RECENT FORAMINIFERA
AROUND PETROLEUM PRODUCTION PLATFORMS
ON THE SOUTHWEST LOUISIANA SHELF

A Thesis

Presented to

the Faculty of the Department of Geology

University of Houston

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

By

Jo Ann Locklin

December, 1981

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ABSTRACT

The Gulf of Mexico outer continental shelf off the southwest Louisiana coast is an area of heavy offshore petroleum production. Six hundred and seventy-three samples were taken from around petroleum production platforms and control sites in the area, in order to assess the effects of petroleum exploration, drilling, and production activity on the marine organisms. A total of 64,326 living foraminifera were recovered, representing 51 species in 35 genera.

Densities up to 372,154 foraminifera per 10 cm^2 were estimated for the summer, partly caused by the large quantities of available food supplied by the Mississippi River, and partly caused by the wet picking method which preserved delicate juvenile tests. *Nonionella basiloba* and *Buliminella bassendorfensis* together account for almost 76% of the total live foraminiferal population.

Slight seasonal variations in the foraminifera population were found. Changes in species composition at the collecting sites are closely related to water depth.

Low standing crops at the shallow inshore stations in the summer were primarily caused by low dissolved oxygen.

Low diversity values, generally not exceeding $\alpha=5$, were found for the foraminifera populations. The low diversity is caused by the large range of seasonal temperatures, movement of sediment by currents and tides, and, to a lesser degree, the variations in salinity.

Negative effects of petroleum drilling operations on the benthonic foraminifera are not supported by this study. The controlling physical factors on the foraminifera populations are those related to the natural environment, water depth, temperature and salinity, tides and currents, and dissolved oxygen.

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INTRODUCTION

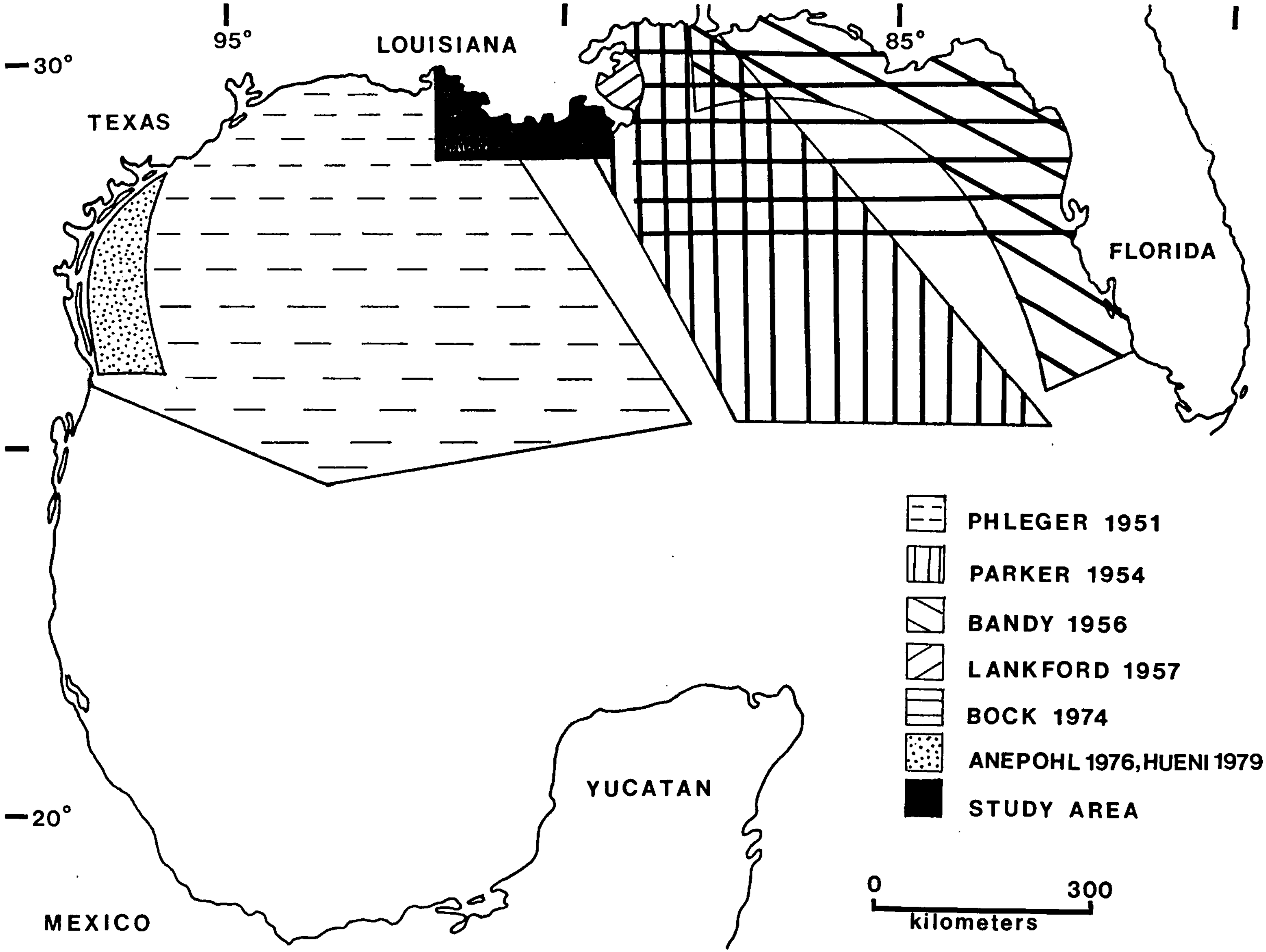
The part of the Louisiana continental shelf covered by this project is an area of heavy offshore petroleum drilling (Text--fig. 1). Although the benthonic foraminifera of the northern continental shelf of the Gulf of Mexico have been well studied for the last three decades, the foraminifera in the study area have not been collected and identified, nor have recent ecological studies on the effects of petroleum production on marine organisms on the continental shelf included foraminifera.

This project was designed to provide identifications and synonymies for foraminifera species found living in the study area, and to assess, with the aid of statistical methods, the effects of the environmental parameters on the living foraminifera.

History of Project

In November, 1977, in response to a solicitation by the Department of the Interior, Bureau of Land Management (BLM), Southwest Research Institute (SwRI), Houston, Texas, submitted to BLM in New Orleans a proposal for a program designed to assess the effect and impact of the Louisiana offshore oil industry on the ecology of the Gulf of Mexico

TEXT-FIG. 1--Location of study area. Areas of Gulf of Mexico continental shelf previously studied for foraminifera are also shown.


95°
85°
30°
20°
LOUISIANA
TEXAS
FLORIDA
MEXICO
YUCATAN
PHLEGER 1951
PARKER 1954
BANDY 1956
LANKFORD 1957
BOCK 1974
ANEPOHL 1976, HUENI 1979
STUDY AREA
0
300
kilometers

outer continental shelf. SwRI was subsequently awarded the BLM contract, and Dr. Rosalie F. Maddocks of the University of Houston Geology Department was subcontracted by SwRI as principal investigator to provide the foraminiferal information necessary to the BLM study. Other aspects of the study provided data on temperature (SwRI personnel), salinity (SwRI), depth (SwRI), dissolved oxygen (SwRI), sediment texture and mineralogy (Dr. W. H. Huang, Texas A&M University), sediment total organic carbon content (Geochem Research, Inc., Houston, Texas), trace elements (SwRI), and other marine organisms (Dr. James H. Baker, SwRI; Dr. L. R. Brown, Mississippi State University; Dr. D. E. Harper, Texas A&M University; LGL, Inc., Bryan, Texas).

All study sites, sampling methods, and sample processing procedures were specifically laid out by BLM in its Request for Proposals (1977) and, with minor exceptions, were adopted by SwRI (SwRI Proposal, 1977). Sample collection was carried out in the spring and summer of 1978 and in the winter of 1979.

Foraminifera identifications and species counts were supplied to SwRI as soon as possible after receipt of the samples. The foraminifera data were included, with other benthonic organism data, in quarterly reports of progress compiled by SwRI on all aspects of the program (SwRI Quarterly Reports, 1978). Throughout the course of the study, quarterly meetings allowed direct exchange of information and ideas among the participants.

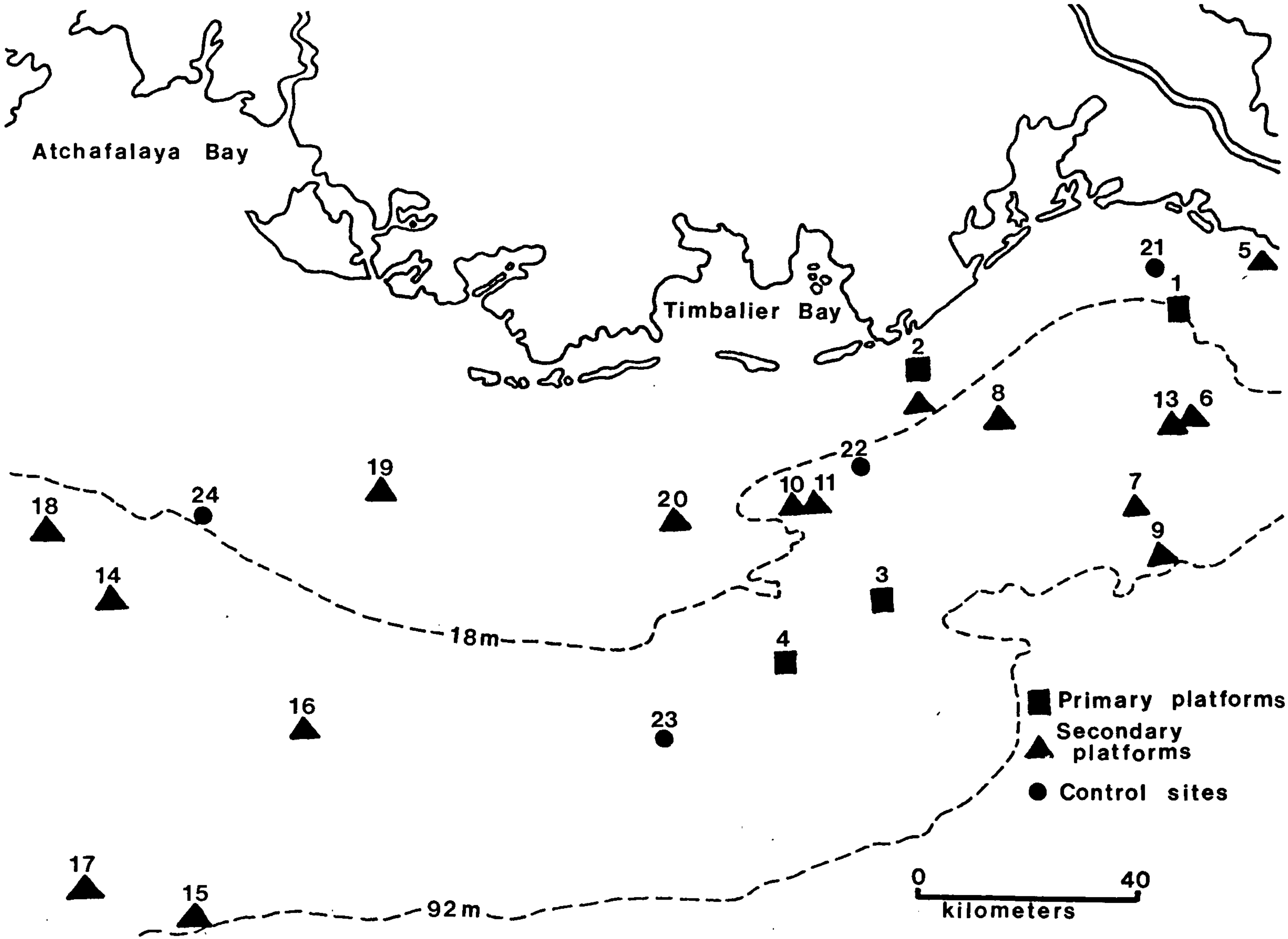
The foraminifera data were completed in the summer of 1978. In addition to species identification and counts, three voucher slides for each species of foraminifera were prepared, two of which were deposited by BLM and SwRI in the United States National Museum. The third set of slides will be kept at the University of Houston. Because only one or two specimens of three of the foraminifera species were available, the University of Houston collection is not complete.

The project was completed in 1980 when SwRI submitted to BLM the Final Report of Ecological Investigations of Petroleum Production Platforms in the Central Gulf of Mexico (SwRI Final Report, 1980).

Regional Setting

The area of the Gulf of Mexico outer continental shelf off the southwest Louisiana coast studied by SwRI (1977, 1978, 1980) for effects of offshore drilling activity extends from the Mississippi River Delta westward to Atchafalaya Bay (Text--fig. 2). Both gas and oil wells

TEXT-FIG. 2--Sampling Locations. (Modified after map supplied by Southwest Research Institute, 1978.)



Atchafalaya Bay
Timbalier Bay
21
5
1
2
8
13
6
22
19
24
18
20
10
11
7
9
14
3
18m
4
16
23
Primary platforms
Secondary platforms
Control sites
17
15
92m
0
40
kilometers

are represented in the platforms selected from more than 2000 offshore structures now known to exist in the northern Gulf of Mexico.

BLM selected four primary platforms, sixteen secondary platforms and four control sites for biological, sedimentological, chemical and hydrographic sampling. (The code for the study sites established by SwRI will be used in this paper. Primary platforms are P, secondary platforms are S, and control sites are C.) The age of the platforms selected ranged from 2 to 23 years, and water depth of the sites ranged from 6 to 98 meters. Distance from shore ranged from 4.8 to 160 kilometers. Most of the platforms selected were located in areas of silty clay or clayey silt sediments.

The four control sites were selected for the purpose of detecting any differences in the environment and the marine fauna in areas relatively remote from petroleum drilling platforms. The control sites selected have never had any type of exploratory, developmental or production activity within the lease block boundaries, and they are as far away as possible from areas of extensive activity. Table 1 is a list of information about the location of each study site (BLM Request for Proposals, 1977).

TABLE 1--List of primary platforms (P), secondary platforms (S), and control sites (C) selected for study.

Study Site	Latitude North	Longitude West	Water Depth (m)	Year Installed	No. of Wells	Distance from Shore (km)	Lease Area
P01	$29^{\circ}07'42''$	$89^{\circ}41'25''$	16	1962	15	19	West Delta
P02	$29^{\circ}02'50''$	$90^{\circ}09'46''$	12	1954	24	5	Bay Marchand
P03	$28^{\circ}40'02''$	$90^{\circ}14'43''$	30	1956	7	37	South Timbalier
P04	$28^{\circ}34'09''$	$90^{\circ}24'32''$	45	1964	9	48	South Timbalier
S05	$29^{\circ}12'32''$	$89^{\circ}32'23''$	9	1962	1	6	West Delta
S06	$28^{\circ}57'08''$	$89^{\circ}41'02''$	52	1965	24	42	West Delta
S07	$28^{\circ}48'34''$	$89^{\circ}47'17''$	65	1965	12	56	West Delta
S08	$28^{\circ}57'37''$	$90^{\circ}01'25''$	27	1957	10	27	Grand Isle
S09	$28^{\circ}44'04''$	$89^{\circ}44'07''$	85	1965	7	64	West Delta
S10	$28^{\circ}49'53''$	$90^{\circ}23'18''$	20	1955	16	19	South Timbalier
S11	$28^{\circ}49'33''$	$90^{\circ}22'36''$	20	1957	12	21	South Timbalier
S12	$28^{\circ}59'07''$	$90^{\circ}09'41''$	17	1965	17	11	South Timbalier
S13	$28^{\circ}56'48''$	$89^{\circ}42'23''$	51	1968	24	40	West Delta
S14	$28^{\circ}41'51''$	$91^{\circ}37'21''$	29	1973	12	67	Eugene Island

TABLE 1--Continued.

Study Site	Latitude North	Longitude West	Water Depth (m)	Year Installed	No. of Wells	Distance from Shore (km)	Lease Area
S15	28°10'02"	91°29'39"	98	1974	21	120	Eugene Island
S16	28°28'28"	91°16'45"	45	1971	18	96	Ship Shoal
S17	28°13'35"	91°41'05"	75	1972	18	160	Eugene Island
S18	28°48'50"	91°44'20"	25	1970	13	51	Eugene Island
S19	28°51'34"	91°07'52"	6	1960	9	43	Ship Shoal
S20	28°48'19"	90°36'29"	18	1969	4	24	South Timbalier
C21	29°12'	89°44'	13	-	-	14	West Delta
C22	28°53'	90°16'	21	-	-	3	South Timbalier
C23	28°27'	90°38'	37	-	-	51	South Timbalier
C24	28°50'	91°27'	18	-	-	62	Eugene Island

Eight sampling stations were located at each of the four primary platforms on four transects originating at the platform toward the north, south, east and west. At each secondary platform two sampling stations were located on a transect originating at the platform and located at distances of 500 meters and 2000 meters to the north. Some of the platform sampling stations were offset from the ideal position because of the network of pipelines on the gulf floor. This was not considered by SwRI and BLM to be a serious problem, and successive samples were taken at the relocated positions.

Single sampling stations were located at each control site. The control sites were defined as circular areas of 2000 meters diameter to minimize resampling of the same exact location (SwRI Proposal, 1977). However, the large area defined for the control sites makes it improbable that the original sampling positions were ever exactly relocated at these sites.

Methods

SwRI Shipboard and Laboratory Methods.

Southwest Research Institute personnel collected the samples in the spring (April-May) and summer (August-September) of 1978, and in the winter (January-February) of 1979. Samples were collected at the primary platforms and control sites during each collecting season. They were collected at the secondary platforms only during the summer. The samples were taken with a Smith-McIntyre grab.

Four grabs were made at each collecting station, and 3.4 cm diameter by 5 cm cores were taken from each grab (SwRI Proposal, 1977). Two cores were taken from the first grab (designated 1.A and 1.B) and one from each of the next three grabs (designated 2.C, 3.D, and 4.E). Six percent (6%) $MgCl_2$ was added to the sediment for ten minutes to anesthetize the foraminifera. The sample was then washed through a 62µ sieve, twice with sea water and once with 4% buffered formalin. The residue was preserved in 5% buffered formalin with glycerin added (1 part to 5 gallons) to deter drying. A 1:1 mixture of Eosin B and Biebrich Scarlet in a 1:1000 concentration was added to each sample.

In the SwRI laboratory (Dr. James H. Baker, personal communication) the cores were washed, and each core from the first three grabs was subdivided into quarters. One of the quarters from the subdivided cores was picked (up to 400 foraminifera) by SwRI technicians. The remaining foraminifera in the quarter-sample were counted. The live foraminifera were then placed in vials, preserved in buffered formalin, and sent to Dr. Rosalie F. Maddocks at the University of Houston. The entire core from the fourth grab was also sent to Dr. Maddocks and is now stored at the University of Houston.

University of Houston Laboratory Methods.

An additional stain of rose Bengal was added to the vials by the author, and the samples were allowed to sit for at least twenty-four (24) hours before identification of the foraminifera was attempted.

The foraminifera were extracted from the vials with a pipette and then placed on faunal slides glued with gum tragacanth. Living foraminifera were identified to the species level and counted while the specimens were still wet on the slides. This prevented juveniles and delicate specimens from breaking apart until they had been identified and counted. The state of preservation of the foraminifera was also noted.

Discussion of the Rose Bengal Stain Method.

Although several methods of staining living foraminifera have been tried, the most efficient and widely accepted is that described by Walton (1952) using rose Bengal. Murray (1973) describes rose Bengal as a protein-specific, aqueous stain that colors protoplasm red. Recent foraminifera workers in the northern Gulf of Mexico using the rose Bengal stain include Fish, Massey, Inabinet & Lewis (1974), Anepohl (1976), and Hueni (1979). Because SwRI was working with a great many more animals than just foraminifera, Eosin B and Biebrich Scarlet in a 1:1 concentration were used for staining animal protoplasm in the samples. However, the very light pink color of the foraminiferal protoplasm imparted by the Eosin B and Biebrich Scarlet made it difficult to distinguish living foraminifera. Heavy shelled opaque miliolids, textulariids, and some rotaliids (Elphidium, Ammonia) were most often mistaken for living specimens. Before the decision was made to add rose Bengal to the vials, crushing many of the specimens was the only effective way to determine whether or not they contained protoplasm. Adding the rose Bengal stain to the samples eliminated the need for crushing heavy foraminiferal tests and made live foraminifera identification quicker and easier.

