Phleger and Parker)

* Bulimina marginata d'Orbigny
* Buliminella elegantissima (d'Orbigny)
* Cassidulina crassa d'Orbigny
Cibicides lobatulus (Walker and Jacob)
Clavulina tricarinata d'Orbigny
Cyclogyra involvens (Reuss)
* Cymbaloporetta squammosa (d'Orbigny)
* Elphidium articulatum (d'Orbigny)
E. discoidale (d'Orbigny)
* E. poeyanum (d'Orbigny)

E. sagrai (d'Orbigny)
Eponides antillarum (d'Orbigny)
Fissurina sp. cf. F. marginata
Gaudryina aequa Cushman
* Glabratella pileola (d'Orbigny)
G. sp. G. pulvinata
* Goesella flintiana (Cushman)
Gypsina discus Göes
G. vesicularis (Parker and Jones)
Hauerina bradyi Cushman

H. ornatissima (Karrer)
Heterostegina antillarum d'Orbigny
Lagena sp. cf. L. gracilis Williamson
L. sulcata (Walker and Jacob)
Massilina crenata (Karrer)
M. inequalis Cushman
* M. tenuissima Bermudez
* Miliolinella circularis (Bornemann)
* M. labiosa (d'Orbigny)
M. suborbicularis (d'Orbigny)

* M. subrotunda (Montagu)
* Monalysidium politum Chapman
Neoalveolina pulchra (d'Orbigny)
Neoconorbina orbicularis (Terquem)
* Nonion pompilioides (Fichtell and Moll)
* Nonionella atlantica Cushman
Peneroplis carinatus (d'Orbigny)
* P. pertusus (Forskal)
P. proteus d'Orbigny
Planorbulina acervalis Brady

Poroeponides lateralis (Terquém)
Pyrgo denticulata (Brady)
P. subsphaerica (d'Orbigny)
Quinqueloculina agglutinans d'Orbigny
Q. angulata (Williamson)
Q. bidentata d'Orbigny
* Q. candeiana d'Orbigny
* Q. compta Cushman
Q. funafutiensis (Chapman)
* Q. laevigata d'Orbigny

* Q. lamarckiana d'Orbigny
Q. norvangi Boltovskoy
* Q. parkeri (Brady) var. occidentalis Cushman
* Q. poeyana d'Orbigny
* Q. sp. cf. Q. seminulum (Linné)
Q. subpoeyana Cushman
Q. tricarinata d'Orbigny
Q. vulgaris d'Orbigny
Reophax bacillaris Brady
Reophax sp.

Robertina bradyi Cushman and Parker
Rosalina bertheloti d'Orbigny
R. floridana (Cushman)
* R. floridensis Cushman
Rotorbinella mira (Cushman)
* R. rosea (d'Orbigny)
* Sigmoilopsis arenata (Cushman)
Siphogenerina dimorpha (Parker and Jones)
Siphonina pulchar Cushman
Sorites marginalis (Lamarck)

Spirillina densepunctata Cushman
Spirolina acicularis (Batsch)
Spiroloculina antillarum d'Orbigny
S. eximia Cushman
S. grateloupi d'Orbigny
S. ornata d'Orbigny
* Textularia agglutinans d'Orbigny
* T. conica d'Orbigny
* Tretomphalus bulloides (d'Orbigny)
* Triloculina linneiana d'Orbigny

T. oblonga (Montagu)
T. planciana (d'Orbigny)
T. transversestriata (Brady)
* T. tricarinata d'Orbigny
* T. trigonula (Lamarck)
* Trochammina globigeriniformis (Parker and Jones)
* T. nana (Brady)
* Uvigerina canariensis d'Orbigny
Valvulina oviedoina d'Orbigny
Vertebralina cassis d'Orbigny

* Virgulina pontoni Cushman
Wiesnerella auriculata (Egger)