Decalcification.

Some of the samples were completely decalcified at the time of identification, and only the protoplasm molds of the foraminifera remained. When the pH of the samples was kept at 7-8, the decalcification problem was eliminated (SwRI Second Quarterly Report, 1978). Parker (1954), in a study of living foraminifera from the northeastern Gulf of Mexico, found that a few of the samples taken from shallow depths showed decalcification, possibly because of the increasing acidity of the samples after collection. She also found that frequent checks of the pH of the samples had to be made in order to maintain the most satisfactory pH of 7-8.

Live/Total Ratios and Densities.

A quarter of the core from the 3.D samples at the N500 stations for primary and secondary platforms and each control site was dried, and the first 300 foraminifera were picked for identification and live/total ratios, except for secondary platform 13, where core 2.C was picked. No live/total counts were received from SwRI for S19, C22 and C23 for the summer collecting season.

Dead foraminifera assemblages in the live/total slides were also compared with the living assemblages from the wet samples in order to determine if relict foraminifera were present. Counts of rotaliids, miliolids, and textulariids were also made from the live/total slides and from the corresponding wet samples, in order to determine if the composition of the foraminiferal groups had changed in response to environmental factors.

Estimations of foraminiferal density were necessary because of the division of the cores into quarters and because only the first 400 foraminifera were picked. SwRI supplied the total foraminiferal counts upon which the estimations are based.

Statistical Methods.

Statistical methods used in this study are the Q-mode cluster analysis employing the cosine theta function (weighted pair group method) of Imbrie & Purdy (1962), and analysis of variance procedures (adapted from Davis, 1973) for the entire foraminiferal population as well as for individual species. Correlation coefficients were calculated for foraminifera groups using physical data supplied by SwRI (Appendix 1).

The clustering method was applied to the foraminiferal data for the primary platforms and the control sites for each of the three collecting seasons. In addition, a clustering program using the foraminiferal data for the summer collecting season from both the primary and secondary platforms and the control sites was run.

Two-way analysis of variance tests were performed on numbers of individuals of foraminiferal species compared with seasons, and on numbers of observations for each foraminiferal species and seasons. One-way analysis of variance tests were performed for each individual species on replicate samples at collecting stations for each collecting season. Significant differences among stations and seasons were checked by the F distribution at the 5% level of significance. The species counts from which the analysis of variance tests were made are stored with the Department of Geology at the University of Houston.

Correlation coefficients (program supplied by Dr. Richard A. Reynolds), comparing numbers of total foraminifera, *Nonionella basiloba*, and *Bulminella bassendorfensis* against mean sediment grain size and total organic carbon, were calculated for the primary platforms and control sites for each collecting season, and for the secondary platforms for the summer. The same foraminifera data were compared with trace metal data for the spring at the primary platforms and control sites and for the summer at the secondary platforms. All data used in calculating the correlation coefficients (except foraminiferal data) were supplied by SwRI.

Physical Characteristics of Study Area

Temperature, Salinity, and Dissolved Oxygen.

Temperature, salinity, and dissolved oxygen measurements for each collecting season were made along the north transect at a distance of 100 meters from each platform, and at each control site. The measurements were taken at the surface and thereafter at 10 meter depth intervals until the bottom was reached (SwRI meterology and hydrography Data, 1980).

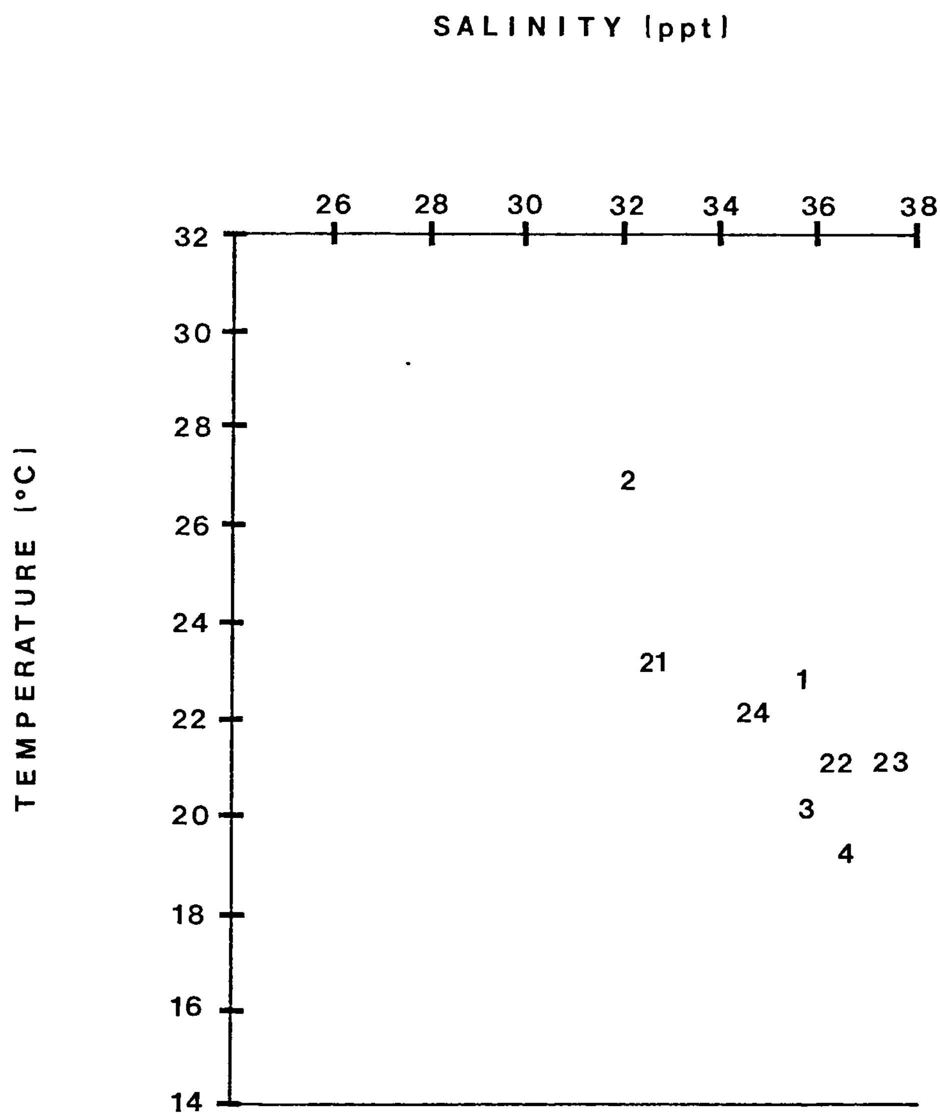
There are large seasonal variations in salinity, temperature, and dissolved oxygen on the Louisiana continental shelf. The shallow inshore stations show the greatest range in temperatures and the lowest salinities. Text-figs. 3-5 show the seasonal salinity and temperature data for 1977-1978 at the study sites for the bottom water measurements.

The same shallow inshore stations generally show the lowest dissolved oxygen measurements. Lowest overall dissolved oxygen was reported for the summer, although some stations had the lowest readings in the spring. The readings were highest over the entire area in the winter.

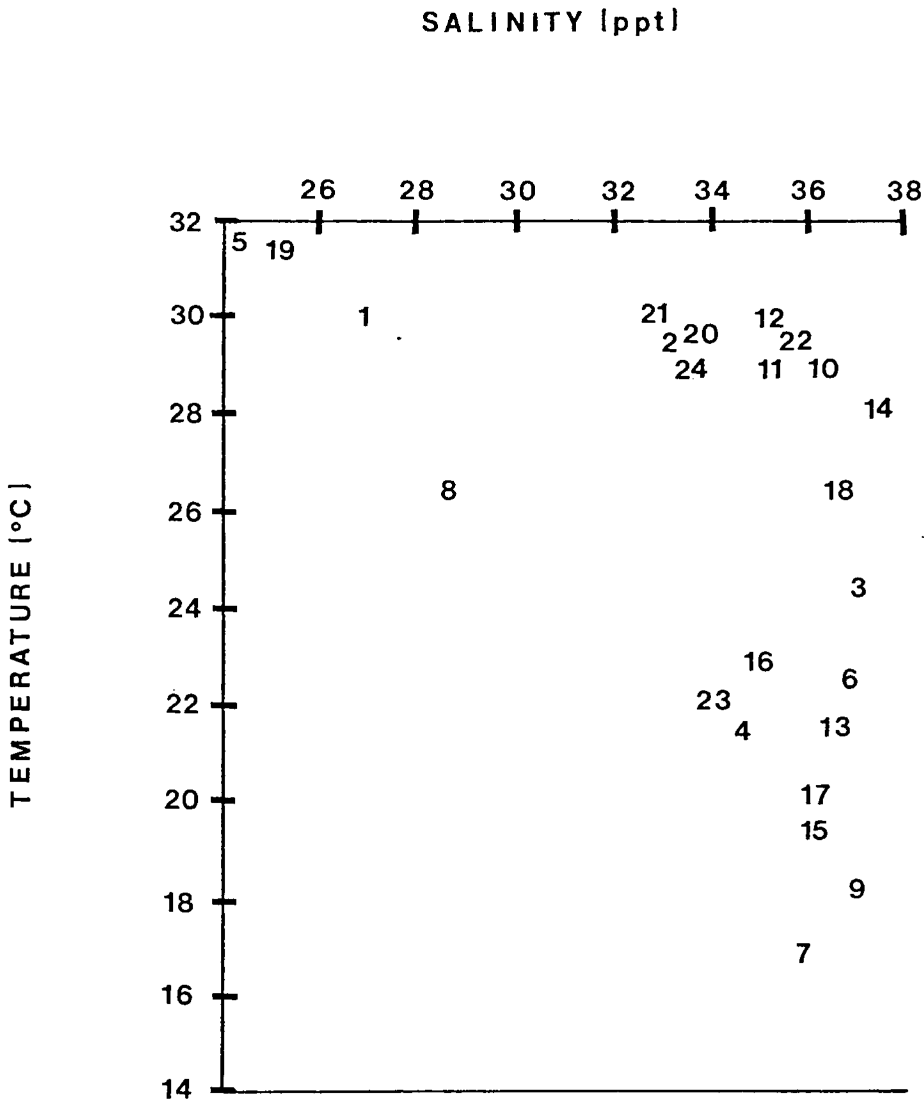
The amount of dissolved oxygen in the sea water is vital to the process of oxidation of organic matter. Because photosynthetic processes produce most of the dissolved oxygen, the upper water layers are the richest in oxygen. Marine water tends to be most oxygen-rich in the spring and early summer, coinciding with photosynthetic blooms and moderate water temperatures. The capacity of water to hold dissolved oxygen decreases with an increase in water temperature.

A significant problem was encountered during sampling on the summer cruise. Dead and dying organisms were found

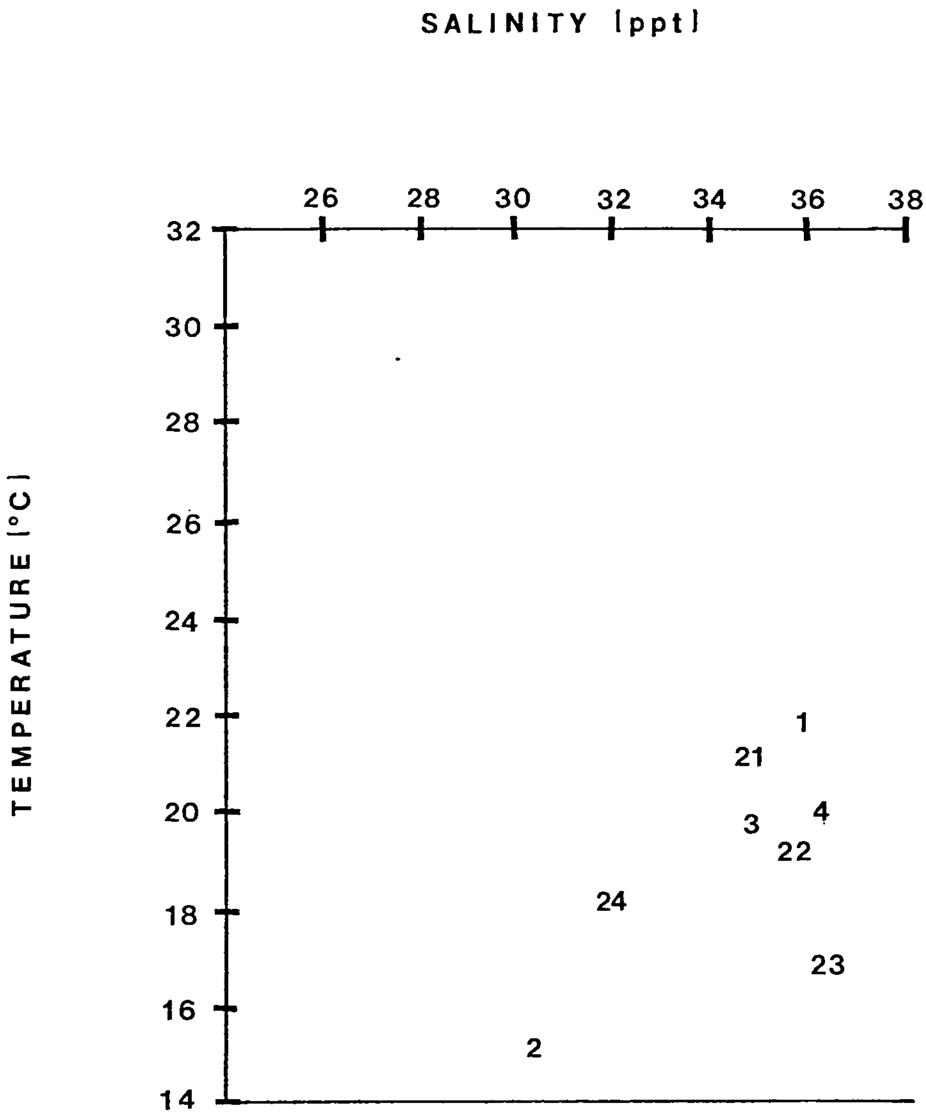
TEXT-FIG. 3--Salinity (parts per thousand) and temperature (°C) data for the spring collecting season, taken nearest the bottom along the north transect at each primary platform and control site.


SALINITY (ppt)
26 28 30 32 34 36 38
TEMPERATURE (°C)
32 30 28 26 24 22 20 18 16 14
2
21
1
24
22
23
3
4

TEXT-FIG. 4--Salinity (parts per thousand) and temperature (°C) data for the summer collecting season, taken nearest the bottom along the north transect at each primary and secondary platform and control site.


SALINITY (ppt)
26
28
30
32
34
36
38
32
30
28
26
24
22
20
18
16
14
TEMPERATURE (°C)
5
19
1
8
21
2
20
24
12
22
11
10
14
18
3
16
6
23
4
13
17
15
9
7

TEXT-FIG. 5--Salinity (parts per thousand) and temperature (°C) data for the winter collecting season, taken nearest the bottom along the north transect at each primary platform and control site.


SALINITY (ppt)
26
28
30
32
34
36
38
32
30
28
26
24
22
20
18
16
14
TEMPERATURE (°C)
1
21
3
4
22
24
23
2

over much of the nearshore Louisiana shelf, apparently caused by low dissolved oxygen (SwRI Second Quarterly Report, 1978). This condition was first noted at the inshore stations on the spring cruise. Live organisms were essentially absent at those stations which had experienced lowered dissolved oxygen for apparently the whole summer. This may have been an exceptional circumstance, as the cruise captain had not seen such conditions in over 20 years of shrimping.

Table 2 shows the seasonal dissolved oxygen measurements taken nearest the bottom along the north transect at each primary and secondary platform, and at each control site.

Sediments.

Sediment samples were also taken at each station during each cruise. Because the collecting sites covered by the BLM-SwRI study are under the influence of not only the Gulf of Mexico currents and tides, but also, to a varying degree, the Mississippi River, the sediment at most of the stations was observed to vary in its composition from one collecting season to the next.

Appendix A shows the seasonal mean sediment grain size at each collecting station at the primary and secondary platforms and control sites (SwRI Sediment Data, 1979).

TABLE 2--Seasonal dissolved oxygen measurements (ppm) taken nearest the bottom along the north transect at each primary and secondary platform, and at each control site.

SPRING

PO1	PO2	PO3	PO4	C21	C22	C23	C24
3.1	6.2	4.4	6.8	3.0	1.6	7.6	1.3

SUMMER

PO1	PO2	PO3	PO4	SO5	SO6	SO7	SO8
9.6	2.4	4.2	3.0	8.4	6.0	4.6	5.0
SO9	S10	S11	S12	S13	S14	S15	S16
4.4	6.3	6.0	4.4	5.0	6.0	4.2	2.7
S17	S18	S19	S20	C21	C22	C23	C24
5.0	6.6	6.2	6.1	2.4	6.0	4.6	6.2

WINTER

PO1	PO2	PO3	PO4	C21	C22	C23	C24
5.8	5.6	6.8	7.4	5.6	7.2	7.4	10.4

Total Organic Carbon.

The total organic carbon content of the sediments was measured for each collecting season (SwRI Total Organic Carbon Data, 1980) at all of the collecting stations. The finer-grained sediments in the study area have a higher percentage of total organic carbon content than the coarser-grained sediments.

The large quantities of organic detritus discharged by the Mississippi River (Lankford, 1959; Phleger, 1976) are incorporated in the sediments nearby, particularly during high water stages. The pH of the sediment varies inversely with the organic carbon and nitrogen content (Boltovskoy & Wright, 1976). The environmental processes that produce relatively coarse and well sorted sediment generally prevent large accumulations of detrital organic material.

Appendix A shows the seasonal total organic carbon content of the sediment in weight percent at the primary and secondary platform stations and at the control sites.

Trace Elements.

Trace metal content in surficial sediments was measured for barium, cadmium, chromium, copper, iron, lead, nickel, vanadium, and zinc in the spring at the primary platforms and control sites, and in the summer at the secondary platforms (SwRI Trace Metal Data, 1980). These are the trace elements commonly found associated with offshore petroleum production. The finer-grained sediments in the study area generally have a higher concentration of trace metal content than the coarser-grained sediments.

It is general knowledge that certain trace elements are necessary for the well-being of various organisms. However, the presence, absence, disequilibria, or interrelations of some of these trace elements in individual organisms can be harmful, resulting in retarded growth, abnormal physical development, and even death (Boltovskoy & Wright, 1976).

Trace metal values for the spring and summer collecting seasons are shown in Appendix A.

Previous Work

The foraminiferal faunas of the coast and northern continental shelf of the Gulf of Mexico have been well documented by previous workers. Kornfeld (1931) studied the recent littoral foraminifera from Texas and Louisiana; Phleger and Parker (1951) revised the nomenclature of northeastern Gulf of Mexico foraminifera; and Andersen (1961) documented the foraminifera from the Pleistocene age Mississippi River mudlumps. Many of the Pleistocene species are still living in the Gulf today.

Other studies of the foraminifera in the northern Gulf of Mexico have been ecologically oriented (Lowman, 1979; Phleger, 1951, 1954, 1955, 1960a, 1960b; Phleger and Parker, 1951; Parker, 1954; Bandy, 1954, 1956; Moore, 1957; Lankford, 1959; Lynts, 1962, 1965, 1966, 1971; Walton, 1964; Loep, 1965; Smith, 1971; Wright and Hay, 1971; Bock, 1974, 1976; Tresslar, 1974a, 1974b; Anepohl, 1976; and Hueni, 1979). These studies have shown foraminifera to be responsive to ecological factors such as temperature and salinity, water depth and distance from shore, nature of substrate, and dissolved oxygen.

The latest ecological studies have used foraminifera as indicators of pollution and environmental change. Foraminiferal response to municipal sewage outfall (Watkins, 1961; Bandy, Ingle and Resig, 1964a, 1964b, 1965a, 1965b; Lidz, 1965; Bartlett, 1972; Sieglie, 1975; Le Furgey and St. Jean, 1976; Bates, James & Spencer, 1979), industrial chemical effluents (Smith, 1971; Schafer and Cole, 1974; Schafer, Wagner and Ferguson, 1975; Buckley, Owens and Schafer, 1974), estuarine dredging and stream discharge modification (Wantland, 1964; Murray, 1970), aquaculture ponds (Clark, 1971; Le Furgey and St. Jean, 1976), and thermal pollution (Christiansen and Ellison, 1965; Sieglie, 1975) is well documented. A recent ecological study designed to assess the effects of the activities of the oil industry on foraminiferal distribution and abundance in Timbalier Bay, Louisiana, remains unpublished (Fish, Massey, Inabet and Lewis, 1974).

GENERAL CHARACTERISTICS OF FORAMINIFERAL POPULATION

Taxonomic Composition

A total of 673 foraminifera samples, yielding 64,326 live individuals, were examined for this paper. Of these, 544 samples were collected with the Smith-McIntyre grab for the purpose of sampling the microscopic benthic fauna. Forty-five species of foraminifera and a combined group of miliolid juveniles, representing 32 genera and 23 families, were found live in these samples and are used as the study material in this paper. An additional 93 foraminifera assemblages were found in samples collected with the Smith-McIntyre grab for the purpose of examining the benthic macrofauna (greater than 500μ) from the collecting stations. The foraminifera found in the latter samples are not included in the statistical part of this study. However, the six additional species are included in the systematics. Table 3 is a list of all of the foraminifera species found living in the BLM-SwRI study samples.

Appendix B contains the raw counts for each foraminifera species collected in the microfauna samples at each of the stations during the collecting seasons. Six species were found only in macrofauna samples, and only 7 species were found in both the microfauna and macrofauna samples.

TABLE 3--Foraminifera species found living in the BLM-SwRI study samples.

Lagenammina atlantica (Cushman, 1944)

Lagenammina diflugiformis (H. B. Brady, 1879)

Reophax scottii Chaster, 1892

Ammoscalaria pseudospiralis (Williamson, 1858)

Alveolophragmium sp.

Bigenerina irregularis Phleger & Parker, 1951

Textularia conica d'Orbigny, 1839

Textularia earlandi Parker, 1952

Textularia mexicana Cushman, 1922

Eggerella advena (Cushman, 1922)

Pyrgo nasuta Cushman, 1935

Pyrgo oblonga (d'Orbigny, 1839)

Quinqueloculina compta Cushman, 1947

Quinqueloculina lamarckina d'Orbigny, 1839

Quinqueloculina sabulosa Cushman, 1947

Quinqueloculina vulgaris d'Orbigny, 1826

Triloculina tricarinata d'Orbigny, 1826

Nodosaria fusta Cushman & Todd, 1945

Dentalina albatrossi (Cushman, 1923)

Lagena spicata Cushman & McCulloch, 1950

Lagena striata d'Orbigny, 1839

Lenticulina bowdenensis Cushman, 1919

Lenticulina calcar (Linnaeus, 1767)

TABLE 3--Continued.

Lenticulina iota Cushman, 1923

Lenticulina sp.

Marginulina obesa Cushman, 1923

Marginulinopsis marginulinoides Goes, 1896

Buliminella elegantissima (d'Orbigny, 1839)

Buliminella bassendorfensis Cushman & Parker, 1937

Bolivina lowmani Phleger & Parker, 1951

Bolivina ordinaria Phleger & Parker, 1952

Bolivina striatula Cushman, 1922

Bulimina marginata d'Orbigny, 1926

Uvigerina parvula Cushman, 1923

Trifarina bella (Phleger & Parker, 1951)

Cancris sagra (d'Orbigny, 1839)

Discorbis nitida (Williamson, 1858)

Rosalina floridensis Cushman, 1931

Eponides antillarum (d'Orbigny, 1839)

Epistominella vitrea Parker, 1953

Cibicides concentricus (Cushman, 1918)

Ammonia beccarii (Linne, 1758)

Elphidium gunteri Cole, 1931

Fursenkoina complanata (Egger, 1893)

Fursenkoina pontoni (Cushman, 1932)

Fursenkoina sp.

Virgulinella pertusa (Reuss, 1861)

TABLE 3--Continued.

Cassidulina crassa d'Orbigny, 1839

Florilus atlanticus (Cushman, 1947)

Nonionella basiloba Cushman & McCulloch, 1940

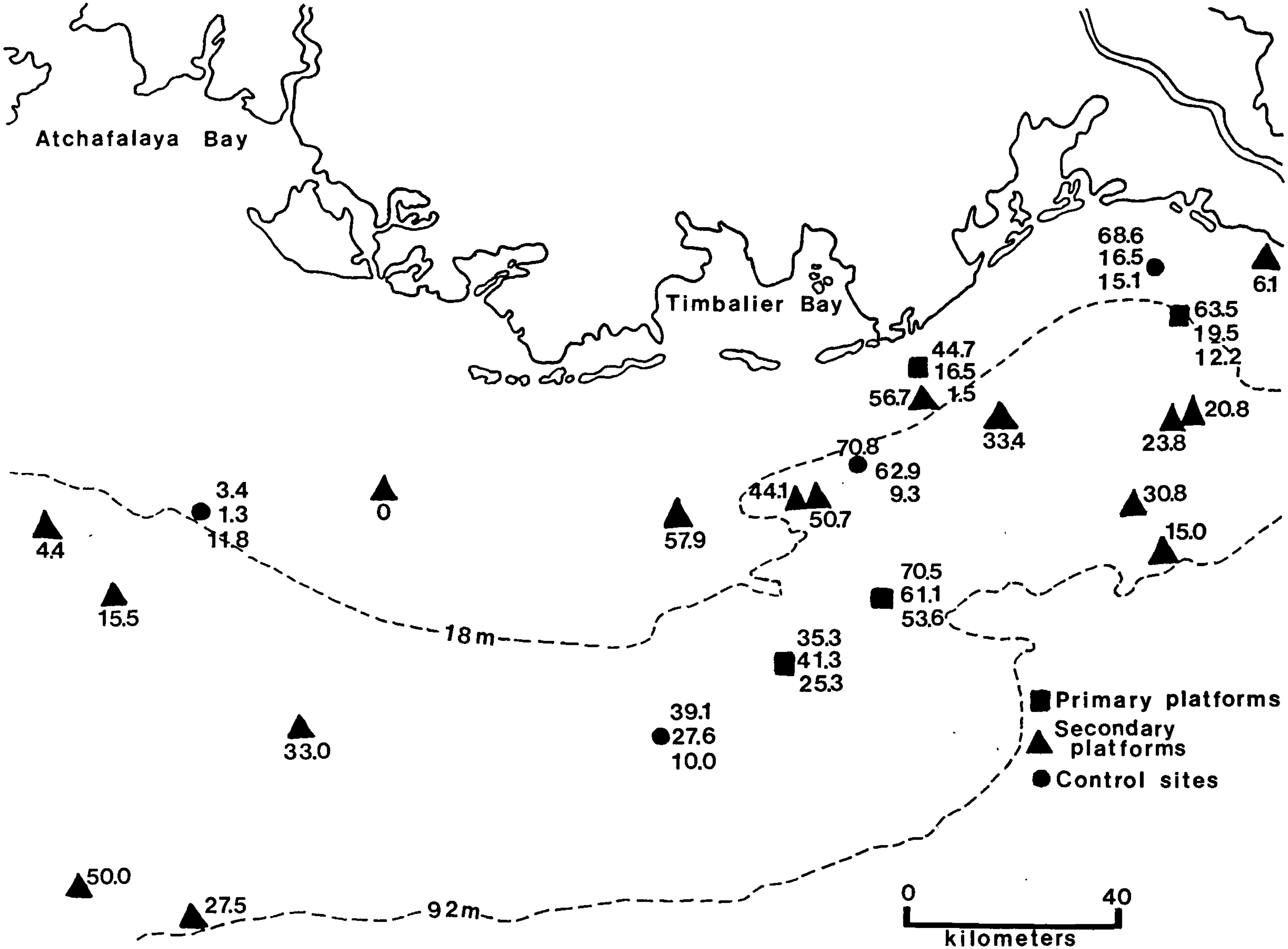
Melonis barleeanum (Williamson, 1858)

Appendix C is a list of raw counts for foraminifera species collected in the macrofauna samples during each of the collecting seasons. All the results discussed in this paper, except for the living/total ratio, are based on the living population data.

Of the 46 foraminiferal taxa used as the study material for this paper, two species, Nonionella basiloba and Buliminella bassendorfensis, account for almost 76 percent of the total live foraminiferal population. In addition, two other species, Bolivina lowmani and Fursenkoina complanata, each account for approximately 6 percent of the total live foraminiferal population. Text-figs. 6-9 show the distribution of these species at the collecting sites in percentage of total foraminiferal population. All other species comprise less than 5 percent of the total living foraminiferal population, and their distributions are not plotted.

The dominant foraminifera in the study area (Nonionella basiloba, Buliminella bassendorfensis, Bolivina lowmani) are representative of a typical inner shelf delta assemblage with high standing crops (Walton, 1964; Lankford, 1959; Lutze and Wolfe, 1976). Abundant foraminifera species were generally represented by high counts of juveniles, possibly coinciding with seasonal "blooms" of these species.

TEXT-FIG. 6--Distribution of Nonionella basiloba as a percentage of total live foraminiferal population. Upper percentage--spring. Middle percentage--summer. Lower percentage--winter. Single numbers at collecting sites are for summer.


Atchafalaya Bay
Timbalier Bay
68.6
16.5
15.1
6.1
63.5
19.5
12.2
44.7
16.5
1.5
56.7
33.4
23.8
20.8
70.8
62.9
9.3
44.1
50.7
30.8
15.0
3.4
1.3
11.8
4.4
0
57.9
15.5
70.5
61.1
53.6
18m
35.3
41.3
25.3
39.1
27.6
10.0
33.0
Primary platforms
Secondary platforms
Control sites
50.0
27.5
92m
0
40
kilometers

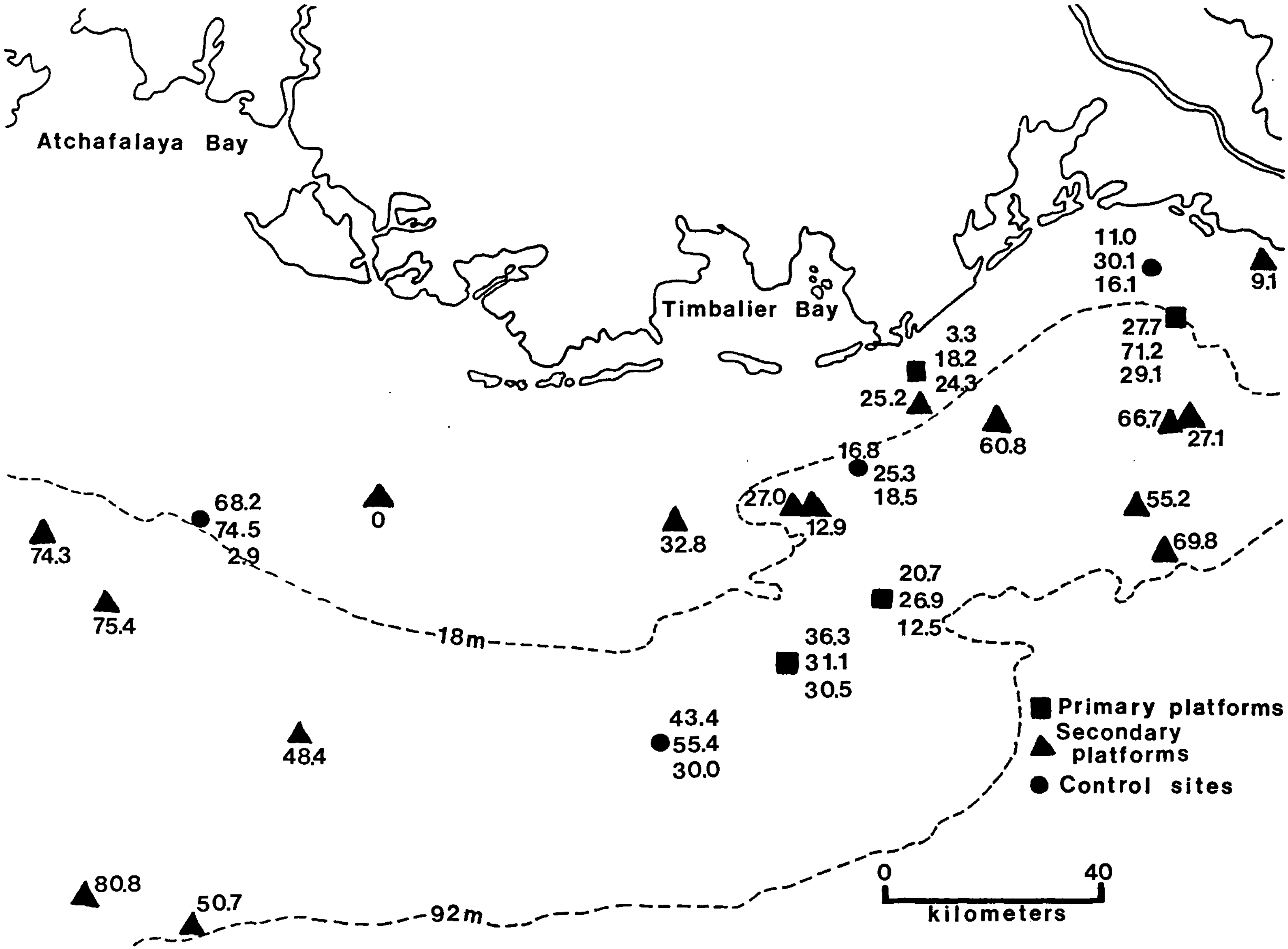
TEXT-FIG. 7--Distribution of *Buliminella bassendorfensis* as a percentage of total live foraminiferal population.

Upper percentage--spring.

Middle percentage--summer.

Lower percentage--winter.

Single numbers at collecting sites are for summer.


Atchafalaya Bay
Timbalier Bay
11.0
30.1
16.1
9.1
27.7
71.2
29.1
3.3
18.2
24.3
25.2
60.8
66.7
27.1
16.8
25.3
18.5
68.2
74.5
2.9
0
27.0
12.9
32.8
74.3
55.2
69.8
75.4
20.7
26.9
12.5
18m
36.3
31.1
30.5
43.4
55.4
30.0
48.4
Primary platforms
Secondary platforms
Control sites
0
40
kilometers
80.8
50.7
92m

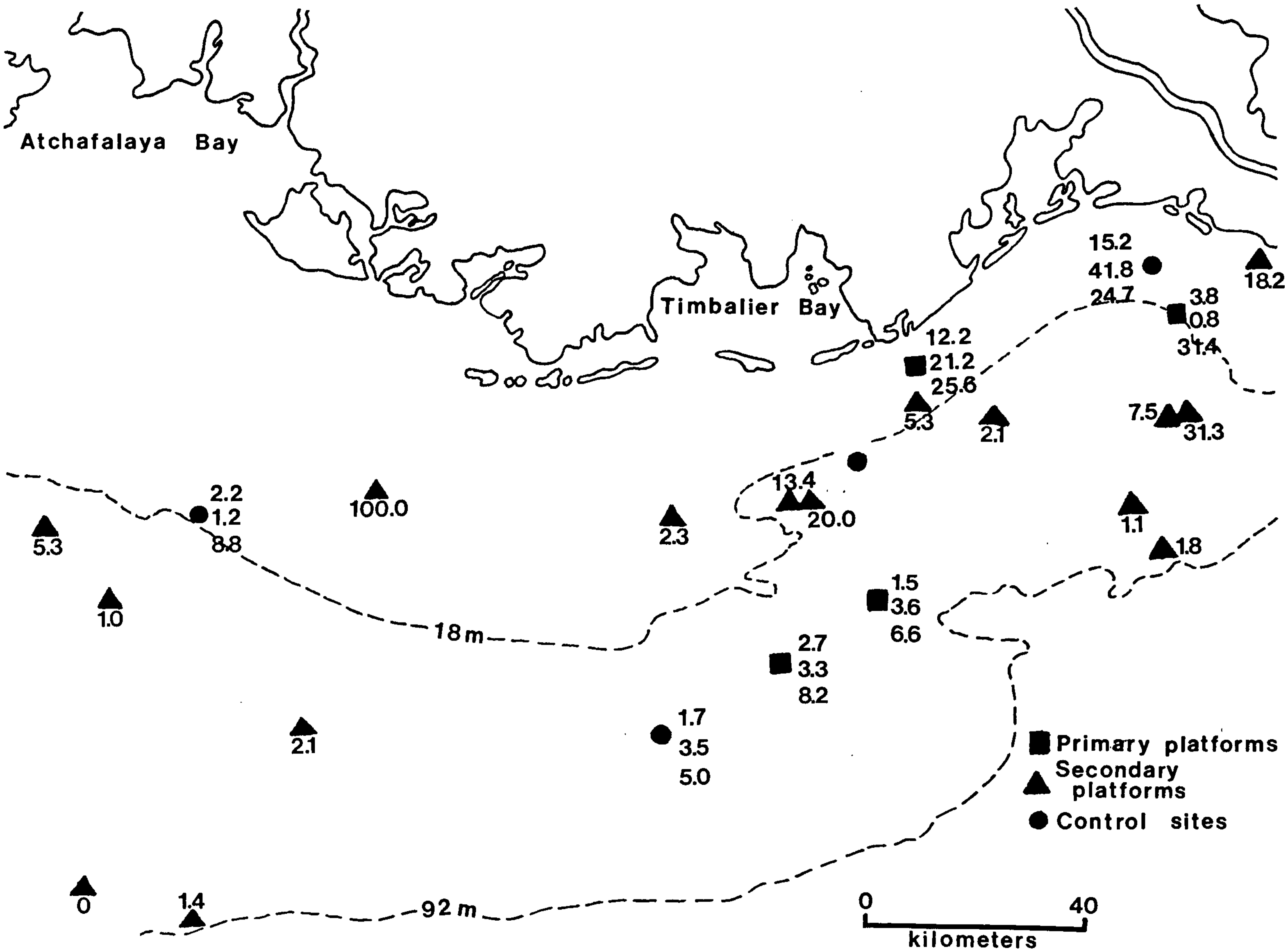
TEXT-FIG. 8--Distribution of *Bolivina lowmani* as a percentage of total live foraminiferal population.

Upper percentage--spring.

Middle percentage--summer.

Lower percentage--winter.

Single numbers at collecting sites are for summer.


Atchafalaya Bay
Timbalier Bay
15.2
41.8
24.7
18.2
3.8
0.8
31.4
12.2
21.2
25.6
5.3
2.1
7.5
31.3
13.4
20.0
2.2
1.2
8.8
100.0
2.3
5.3
1.1
1.8
1.0
1.5
3.6
6.6
18 m
2.7
3.3
8.2
2.1
1.7
3.5
5.0
Primary platforms
Secondary platforms
Control sites
0
1.4
92 m
0
40
kilometers

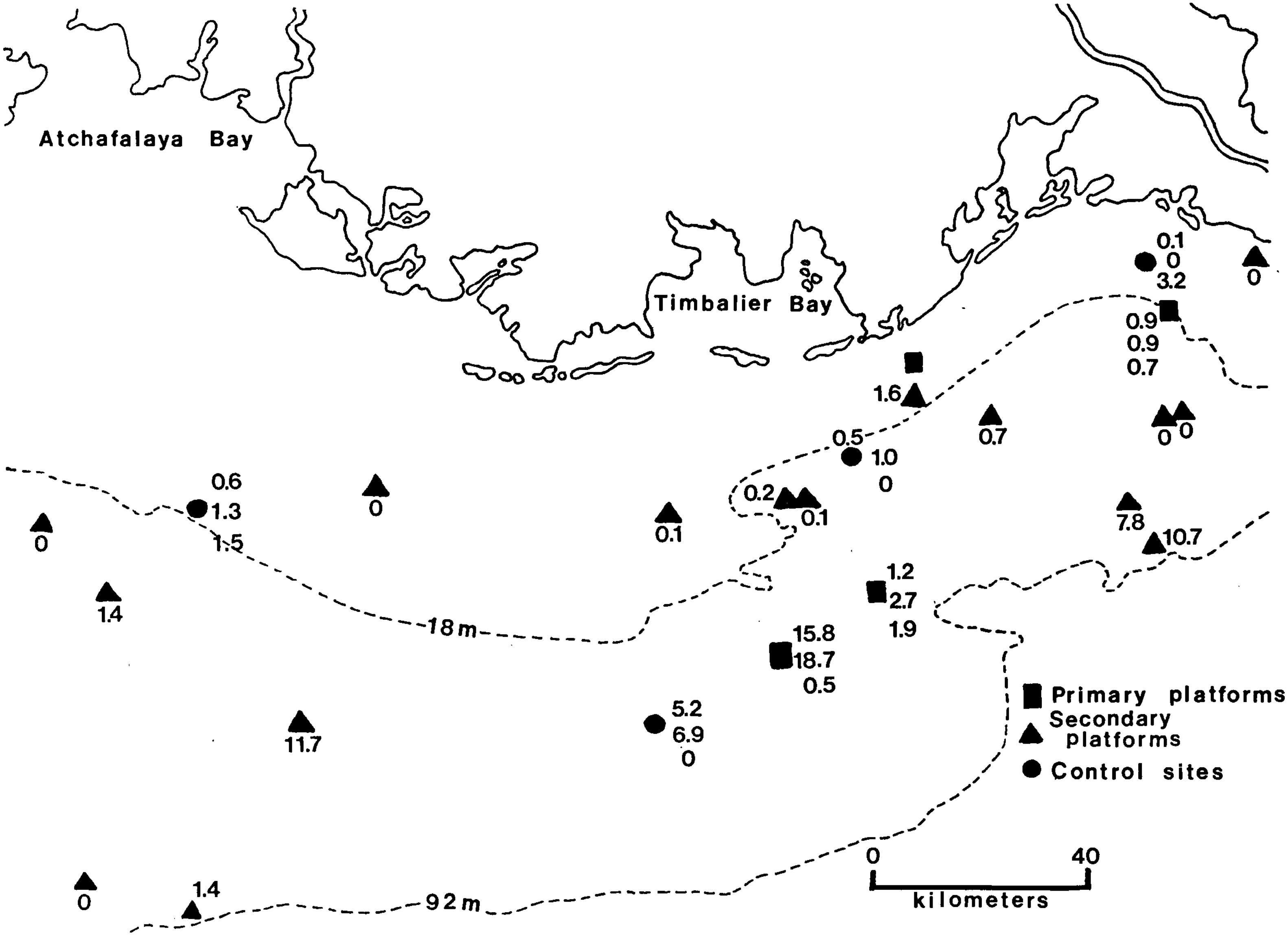
TEXT-FIG. 9--Distribution of _Fursenkoina complanata_ as a percentage of total live foraminiferal population.

Upper percentage--spring.

Middle percentage--summer.

Lower percentage--winter.

Single numbers at collecting sites are for summer.


Atchafalaya Bay
Timbalier Bay
18m
92m
0.1
0
3.2
0
0.9
0.9
0.7
1.6
0.7
0
0
0.5
1.0
0
0.6
1.3
1.5
0
0
0.1
0.2
0.1
7.8
10.7
1.4
1.2
2.7
1.9
15.8
18.7
0.5
5.2
6.9
0
11.7
0
1.4
Primary platforms
Secondary platforms
Control sites
0
40
kilometers

High juvenile counts for Nonionella basiloba and Bulimi- nella bassendorfensis were typical in the spring samples, although juveniles were present for all collecting seasons. The highest juvenile counts for Ammonia beccarii and Lagenammina atlantica occurred in the winter.

The adult foraminifera from the study area are small. Phleger (1976) noted that the average specimen size, particularly of the dominant species, is generally smaller in faunas with large populations than in those with low standing crops. This is because the specimens mature and reproduce rapidly under optimum conditions of abundant food and relatively pleasant physical surroundings. Lankford (1959), studying the foraminifera of the east Mississippi delta margins, found that Bolivina lowmani and Nonionella basiloba are about 20 percent smaller in zones of high production than in zones with lower standing crops.

Bradshaw (1957) found that when specimens of Ammonia beccarii were grown under conditions of abundant food and optimum temperature and salinity, they reproduced rapidly and individuals were relatively small. Specimens grown under marginal conditions grew more slowly and were larger in size than the others.

Two species found in the samples in relatively high numbers (Fursenkoina sp. and Lenticulina sp.) apparently have not been described and named in the foraminiferal literature for the Gulf of Mexico used for this paper. If a more thorough research of the foraminiferal literature shows that these two species indeed have not been previously described and do not have a valid name, then this will be done.

Juvenile Identification

Juvenile foraminifera of the dominant species (*Nonionella basiloba*, *Buliminella bassendorfensis*) in the samples were easy to identify. A size range of individuals with from 3 to 12 chambers was commonly present in most of the samples, and all the sizes between the 3-chambered juveniles and the 12-chambered adults were noted.

Identification of miliolid juveniles was difficult. The reasons for this are the quniqueloculine arrangement of the first chambers in the miliolid group and the occurrence of several miliolid species together in the samples. Two hundred and five specimens were unidentified and were grouped together for statistical purposes as miliolid juveniles.

Bigenerina irregularis juveniles also were hard to identify. These foraminifera are initially biserial and become uniserial when about half their adult size is reached. The biserial stage was first tentatively identified as a species of *Textularia*, until samples were found that contained both juvenile and adult stages and the transition could be noted.

No juveniles of *Eponides antillarum* were found in the samples. As it is unlikely that this species has no juveniles, alternative hypotheses must be considered. *Epistominella vitrea* may be the juvenile of *Eponides antillarum*. It is abundant in the spring, when specimens of *E. antillarum* are found mainly in the macrofauna samples, and it is virtually absent in the summer and winter, when specimens of *E. antillarum* are common in the microfauna samples but absent from macrofauna samples. However, as there are differences in the apertures of the two species, they may both be valid, and other reasons may be ncessary to explain the failure to find juvenile specimens of *Eponides antillarum*.

It was generally found that juvenile foraminifera are sufficiently like the adult forms for easy identification, when both stages are present in the samples. Large chambered species like *Fursenkoina pontoni* are easiest to identify.

Density

For the spring collections, a low of 2,858 individuals per 10 cm^2 was estimated at PO2 W500 and W2000, and a high of 309,382 individuals per 10 cm^2 was estimated at C22.

For the summer collections, a low of 124 individuals per 10 cm^2 was estimated at S13 N500 and S15 N500, and a high of 372,154 individuals per 10 cm^2 was estimated at PO4 S2000.

For the winter collections, a low of 994 individuals per 10 cm^2 was estimated at PO2 E500, and a high of 88,625 individuals per 10 cm^2 was estimated at PO3 E2000.

In the BLM South Atlantic Outer Continental Shelf project, Sen Gupta (1979) and Sen Gupta, Lee and May (1981) reported densities of 10 to 65,420 individuals per 10 cm^2. Matoba (1976) reported a high of 432 individuals per 10 cm^2 off the mouth of the Yoneshiro River in the Japan Sea.

In the Gulf of Mexico, Walton (1964) reported up to 1000 individuals per 10 cm^2 in shallow water (11-18 meters). Phleger (1955) found an average of 9,000 individuals per 10 cm^2 in the Mississippi delta. Lankford (1959) reported populations of 8,240 individuals per 10 cm^2 in the same area. Parker (1954) reported 206 individuals per 10 cm^2 in the northeastern Gulf of Mexico. In the BLM South Texas Outer Continental Shelf project, Anepohl (1976) reported densities of 435 individuals per 10 cm^2. Bock

(1974) reported densities up to 77,333 individuals per 10 cm^2 in the MAFLA area.

The densities reported in this study are much higher than generally reported. Sample preparation and processing appears to be partly responsible for the high population counts in the study area. The wet picking method preserves the tests of juveniles and delicate species that would be destroyed in the drying process.

The large standing crop of foraminifera on the southwestern Louisiana shelf is also partly caused by the presence of the Mississippi River nearby. Phleger (1976) stated that the principal factor governing the size of the standing crop of living foraminifera is the quantity of available food. Because there is a rich supply of nutrients and other trace materials associated with rivers transporting high sediment loads, large populations are found to occur on the shelf off the distributaries of the Mississippi.

Many of the most abundant species were represented by high counts of juveniles, possibly coinciding with a seasonal "bloom" of these foraminifera. Juveniles of *Nonionella basiloba* and *Buliminella bassendorfensis* were present in samples from all of the collecting seasons, although they were most numerous in the spring. Juveniles of Ammonia beccarii and Lagenammina atlantica were more abundant in the winter.

The low standing crops at PO2 for the spring and winter collections are apparently caused by rapid sedimentation rates and excessive turbidity (Galloway, 1978). PO2 is the shallowest of the primary study sites and is most affected by the westward movement of the sand and silt discharged by the Mississippi River. Frerichs (1969) observed a reduction in the benthonic foraminifera populations in areas of rapid sedimentation and high turbidity.

The low standing crops at the shallow inshore stations in the summer were probably caused by the low dissolved oxygen found over much of the area. The highest standing crops in the summer were generally found at the deeper water stations. PO4 had the highest estimated standing crop in the summer collecting season. These high standing crops at the deep water stations are probably caused by the relative stability of the physical conditions. At 45 meters water depth, PO4 would be the least affected of all the primary platforms and control sites by storm and current action, runoff, and temperature and salinity changes. Not enough information is available to explain the low standing crops at S15 (98 meters) and S13 (51 meters) for the summer collecting season.

High standing crops in the study area appear to follow seasonal trends. The highest standing crops occur in the spring and summer, when temperatures are high and ocean waters are warm, and the lowest standing crops occur in the winter when temperatures are low and ocean waters are colder.

Pathology

The condition of the foraminifera with regard to abnormalities that might indicate industrial and chemical pollution caused by oil drilling and production activities was noted throughout the study.

Several specimens of *Buliminella bassendorfensis* were noted to have two and three apertures in these samples. A single specimen of *Nonionella basiloba* with two apertures was also found. These abnormalities were probably caused by breakage of the apertural chamber. When the broken part of the last chamber is not healed, a second, and even third, aperture is created (Cushman & Jarvis, 1930; Ellison, 1953; Dhillon, 1969, 1970).

Several specimens of *Nonionella basiloba* and *Florilus atlanticus* with irregular chambers were found in the samples. Myers (1943) noted that chambers added in the summer are often larger than those formed during the winter, giving the test a somewhat irregular form. Any rapid change in the physio-chemical environment (such as salinity, nutrient supply, temperature, trace element concentration) may be reflected in the normal rate and nature of test growth. Some of the Cibicides concentricus individuals in the samples show test irregularities caused by attachment to a hard substrate (Boltovskoy & Wright, 1976).

A single twinned specimen of Ammonia beccarii was found in the samples. Twinned Globigerina specimens were previously observed by Earland (1933, 1934, 1936), who explained their origin as the result of plastogamy, and Boltovskoy (1966) and Boltovskoy & Boltovskoy (1970). Boltovskoy considered the plastogamy explanation unsatisfactory because of the size differences between the two participants and because the apertures were not in proximity with each other. Apparently the true origins of twinned tests are unknown.

Several specimens of Ammoscalaria pseudospiralis with turbellarian cocoons attached were found in the samples. Some deformation of the tests results, because the foraminifera enveloped the cocoons with new chambers. Turbellarian cocoons have been described as epibionts

(Boltovskoy, 1963) and parasites (Le Campion, 1970).

The small number of abnormal individuals found in the samples does not seem excessive, and it appears that most of these deformities can be explained by mechanical causes. *Buliminella bassendorfensis* seems susceptible to abrasion of the final chamber, and creation of new apertures is probably common in this species.

There are no apparent foraminiferal abnormalities caused by pollution from oil drilling and production activity in the study area.

Live/Total Ratios

The live/total ratios at the study sites are shown in Table 4. The ratios were highest in the spring, lower in the summer, and lowest in the winter. Both the highest and lowest ratios occurred at the secondary platforms. S10 had a live/total ratio of 0.390; S07, S13, S14, S15, S17, and S20 had no live foraminifera. The most abundant live specimens in the slides were the same species which occurred in large numbers in the wet samples (*Nonionella basiloba*, *Buliminella bassendorfensis*, *Bolivina lowmani*, and *Ammonia beccarii*). Generally, the live/total ratios fluctuate with the size of the standing crops at the primary platforms and control sites. The largest standing

TABLE 4. Live/total ratios of Foraminifera by site and collecting season.

	Live/Total Ratio			
Site	Spring	Summer	Winter	Average
PO1	0.070	0.004	0.003	0.026
PO2	0.144	0.167	0.000	0.104
PO3	0.270	0.082	0.034	0.129
PO4	0.275	0.196	0.078	0.183
SO5		0.032		
SO6		0.006		
SO7		0.000		
SO8		0.285		
SO9		0.017		
S10		0.390		
S11		0.067		
S12		0.211		
S13		0.000		
S14		0.000		
S15		0.000		
S16		0.103		
S17		0.000		
S18		0.000		
S19		-		
S20		0.000		
C21	0.330	-	0.067	
C22	0.190	-	0.054	
C23	0.080	0.101	0.008	
C24	0.208	0.203	0.024	

crop and live/total ratios at most of the study sites occurred in the spring at PO3 and PO4. Lower standing crops and live/total ratios were found in the summer at the primary platforms and control sites. Most stations had the lowest of all foraminifera standing crops and live/total ratios in the winter. PO4 had the highest live/total ratio of all primary platforms and control sites for the winter sampling season, although the ratio was lower than ratios for the spring and summer at PO4.

Commonly the live/total assemblages (300 specimens) contained fewer than 75 live foraminifera. It is believed the drying process destroys the shells of the juveniles, which are delicate, and which make up a large percentage of the specimens in the wet samples. Small tests are not abundant in the dead material in the assemblages, although they normally comprise a big percentage of the live population in the wet samples. In future studies estimating foraminifera densities using live/total ratios, data from wet samples apparently would be more accurate than that from dried samples.

Relict Faunas.

Some of the live/total slides contain dead species which have not been found alive in any of the material. The dead species include Reussella atlantica, Amphicoryna *roedereri*, *Rectobolivina advena*, *Lenticulina lowmani*, *Lenticulina* sp., *Bolivina simplex*, *B. mexicana*, *B. spinata*, *Globigerinoides rubra*, *Guttulina* sp., *Saracenaria* sp., *Textularia* spp., *Eponides* sp., *Lagena* sp., and *Globorotalia* spp. These species are not included in the systematics. Many of these species were identified by Andersen (1961) from mudlump islands off the mouth of the passes of the Mississippi River and may be eroding from previously deposited marine sediments and being redeposited as part of the sediment load of the Mississippi River. Storm tides may also be responsible for moving the empty foraminiferal tests into the area from deeper waters. An alternative explanation is that the species are living in the area but are extremely rare and no live specimens were found.

The dead species are distributed uniformly throughout the sampling area. They are not concentrated at any of the collecting sites.

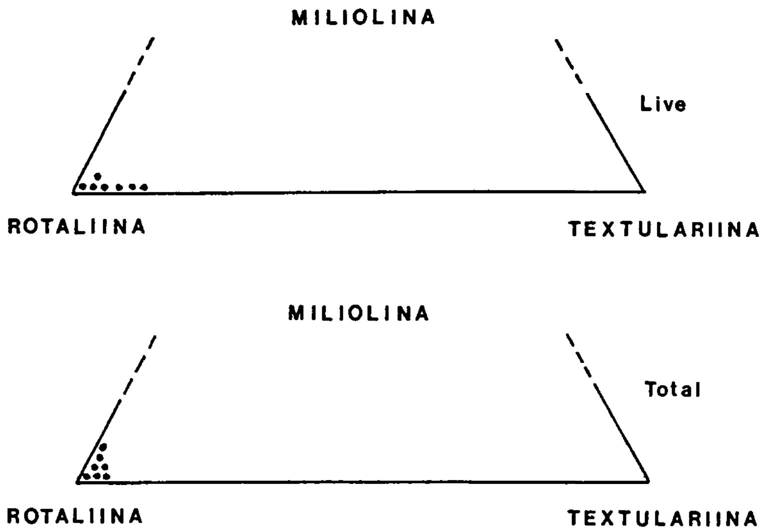
Skeletal Composition.

The skeletal composition plots for the live assemblages look like the composition plots for the dead assemblages (Text-fig. 10). The Rotaliina comprise 90-100 percent of the total assemblage in both sets of plots. Except for a few individuals of species that were not found living in

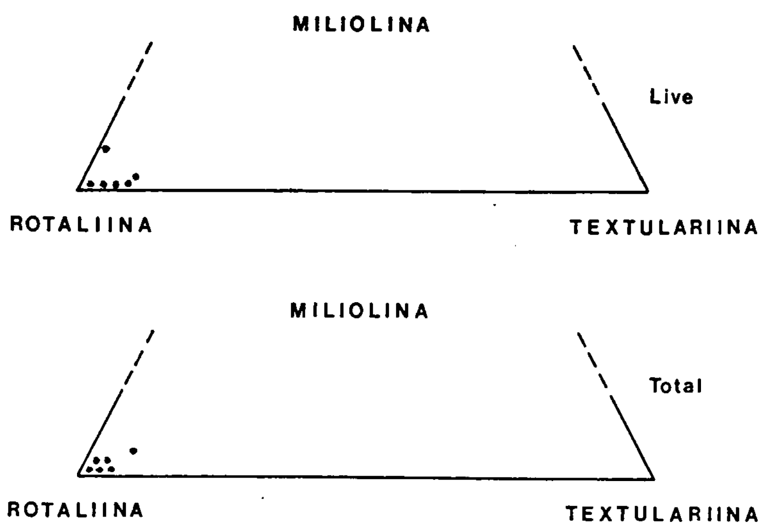
TEXT--FIG. 10--Triangular plots of percentages of rotaliid, miliolid, and textulariid foraminifera found in the wet samples and in the live/total slides from the N 500 3.D or C 3.D samples, all collecting seasons.

1. Primary Platforms and Control Sites, Spring.
2. Primary Platforms and Control Sites, Summer.
3. Primary Platforms and Control Sites, Winter.
4. Secondary Platforms, Summer.

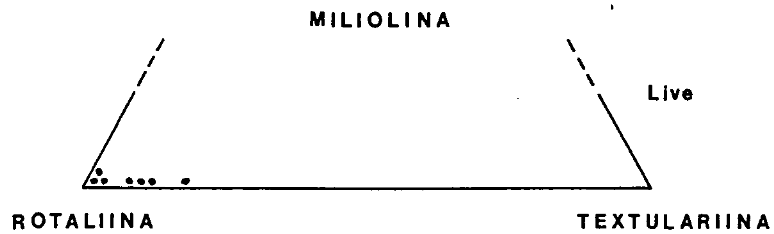
1. SPRING, PRIMARY AND CONTROL

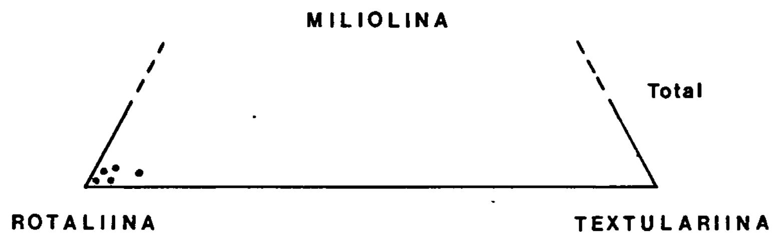


2. SUMMER, PRIMARY AND CONTROL

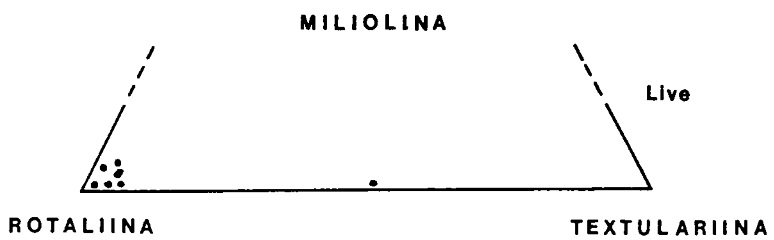


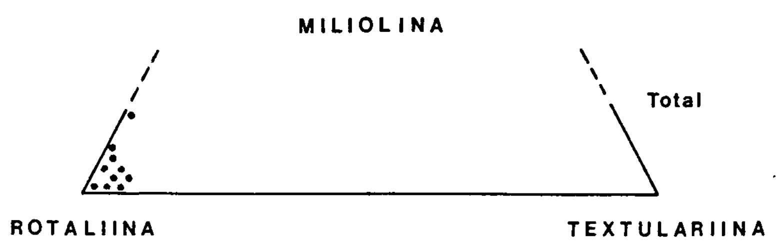
3. SUMMER, SECONDARY





4. WINTER, PRIMARY AND CONTROL





the area, the species composition is also the same. Significant post mortem changes, such as dissolution of the calcareous tests and transportation and mixing effects, were not noted.

The Rotaliina are the most abundant foraminiferal group in the study area. Nonionella basiloba, Buliminella bassendorfensis, and Bolivina lowmani are the dominant species at all of the primary platforms. However, each platform is characterized by a slightly different association of less abundant foraminifera species. Miliolina are absent at PO4, and only a few are found at PO1 and PO3. PO2 has a large number of Quinqueloculina vulgaris that accounts for greater than 10 percent of the total live population at most of the stations. PO2, the shallowest of the primary platforms, is also characterized by abundant Ammonia beccarii. Buliminella elegantissima and Bolivina striatula are common species at PO2. Although a variety of textulariine species occur at all of the primary platforms, except for Lagenammina atlantica, a common species, they are rare (less than 1 percent of the total live population). Another textulariine, Reophax scottii, was common at PO4 in the spring and summer samples. The deeper water primary platforms, PO3 and PO4, have large populations of

Cibicides concentricus, Epistominella vitrea, and Fursenkoina complanata that were not found in large numbers at the other primary platforms.

The control sites are more homogeneous in foraminifera species composition than the primary platforms. Nonionella basiloba was the dominant species at C21, C22, and C23. Buliminella bassendorfensis and Ammonia beccarii are dominant at C24. Bolivina lowmani is also a prominent species at C21 and C22. The miliolines are not an important group at any of the control sites. Although a variety of textulariine are found at all of the control sites, they are rare.

Nonionella basiloba and Buliminella bassendorfensis are the dominant species at all of the secondary platforms in the summer collecting season. In addition, Bolivina lowmani is abundant at S10 and S11, Fursenkoina complanata is abundant at S09, and Ammonia beccarii is abundant at S12. The other species found in the study area occur sporadically at the secondary platforms. Species not found in samples from any of the other stations were collected at the deep water secondary platforms S15 (98 meters) and S17 (75 meters). They are Lenticulina bowdenensis, Lenticulina calcar, Nodosaria fusta, and Dentalina albatrossi. These species are found only in the macrofauna samples (greater than 500μ). Because of their large size, they are not found in any of the microfauna samples from S15 and S17.

Large numbers of Textulariina, known to thrive in polluted areas (Bandy, Igle and Resig, 1964a, 1964b, 1965a, 1965b), are not present in the samples. There are no apparent negative effects of petroleum drilling and production activity on the skeletal makeup of the foraminiferal population in the study area.

Species Diversity and Equitability

Species diversity is the relationship of the number of species to the number of individuals in an assemblage and is recognized as a measure of environmental stability. Unstable environments are generally inhabited by a few species that occur in large numbers (Lankford, 1959; Walton, 1964; Gibson, 1966; Murray, 1971; Valentine, 1973; Lutze & Wolfe, 1976). If all assemblages contained the same number of individuals, the numbers of species could be compared directly. However, it is generally necessary to compare different sizes of assemblages. Diversity values for the foraminifera samples collected in this study have been determined by means of the Fisher alpha index (Fisher, Corbett & Williams, 1943). These values are given in Appendix D and summarized in Text-figs. 11-13.

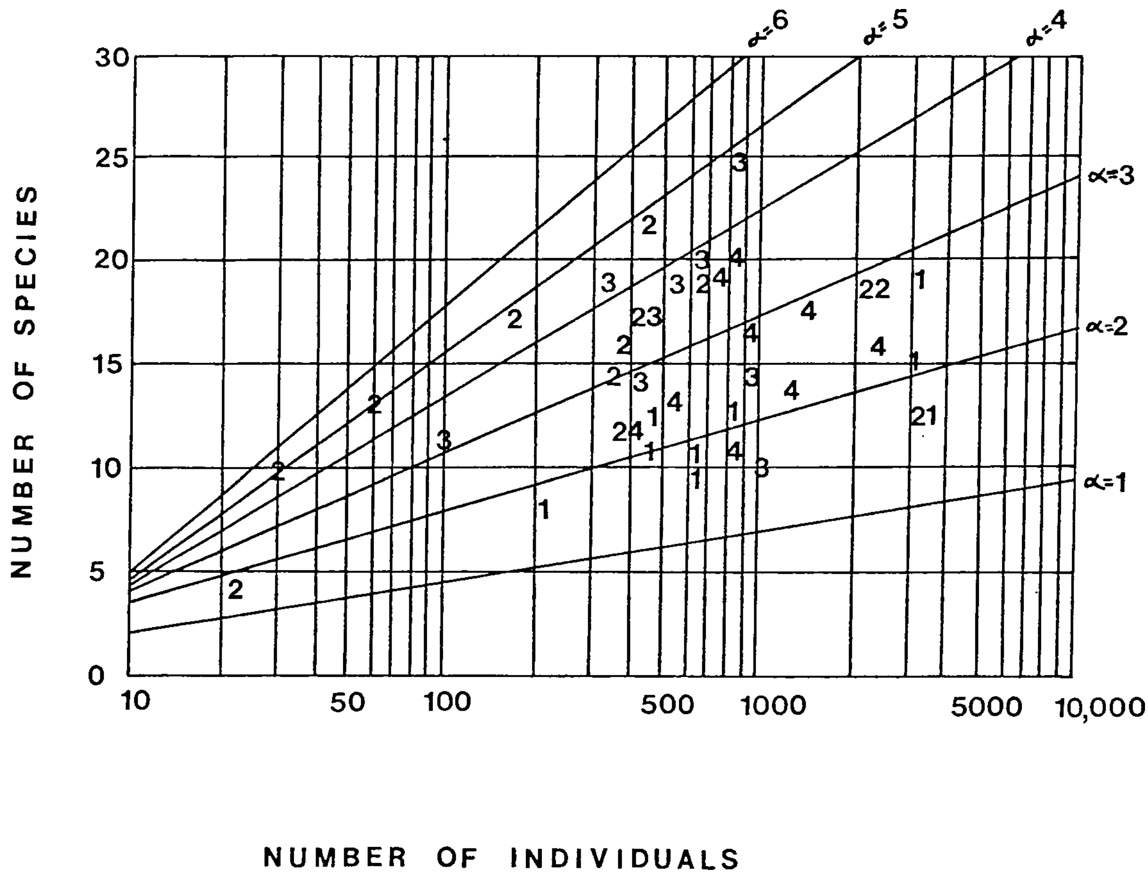
The expression for the Fisher alpha is $\alpha=\frac{n_1}{\chi}$, where χ is a constant having a value less than one (this can be read from fig. 25 of Williams, 1964), and n_1 can be calculated from $N(1 - \chi)$, N being the size of the population (Fisher, Corbett & Williams, 1943). Because curves have been plotted that allow diversity to be read directly when the number of species and the number of individuals is known, it is not necessary to calculate alpha for each sample.

Murray (1968, 1971, 1973, 1976, 1979) and Wright and Murray (1972) have effectively used the Fisher alpha index to describe populations of living foraminiera in many kinds of environments (lagoons and estuaries, tidal marshes, deltas, and open ocean).

The diversity values for the foraminiferal populations in the study area fall within the range of diversity found by Murray (1973, fig. 101) for nearshore shelf seas. The diversity values are low and generally do not exceed $\alpha=5$.

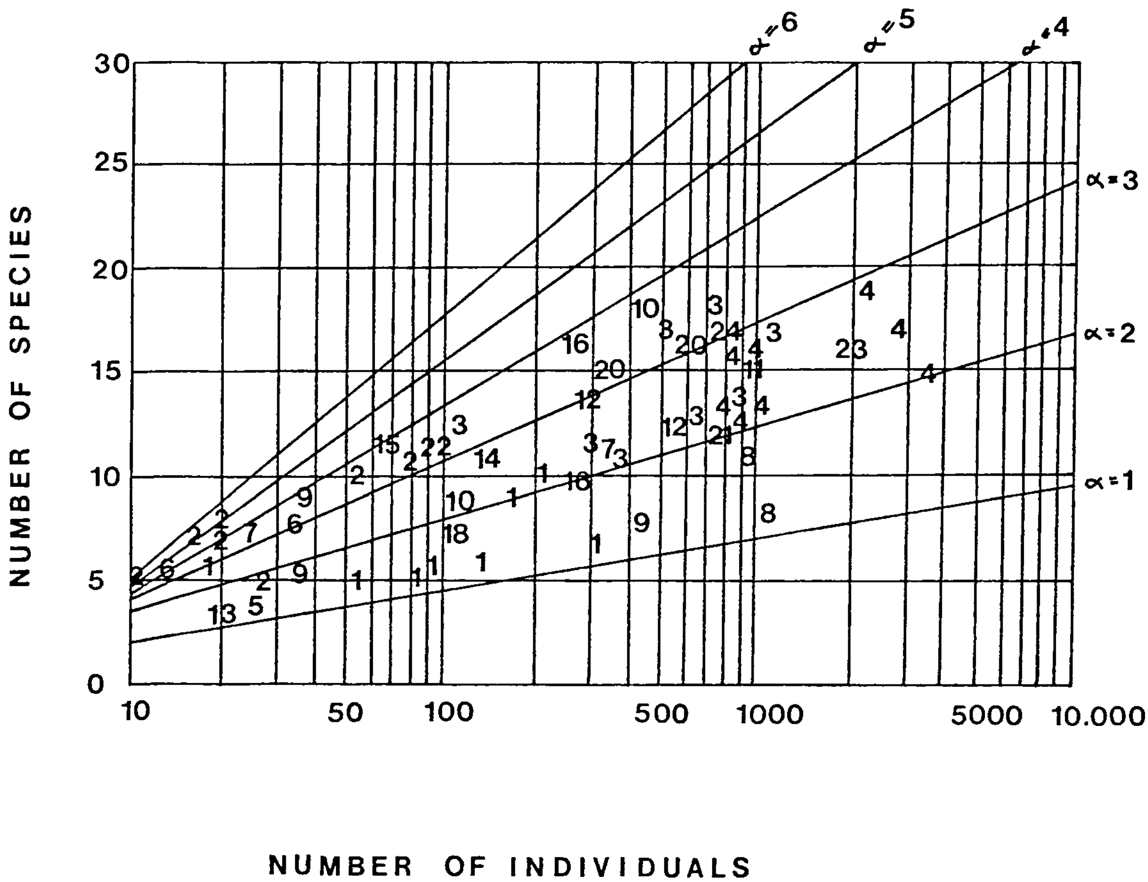
In general, in the spring and summer, stations at PO1 had the lowest diversity, and stations at PO2 had the highest diversity. In the winter, diversity was high at stations around PO3 and PO4 and at all control sites except

TEXT-FIG. 11--Fisher-Alpha diversity at all primary platforms and control sites for the spring collecting season.

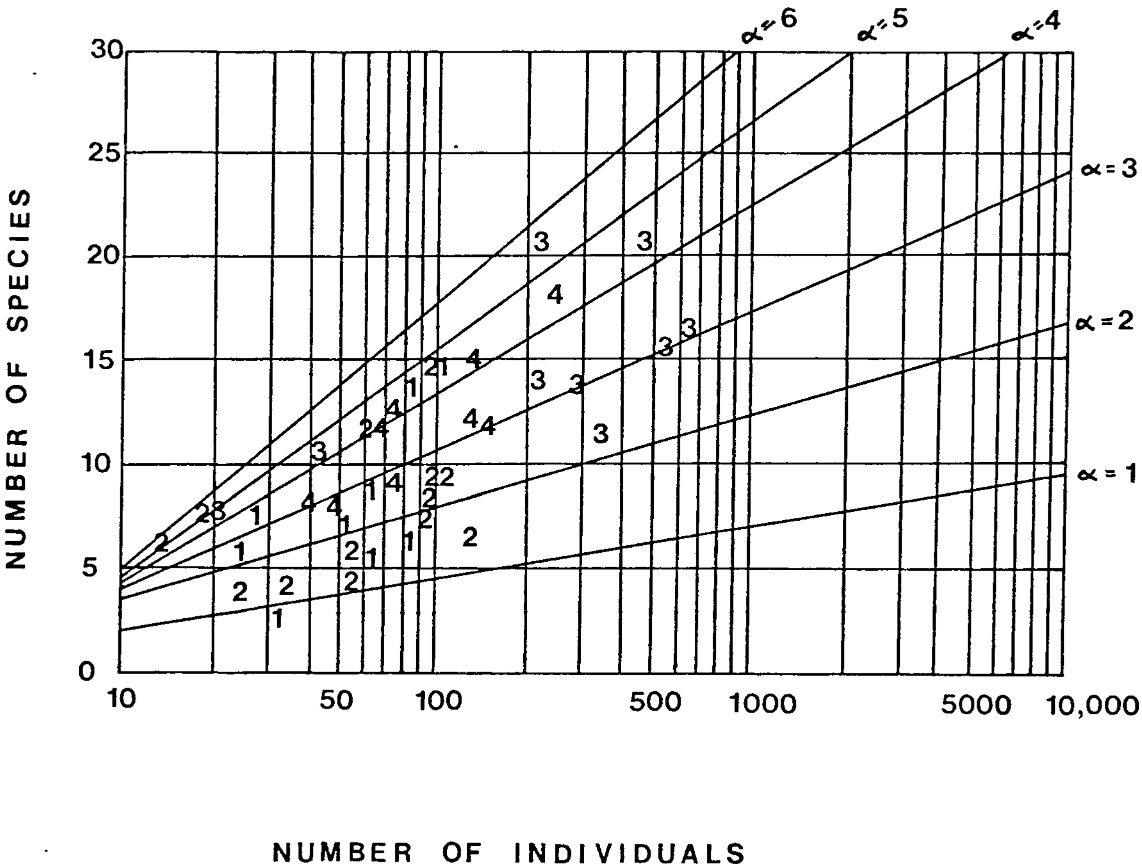


NUMBER OF SPECIES
NUMBER OF INDIVIDUALS
α=6
α=5
α=4
α=3
α=2
α=1
0
5
10
15
20
25
30
10
50
100
500
1000
5000
10,000

TEXT-FIG. 12--Fisher-Alpha diversity at all primary and secondary platforms and control sites for the summer collecting season.


NUMBER OF SPECIES
NUMBER OF INDIVIDUALS
α=6
α=5
α=4
α=3
α=2
α=1
0
5
10
15
20
25
30
10
50
100
500
1000
5000
10.000

TEXT-FIG. 13--Fisher Alpha diversity at all primary platforms and control sites for the winter collecting season.


NUMBER OF SPECIES
NUMBER OF INDIVIDUALS
α=6
α=5
α=4
α=3
α=2
α=1
0
5
10
15
20
25
30
10
50
100
500
1000
5000
10,000

C22. Diversity was low at PO1 and PO2 stations and at C22.

Both PO1 and PO2 are shallow inshore platforms. Although PO2 had lower standing crops than PO1, it has a miliolid fauna not found at PO1. The higher diversity of the deeper water platform stations in the winter is probably because the environmental conditions are somewhat more stable in the deeper waters than at the shallower platforms. Temperatures are colder at the inshore stations, and these stations would also be the most affected by sediment movement during winter storms. Fresh water runoff, which is more abundant in the winter, would also affect the shallower stations more than the deeper stations.

Species diversity is low over this entire area of the Louisiana shelf. In general, the low diversity is caused by the large range of seasonal temperatures, movement of sediment by currents and tides, and, to a lesser degree, the variations in salinity, and does not appear to be influenced by the petroleum drilling and production activity.

RESULTS OF STATISTICAL ANALYSES

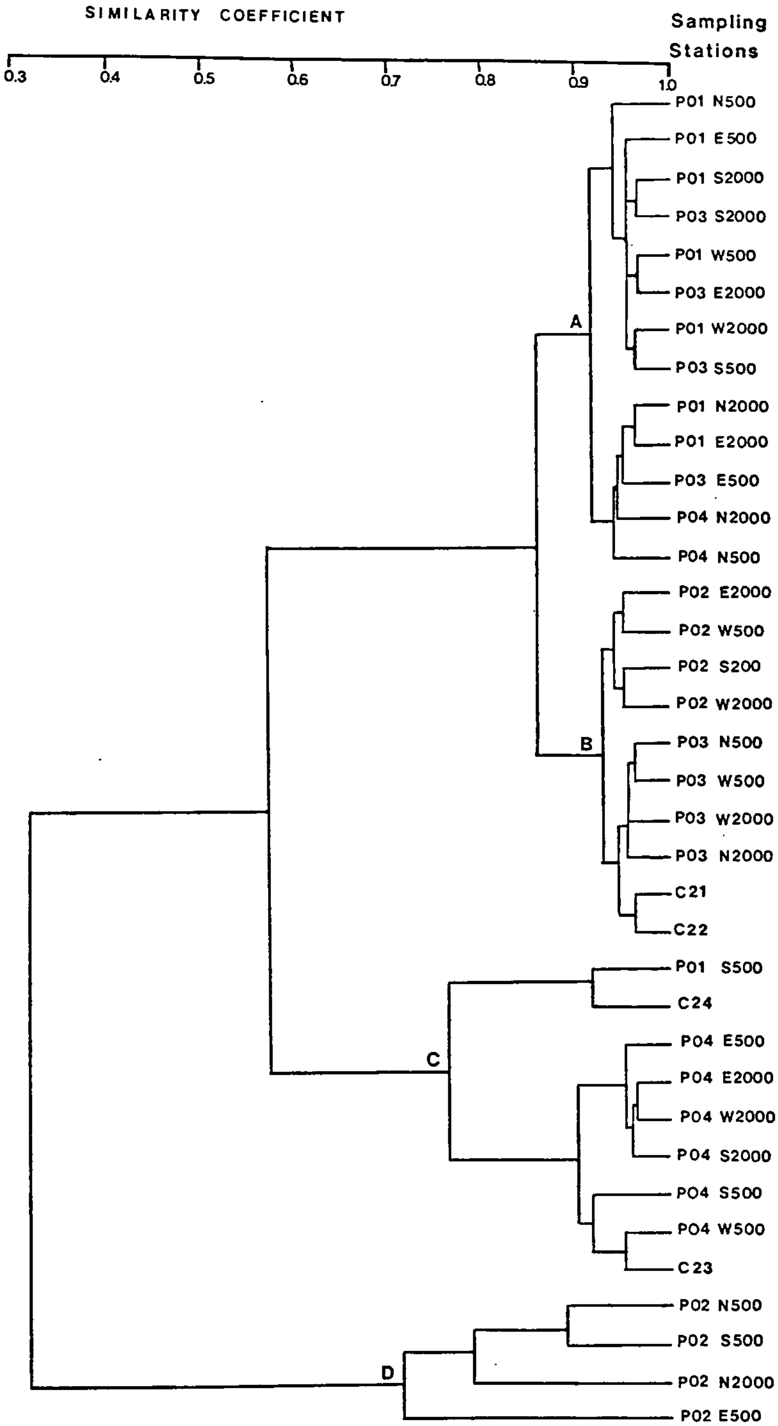
Cluster Analysis

The cluster dendrograms are in Text-figs. 14-17. Douglas (1972), Brasier (1975), Sen Gupta (1979), and Scott, Schafer and Medioli (1980) have successfully applied cluster analysis to foraminiferal problems.

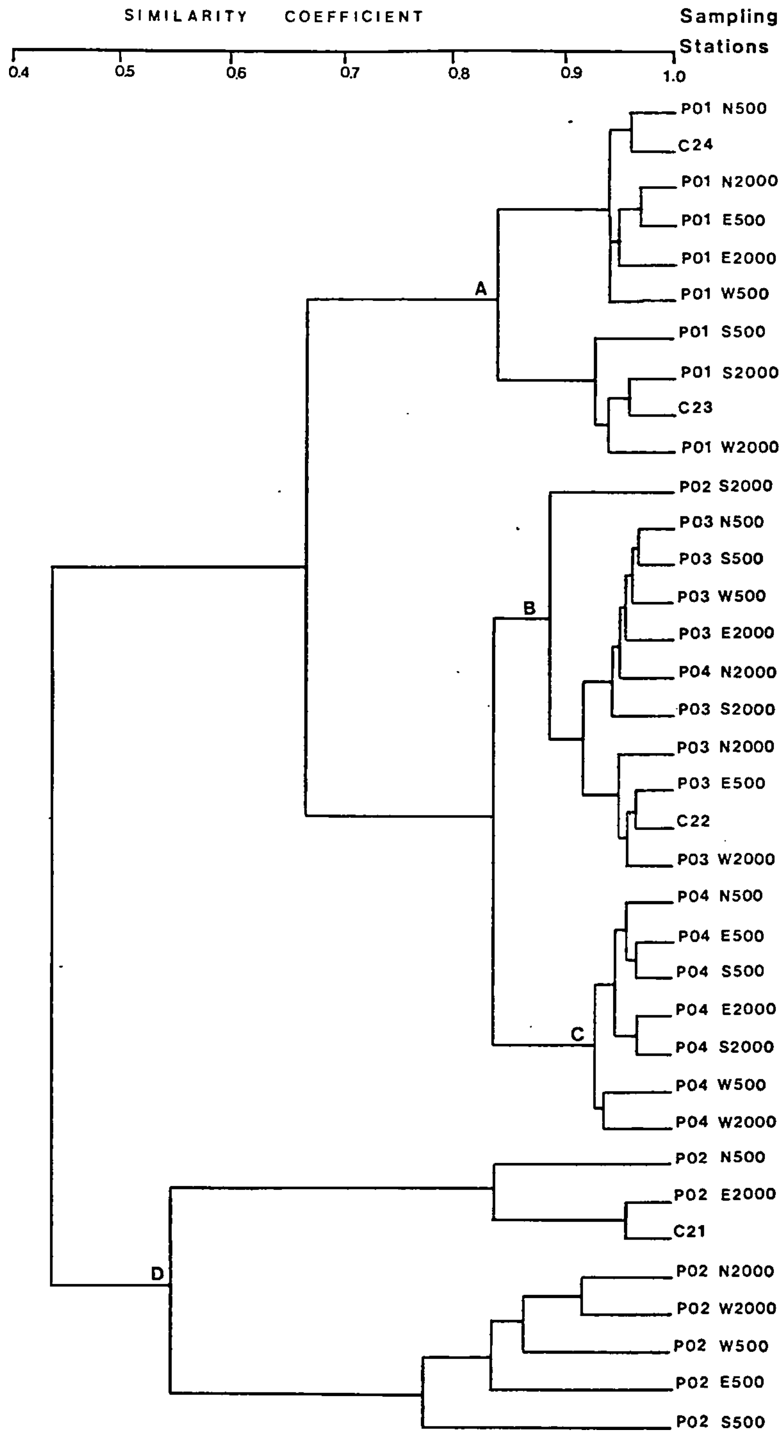
The entire foraminifera data set was used for the cluster analysis programs for each collecting season. At the 0.90 significance level, there is not much dissimilarity in the clustering levels of the stations in the study area. However, a depth gradient does exist in the area, and this is apparent in the small clusters of stations from the same platform within the larger cluster groups. Arbitrary cluster groups are identified by letters on the dendrograms, and these letters are then used to show the clusterings on the cluster distribution maps. The summer dendrogram for the primary platforms and control sites shows this clustering most clearly. When the secondary platform stations are included in the cluster for the summer, the secondary stations are interspersed among the primary stations.

The clustering of the control sites was somewhat different than expected. In the spring, C21 and C22 paired

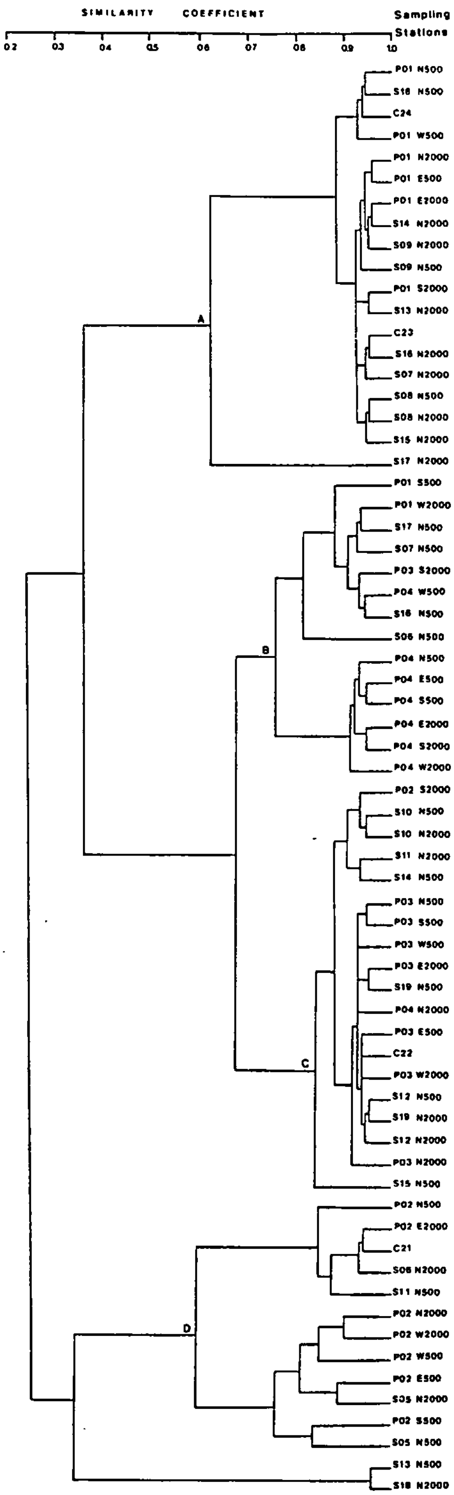
TEXT-FIG. 14--Results of Q-mode cluster analysis, primary platforms and control sites, spring. Arbitrary cluster groups are identified by letter symbols.


SIMILARITY COEFFICIENT
Sampling Stations
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
A
B
C
D
P01 N500
P01 E500
P01 S2000
P03 S2000
P01 W500
P03 E2000
P01 W2000
P03 S500
P01 N2000
P01 E2000
P03 E500
P04 N2000
P04 N500
P02 E2000
P02 W500
P02 S200
P02 W2000
P03 N500
P03 W500
P03 W2000
P03 N2000
C21
C22
P01 S500
C24
P04 E500
P04 E2000
P04 W2000
P04 S2000
P04 S500
P04 W500
C23
P02 N500
P02 S500
P02 N2000
P02 E500

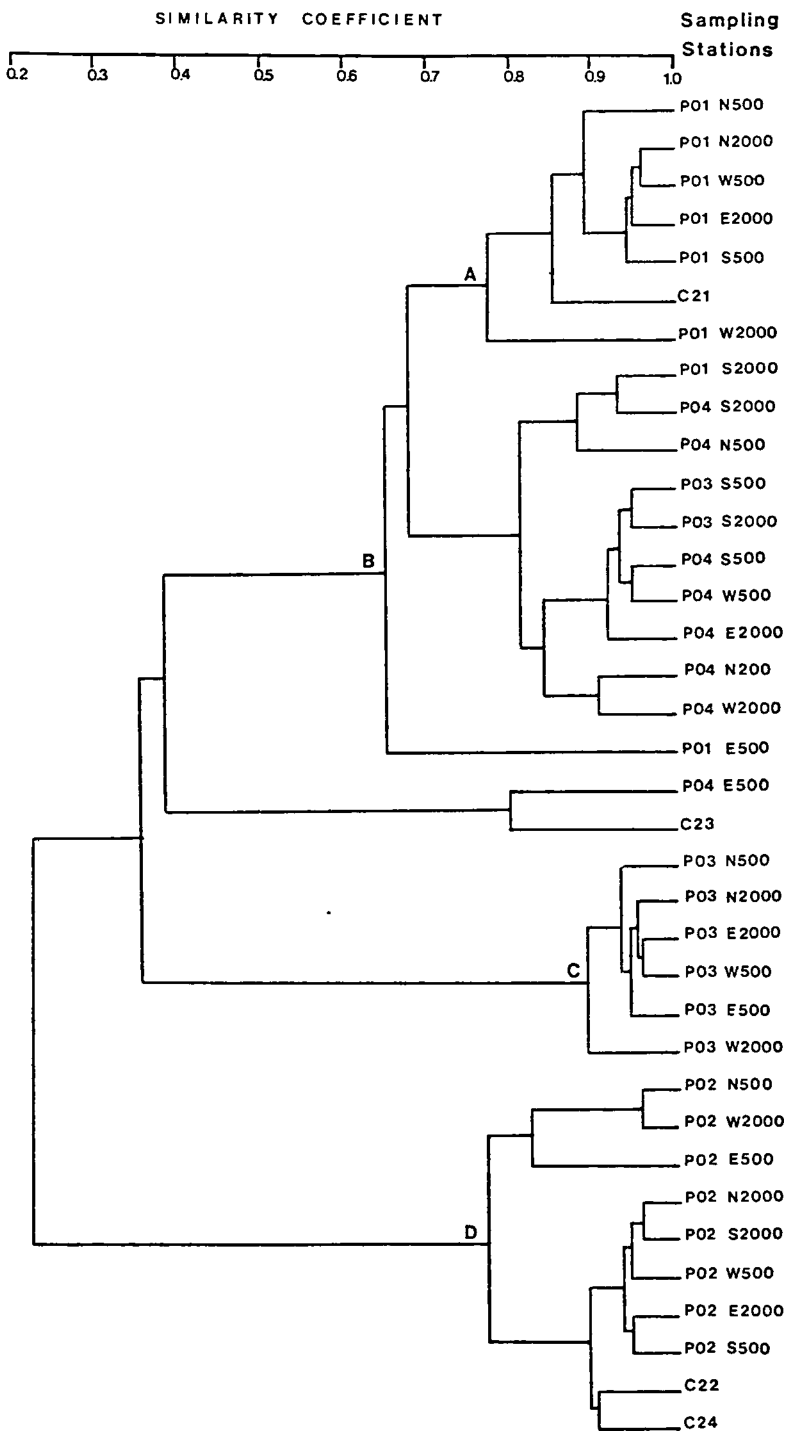
TEXT-FIG. 15--Results of Q-mode cluster analysis, primary platforms and control sites, summer. Arbitrary cluster groups are identified by letter symbols.


SIMILARITY COEFFICIENT
Sampling Stations
0.4
0.5
0.6
0.7
0.8
0.9
1.0
A
B
C
D
P01 N500
C24
P01 N2000
P01 E500
P01 E2000
P01 W500
P01 S500
P01 S2000
C23
P01 W2000
P02 S2000
P03 N500
P03 S500
P03 W500
P03 E2000
P04 N2000
P03 S2000
P03 N2000
P03 E500
C22
P03 W2000
P04 N500
P04 E500
P04 S500
P04 E2000
P04 S2000
P04 W500
P04 W2000
P02 N500
P02 E2000
C21
P02 N2000
P02 W2000
P02 W500
P02 E500
P02 S500

TEXT-FIG. 16--Results of Q-mode cluster analysis, primary and secondary platforms and control sites, summer. Arbitrary cluster groups are identified by letter symbols.


SIMILARITY COEFFICIENT
Sampling Stations
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
A
B
C
D
P01 N500
S16 N500
C24
P01 W500
P01 N2000
P01 E500
P01 E2000
S14 N2000
S09 N2000
S09 N500
P01 S2000
S13 N2000
C23
S16 N2000
S07 N2000
S08 N500
S08 N2000
S15 N2000
S17 N2000
P01 S500
P01 W2000
S17 N500
S07 N500
P03 S2000
P04 W500
S18 N500
S06 N500
P04 N500
P04 E500
P04 S500
P04 E2000
P04 S2000
P04 W2000
P02 S2000
S10 N500
S10 N2000
S11 N2000
S14 N500
P03 N500
P03 S500
P03 W500
P03 E2000
S19 N500
P04 N2000
P03 E500
C22
P03 W2000
S12 N500
S19 N2000
S12 N2000
P03 N2000
S15 N500
P02 N500
P02 E2000
C21
S06 N2000
S11 N500
P02 N2000
P02 W2000
P02 W500
P02 E500
S05 N2000
P02 S500
S05 N500
S13 N500
S18 N2000

TEXT-FIG. 17--Results of Q-mode cluster analysis, primary platforms and control sites, winter. Arbitrary cluster groups are identified by letter symbols.


SIMILARITY COEFFICIENT
Sampling Stations
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
P01 N500
P01 N2000
P01 W500
P01 E2000
P01 S500
C21
P01 W2000
P01 S2000
P04 S2000
P04 N500
P03 S500
P03 S2000
P04 S500
P04 W500
P04 E2000
P04 N200
P04 W2000
P01 E500
P04 E500
C23
P03 N500
P03 N2000
P03 E2000
P03 W500
P03 E500
P03 W2000
P02 N500
P02 W2000
P02 E500
P02 N2000
P02 S2000
P02 W500
P02 E2000
P02 S500
C22
C24
A
B
C
D

together and were included in a cluster of PO3 stations. C23 paired, as was anticipated, with a station from PO4. However, C24 paired with a station from PO1. In the summer dendrogram for the primary platforms and control sites, both C24 and C23 paired with stations from PO1, C21 paired with a station from PO2 and C22 paired with a station from PO3. In the fall, C22 and C24 were most similar to each other, C21 was most similar to stations from PO1, and C23 paired with a station from PO4.

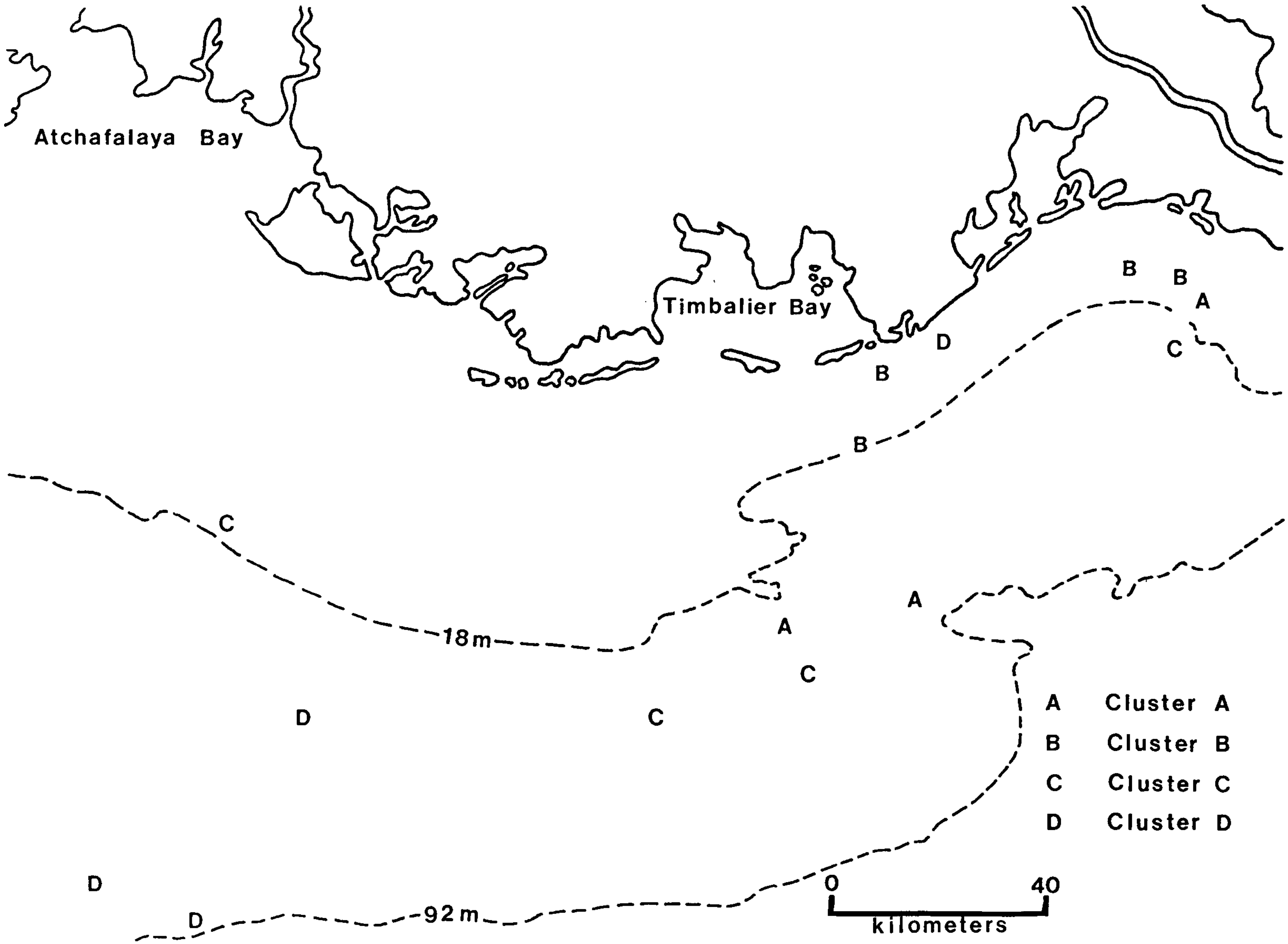
Text-figs. 18-21 show the distribution of the major clusters. As many workers have found, water depth appears to be a major factor in foraminiferal species distribution in the study area.

Analysis of Variance

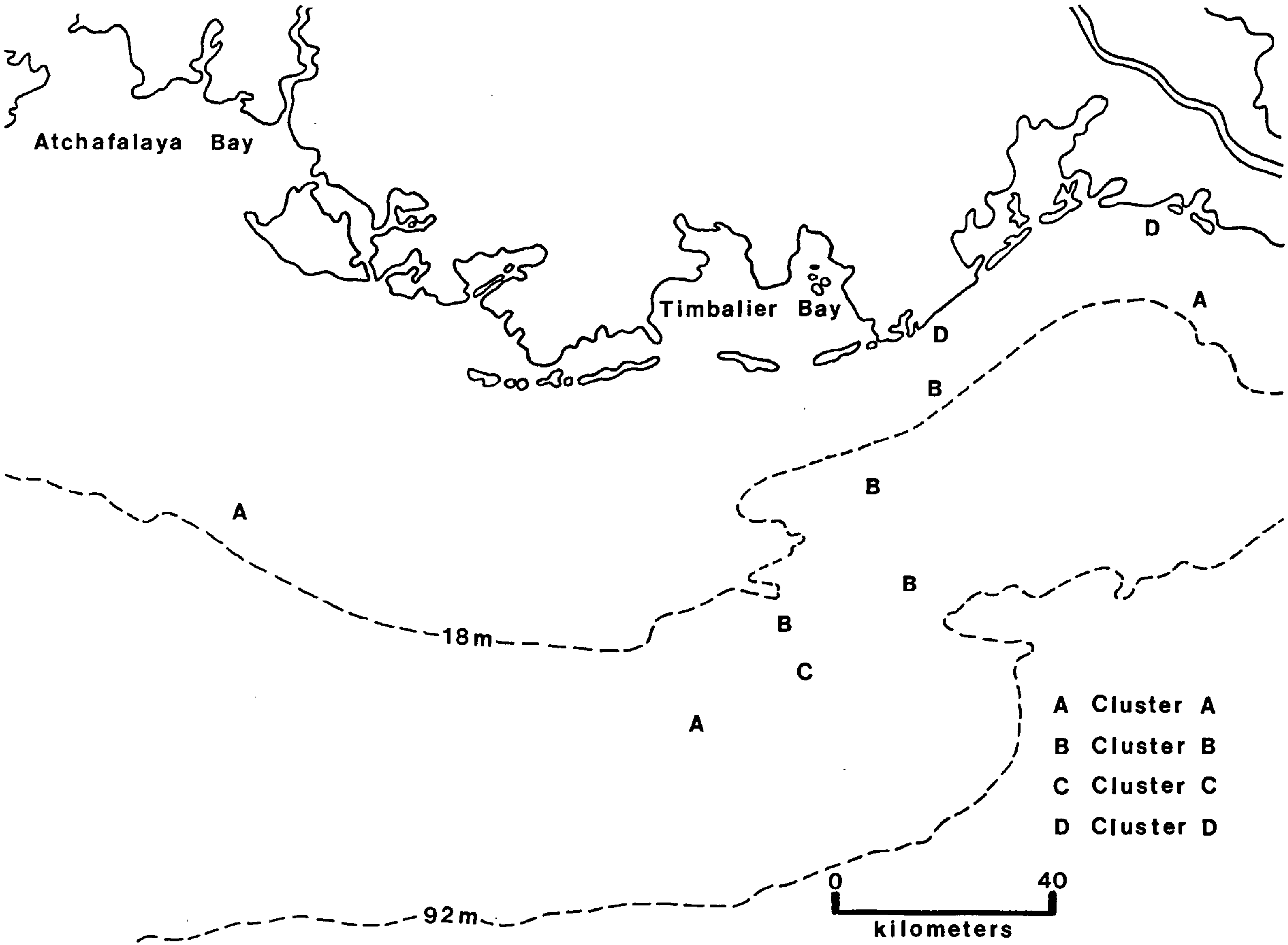
Two-way ANOVA tests were performed on numbers of individuals of species compared with seasons, and on numbers of observations for each species compared with seasons. Some significant difference was found for both of these tests at the 0.05 percent level. The results are reported in Appendix E.

One-way ANOVA tests were performed on replicate samples at collecting stations for each species for each collecting season. It was found that there was a greater

TEST-FIG. 18--Distribution of station clusters, primary platforms and control sites, spring. Clusters A, B, C, and D identify arbitrary cluster groups as shown on the spring cluster dendrogram.

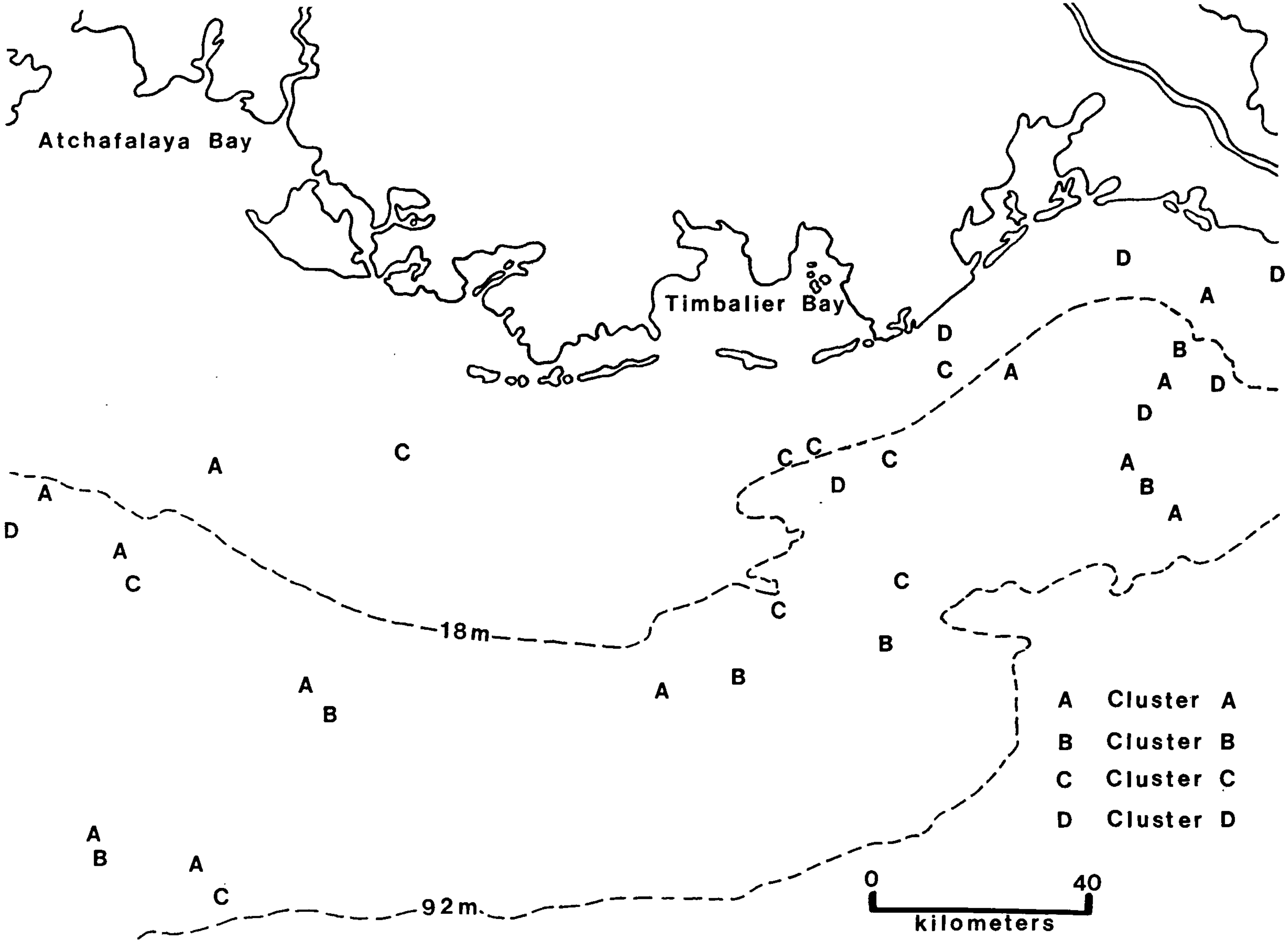

Atchafalaya Bay
Timbalier Bay
B
B
A
D
C
B
B
C
18m
A
A
C
D
C
D
D
92m
0
40
kilometers
A Cluster A
B Cluster B
C Cluster C
D Cluster D

TEXT-FIG. 19--Distribution of station clusters, primary platforms and control sites, summer. Clusters A, B, C, and D identify arbitrary cluster groups as shown on the summer dendrogram.

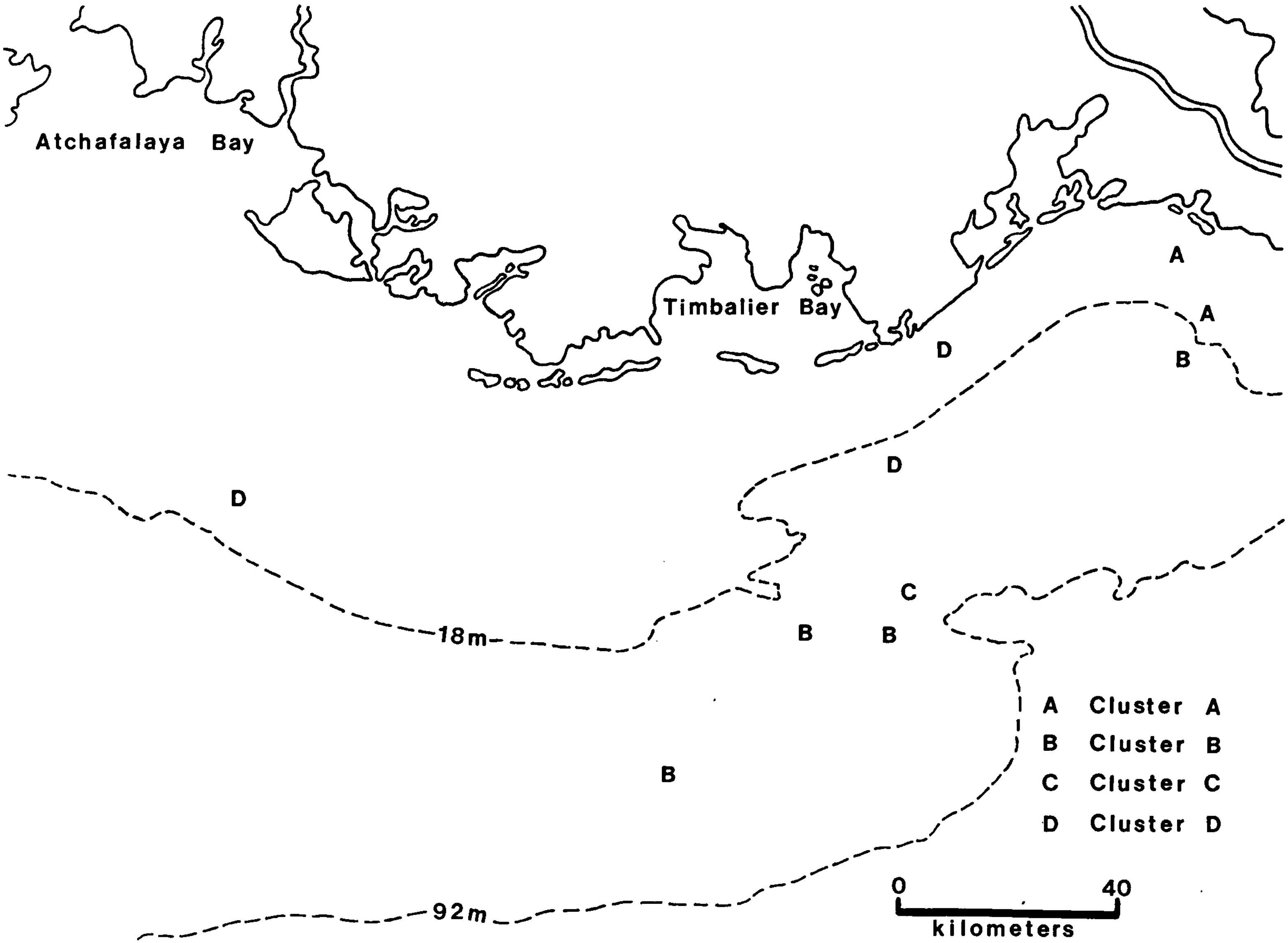


Atchafalaya Bay
Timbalier Bay
A
B
C
D
18m
92m
A Cluster A
B Cluster B
C Cluster C
D Cluster D
0
40
kilometers

TEXT--FIG. 20--Distribution of station clusters, primary platforms, secondary platforms, and control sites, summer. Clusters A, B, C, and D identify arbitrary cluster groups as shown on the summer dendrogram.


Atchafalaya Bay
Timbalier Bay
18m
92m.
0
40
kilometers
A Cluster A
B Cluster B
C Cluster C
D Cluster D

TEXT-FIG. 21--Distribution of station clusters, primary platforms and control sites, winter. Clusters A, B, C, and D identify arbitrary cluster groups as shown on the winter dendrogram.


Atchafalaya Bay
Timbalier Bay
A
A
B
D
D
D
C
B
B
B
18m
92m
A Cluster A
B Cluster B
C Cluster C
D Cluster D
0
40
kilometers

variation among the stations than there was within the replicate samples when the species occurred at a large proportion of the collecting stations. When the species occurred at only a few stations, but in many of the replicate samples, there was a greater variation within the replicate samples than among the stations. The results of the ANOVA tests for each significant species are found in Appendix E.

As shown by the two-way ANOVA tests, there is some seasonal variation in the foraminifera population in the study area. Although population counts are lowest in the winter, the composition of the fauna does not change markedly. *Nonionella basiloba* and *Buliminella bassendorfensis* continue to be the dominant species in the samples in every collecting season. However, *Ammonia beccarii* and *Lagenammina atlantica* occur in the winter samples in large numbers and account for much higher percentages of the total live foraminiferal population than when all collecting season counts are combined.

The one-way ANOVA tests show that species composition varies from station to station. The dominant species are quite constant between replicate samples at individual stations, but their numbers may vary considerably between stations. Rarer species, which are found at only a few of the collecting stations, vary considerably between the replicate samples at the individual stations. Changes in species composition from station to station are closely related to water depth.

Correlation Coefficients

Correlation coefficients were calculated that compare total foraminifera counts, total *Buliminella bassendorfensis* counts, and total *Nonionella basiloba* counts with weight percent of total organic carbon; barium, cadmium, chromium, copper, iron, lead, nickel, vanadium, and zinc in ppm; and mean sediment grain size. Except for the trace elements, which were measured in the spring at the primary platforms and control sites and in the summer at the secondary platforms, the data are for all collecting seasons. The correlation coefficients are shown in Table 5.

The correlation values are so low that no significant trends are apparent. Significance was determined from Koch and Linck (1971), Table 1-A. Thirty-six pairs of variables were calculated for the primary platforms and control sites, 32 pairs of variables for the secondary platforms.

TABLE 5--Correlation coefficients comparing total foraminifera counts, total *Buliminella bassendorfensis* counts, and total *Nonionella basiloba* counts with total organic carbon, trace metals, and mean sediment grain size, all collecting seasons.

SPRING	Total Organic Carbon	Barium	Cadmium	Chromium	Copper	Iron	Nickel	Lead	Vanadium	Zinc	Mean Grain Size
Total Foraminifera	0.3516*	0.0330	0.0919	0.4076*	0.1156	0.2148	0.0190	0.4343*	0.1845	0.3627*	0.1648
Buliminella bassendorfensis	0.4597*	0.1488	0.3536*	0.6660*	0.1523	0.3955*	0.0306	0.7733*	0.1966	0.4920*	0.3606*
Nonionella basiloba	0.1246	0.2416	0.0592	0.1580	0.0400	0.0075	0.0445	0.0851	0.0637	0.2073	0.0539
SUMMER											
Total Foraminifera	0.1220										0.0473
Buliminella basssendorfensis	0.2630										0.2294
Nonionella basiloba	0.1599										0.2488

TABLE 5--Continued.

SUMMER	Total Organic Carbon	Barium	Cadmium	Chromium	Copper	Iron	Nickel	Lead	Vanadium	Zinc	Mean Grain Size
Secondary Platforms											
Total Foraminifera	0.0188	0.0614	0.1414	0.2468	0.0163	0.2354	0.2127	0.0436	0.1645	0.3420*	0.1170
Buliminella bassendorfensis	0.0305	0.1311	0.0348	0.2121	0.0247	0.1882	0.0863	0.1245	0.1053	0.4563*	0.0397
Nonionella basiloba	0.0568	0.0175	0.2089	0.2094	0.0540	0.2007	0.2776*	0.0467	0.1588	0.1622	0.1944
WINTER											
Total Foraminifera	0.4898*										0.6116*
Buliminella bassendorfensis	0.0326										0.1274
Nonionella basiloba	0.4587*										0.6350*

Correlation coefficients for foraminiferal groups and total organic carbon, trace metals, and mean sediment grain size.

*Indicates significance from Table 1-A, Koch and Link (1971).

Mean Grain Size.

The correlation coefficients that compare mean grain size against total foraminifera and total specimens of *Nonionella basiloba* show no signifibance in the spring and summer. However, comparison of *Buliminella bassendorfensis* with mean grain size shows a high correlation at the primary platforms and control sites for the spring collecting sezson. However, there is no clear reason why this high correlation exists. Comparisons of *Buliminella bassendorfensis* with mean grain size for the summer and winter are not significant. Comparisons of total foraminifera and *Nonionella basiloba* with mean grain size for the winter season show high correlations. The numbers of *Nonionella basiloba* increase as mean grain size increases. This presumably explains the high correlation for the total foraminifera counts. The high *Nonionella basiloba* counts all came from PO3 at stations where sand and silty sand was found and may be an indication of the species' optimum substrate and depth requirements in the study area.

There were no significant correlations between foraminifera groups and mean sediment grain size at the secondary platforms.

Total Organic Carbon.

Comparisons of total organic carbon with foraminifera groups show high correlations for total foraminifera and *Buliminella bassendorfensis* in the spring and total foraminifera and *Nonionella basiloba* in the winter. In the spring, *Buliminella bassendorfensis* increased in numbers as the total organic carbon content of the sediment increased. The highest counts of *Buliminella bassendorfensis* were from silty sediments at PO4. In the winter, the numbers of total foraminifera and *Nonionella basiloba* increased as the total organic carbon content of the sediment decreased. High counts of *Nonionella basiloba* occur in the sandy sediments at PO3 that contain small amounts of organic carbon.

There was no high correlation of foraminifera and total organic carbon in the summer.

Trace Elements.

High correlations of chromium, lead, and zinc with the total foraminifera population, and of cadmium, chromium, iron, lead, and zinc with *Buliminella bassendorfensis* were calculated for spring at the primary platforms and control sites. There are apparent increases in numbers of both groups as the trace metal content of the sediment increases.

In the summer, at the secondary platforms, high correlations of total foraminifera and Buliminella bassendorfensis with zinc, and Nonionella basiloba with nickel were calculated. Large numbers of Buliminella bassendorfensis were found in the silts around PO4 in the spring. Large numbers of Nonionella basiloba are correlated with the lowest amounts of nickel at the secondary platforms in the summer. These are generally platforms with coarse silt to very fine sand sediments. No other significant correlations of trace metals with the foraminifera were calculated for the secondary platforms. Apparently Buliminella bassendorfensis prefers the fine-grained sediments and these are the sediments that trap and hold the trace metals (SwRI Final Report, 1980). Not enough information exists to explain the high nickel counts at the secondary platforms in the summer. Similar high nickel levels were not found at the primary platforms and control sites in the spring.

Significant trends in the correlation of foraminifera groups with organic carbon, trace elements, and mean grain size apparently are closely related to water depth. Buliminella bassendorfensis prefers fine-grained sediments in deeper waters that trap high amounts of trace elements and organic carbon. *Nonionella basiloba* prefers shallower waters and coarser grained sediments, and the coarse-grained sediments trap and hold lesser amounts of trace metals and organic carbon.

Summary of Statistical Analyses

Q-mode cluster analysis of the foraminifera shows little dissimilarity in the clustering levels of the stations in the study area. Small clusters of stations from the same platform within the larger cluster groups are apparently related to water depth.

Two-way ANOVA tests on numbers of individuals of species compared with seasons, and on numbers of observations of each species compared with seasons show slight significant seasonal variations in the foraminifera population in the study area. One-way ANOVA tests show that species composition varies from station to station.

Correlation coefficients calculated by comparing foraminifera groups with total organic carbon, trace metals, and mean sediment grain size, indicate that high correlations of these variables are closely associated with water depth. *Buliminella bassendorfensis* apparently prefers deeper waters where fine-grained sediments trap and hold relatively large amounts of trace materials and organic carbon. *Nonionella basiloba* prefers the coarser-grained sediments at the shallower water stations, and lesser amounts of trace metals and organic carbon are trapped in these sediments.

There are no apparent negative effects of petroleum drilling and production on the foraminiferal population in the study area. Foraminiferal distribution trends are closely related to water depth and do not seem to be influenced by the activities of the offshore oil industry.

FORAMINIFERAL DISTRIBUTION TRENDS

The foraminifera in the study area are typical of an inner shelf assemblage with high standing crops and low diversity. Although the water depths of the collecting stations range from 6 to 98 meters, two foraminifera species, *Nonionella basiloba* and *Buliminella bassendorfensis*, were found to be dominant throughout the sampling area. A chart of the depths at which each of the foraminifera species were found is shown in Table 6. This apparent lack of depth zonation for the dominant foraminifera species may be in part attributed to the runoff from the Mississippi River. Because the study area is near the Mississippi delta, deltaic conditions may still be influencing the findings. The wet picking methods may also be influencing the findings. Because many of the individuals are juveniles, keeping the samples wet preserved delicate juvenile tests that might have been destroyed in the drying process.

Seasonable distribution of the foraminifera species is not significant in the study area. The two dominant species, *Nonionella basiloba* and *Buliminella bassendorfensis*, are dominant in every collecting season, although in reduced numbers in the summer and winter. Other species (*Ammonia beccarii*, *Epistominella vitrea*, *Lagenammina atlantica*) do

Table 6. Depth Ranges for Foraminifera

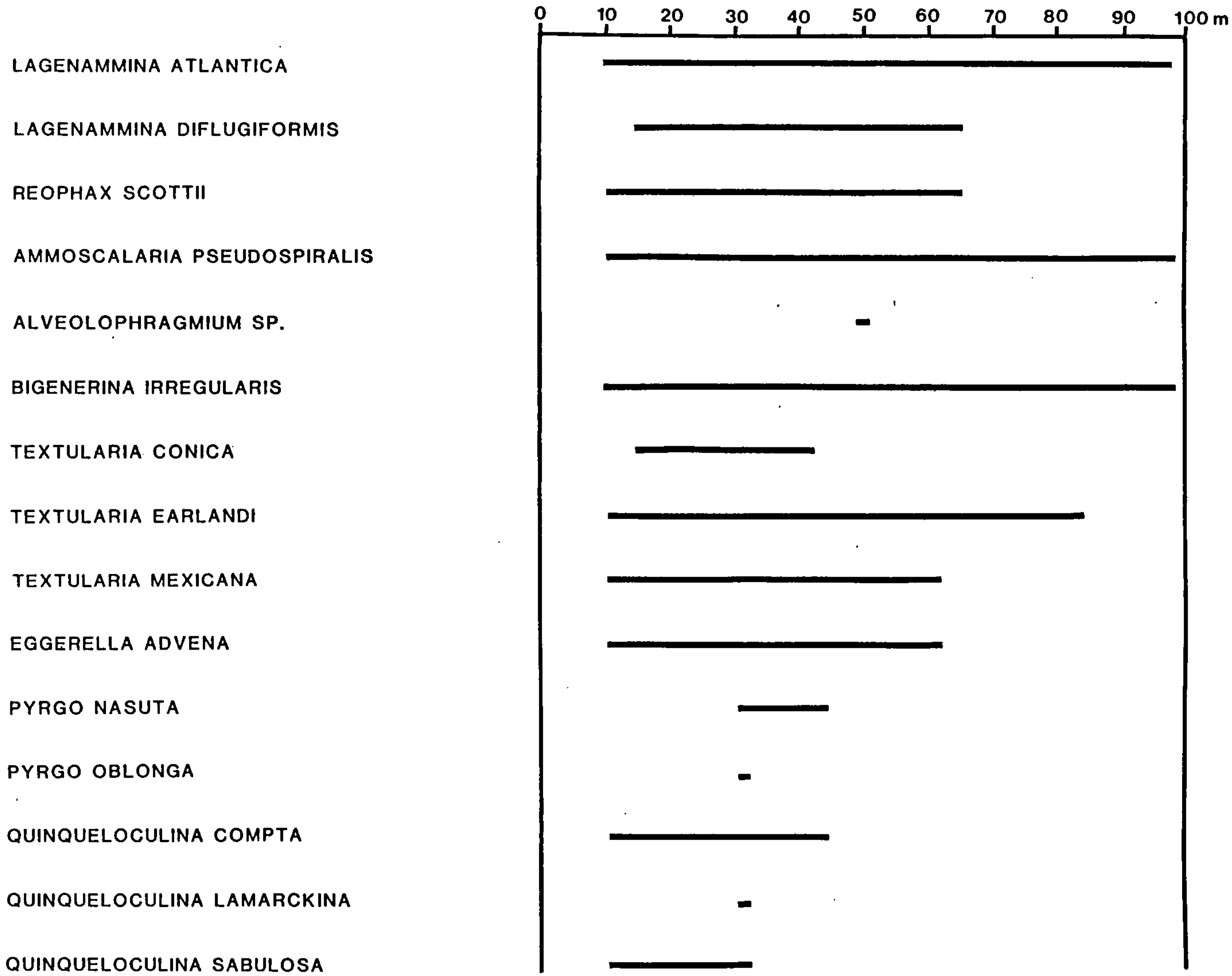


Table 6. (Continued)

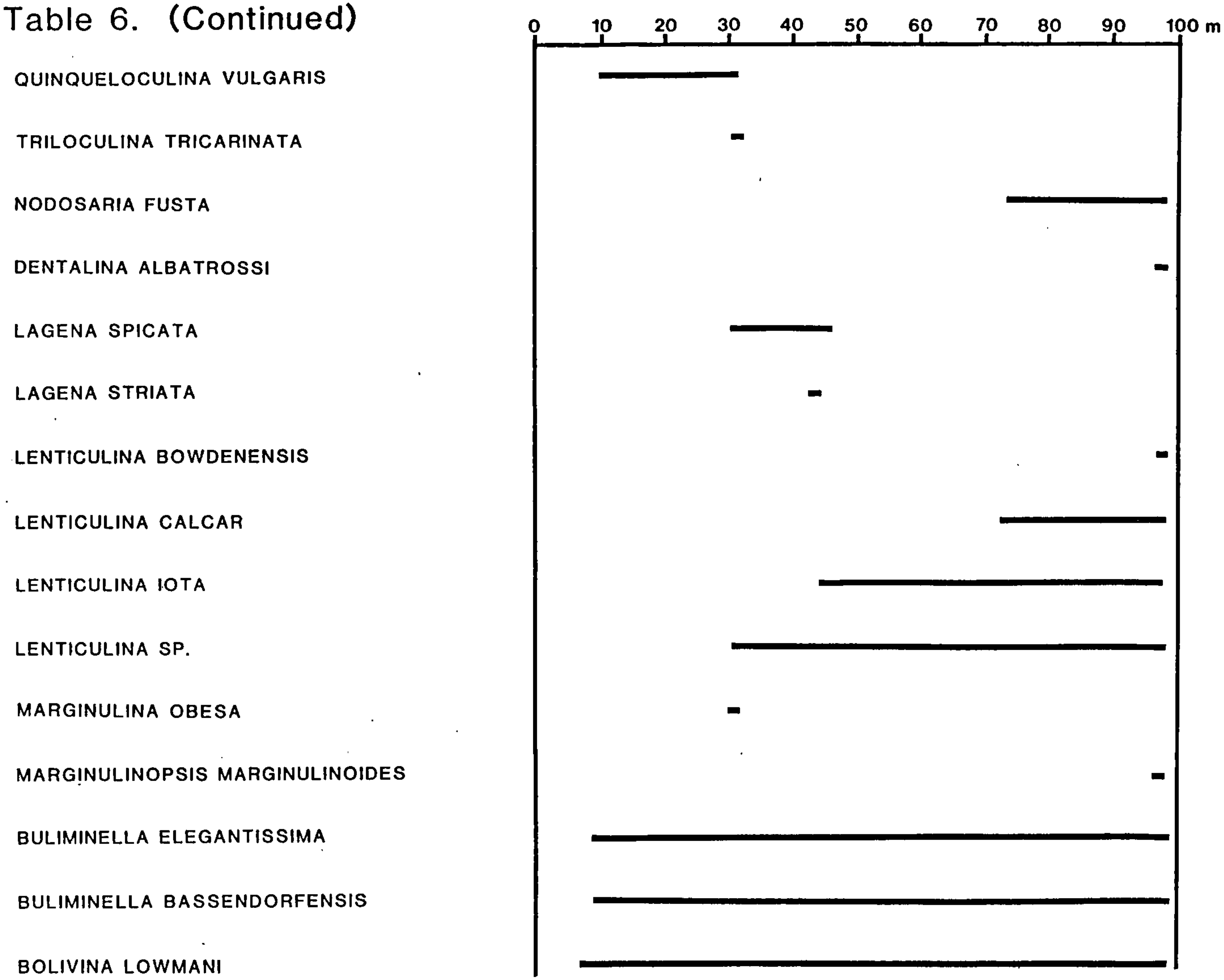


Table 6. (Continued)

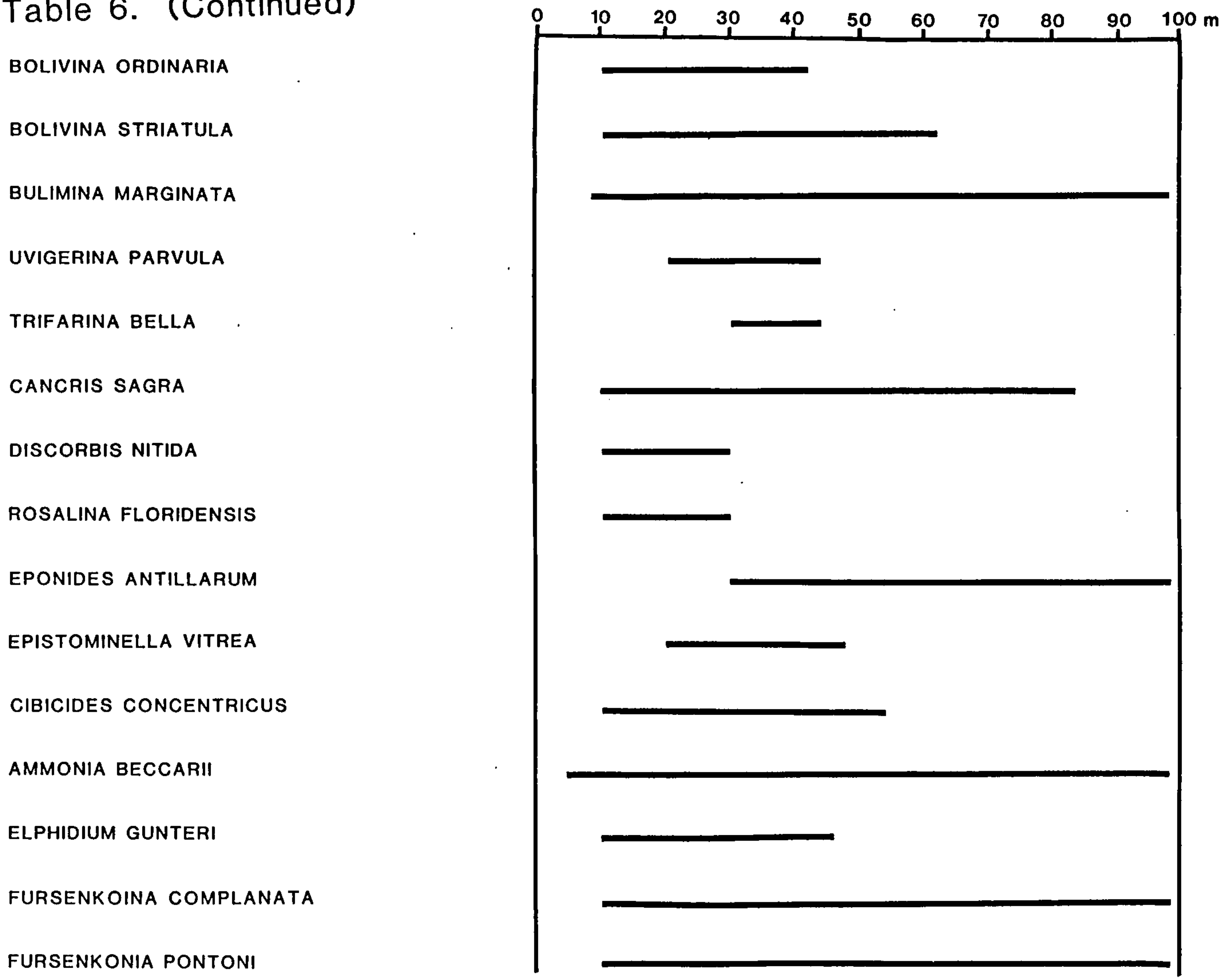
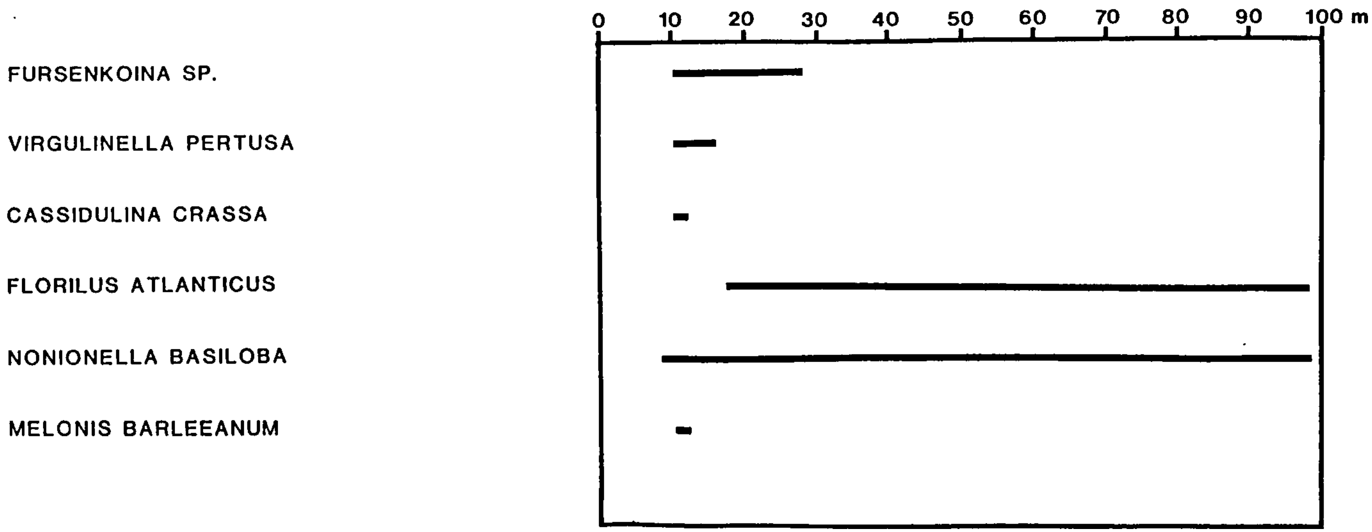


Table 6. (Continued)



show seasonal variations. Both Ammonia beccarii and Lagenammina atlantica are most abundant in the winter, and Epistominella vitrea is abundant only in the spring.

The primary controlling factor on the less common foraminifera species in the assemblages appears to be water depth. At the primary platforms, miliolina are absent at PO1 and PO4, abundant at PO2, and rare at PO3. Quinqueloculina vulgaris is the dominant milioline at PO2. A variety of textulariina are present at all of the primary platforms. However, they are most abundant at PO3 and PO4. Reophax scottii is common at PO4 in the spring and summer and Lagenammina atlantica is common at both PO3 and PO4. The rotaliine Bolivina lowmani is found at all of the primary platforms, but is most abundant in the winter at PO1 and PO2. Cibicides concentricus is abundant at PO3 and PO4 in the winter, and Epistominella vitrea and Fursenkoina complanata are common only at PO4, Epistominella vitrea only in the spring, and Fursenkoina complanata in both the spring and summer.

At the control sites Buliminella bassendorfensis, Nonionella basiloba, and Bolivina lowmani are dominant at C21 and C22, Buliminella bassendorfensis is dominant at C23, and Lagenammina atlantica and Buliminella bassendorfensis are dominant at C24. Ammonia beccarii is also dominant at C24 in the winter.

At the secondary platforms, during the summer sampling season, Buliminella bassendorfensis and Nonionella basiloba dominate the foraminifera assemblages. Fursenkoina complanata is an abundant species at S09, Bolivina lowmani is abundant at S09 and S10, and Ammonia beccarii is abundant at S12.

Several species, Lenticulina calcar, Lenticulina bowdenensis, Nodosaria fusta, Dentalina albatrossi, and Marginulinopsis marginulinoides, were found only at the two deepest water platforms, S15 and S17, in the summer. Although only a few foraminifera were collected at S17, Buliminella bassendorfensis and Nonionella basiloba were the dominant foraminifera in the microsamples at S15. At 98 meters, S15 is the deepest collecting site in the study area.

There are no apparent negative effects of petroleum production drilling on the foraminifera in the study area. Densities up to 372,154 foraminifera per 10 cm^2 were estimated for the summer in the study area. These densities are much higher than any previously reported. There is no appreciable difference in either the composition of the foraminifera assemblages or in the numbers of foraminifera collected at the drilling platforms and the control sites. The physical factors controlling the foraminifera populations are related to natural environment (water depth, temperature and salinity changes, tide and current action, dissolved oxygen) and not to man-induced activities stemming from petroleum drilling.

CONCLUSIONS

Over twenty years of petroleum exploration, drilling, and production activity have produced no apparent negative effects on the foraminiferal population in the study area.

The large standing crops dominated by Nonionella basiloba and Buliminella bassendorfensis are characteristic of an inner shelf delta assemblage. The high densities and the small size of the specimens are partly caused by the presence of the Mississippi River nearby, which discharges large quantities of available food. Sample preparation and processing is also partly responsible for the high population counts in the study area. The wet picking method preserves the tests of juveniles and delicate species that would be destroyed in the dry sampling process.

Large numbers of deformed foraminifera and large percentages of agglutinated species, which would indicate industrial and chemical pollution of the marine waters by the petroleum industry, are not present in the samples.

There is some seasonal variation in the foraminifera population in the study area. Although Nonionella basiloba and Buliminella bassendorfensis continue to be the dominant species, their numbers generally decrease in the winter, and some of the less common species increase in numbers.

Cluster analysis shows that changes in species composition from station to station are closely related to water depth.

Correlation coefficients that compare foraminifera groups with total organic carbon, mean sediment grain size, and trace metals commonly associated with the petroleum industry show no significant trends. However, there are trends that are apparently related to water depth. *Buliminella bassendorfensis* prefers fine-grained sediments that trap and hold large amounts of organic carbon and trace metals. *Nonionella basiloba* prefers shallower water and coarser grained sediments that incorporate lesser amounts of these materials.

The low dissolved oxygen was the greatest factor in the decline in the foraminiferal population in the summer and winter collecting seasons. The low dissolved oxygen was first noted in the spring at the shallow inshore stations and continued throughout the summer, killing the foraminifera that were living in the area.

The low diversity of the foraminifera population in the study area is caused by the large range of seasonal temperatures, movements of sediments by currents and tides, and variations in salinity. The low species diversity is not caused by the exploration, drilling, and production activities of the Louisiana offshore oil industry.

SYSTEMATICS

The classification used in this paper is that of Loeblich and Tappan (1964, 1974).

Because no new species were found in this study and the existing species have all been well illustrated elsewhere, no illustrations were considered necessary.

All the results discussed in this section, except for the living/total ratio, are based on the living population data. References to frequency of species are defined as follows: abundant = over 10% of the live population, common = between 1 and 10% of the live population, and rare = less than 1% of the live population.

Phylum PROTISTA Haeckel, 1866

Subphylum SARCODINA Schmarda, 1871

Class RHIZOPODEA von Siebold, 1845

Order FORAMINIFERIDA Eichwald, 1830

Suborder TEXTULARIINA Delage & Herouard, 1896

Superfamily AMMODISCACEA Reuss, 1862

Family SACCAMMINIDAE Brady, 1884

Subfamily SACCAMMININAE Brady, 1884

Genus *LAGENAMMINA* Rhumbler, 1911

LAGENAMMINA ATLANTICA (Cushman, 1944)

Proteonina atlantica CUSHMAN, 1944, p. 5, Pl. 1, fig. 4; PARKER, 1954, p. 481, Pl. 1, fig. 1; BANDY, 1956, p. 196; PHLEGER, 1956, p. 117; PHLEGER, 1960, Pl. 7, fig. 29.

Proteonina comprima PHLEGER & PARKER, 1951, p. 2, Pl. 1, figs. 1-3.

Reophax atlanticus (Cushman). PARKER, 1952, p. 393.

Lagenammina atlantica (Cushman). LANKFORD, 1959, p. 2098, Pl. 1, fig. 1.

Diagnosis.--A species of *Lagenammina* consisting of a single oval chamber without a distinct neck, but contracted toward the apertural end. Test agglutinated, wall of fine weakly-cemented material; aperture small, at tapered end of chamber.

Material.--950 living specimens.

Distribution.--*Lagenammina atlantica* is a common species in the study area, composing 1.14% of the total live foraminiferal population. It is most abundant in the winter samples, where it makes up 8.08% of the living specimens.

L. atlantica was found living at most of the sampling stations at the primary platforms for all collecting seasons except the W500 and W2000 stations at P02. It was found living at all control sites except C21 in the spring and C22 in the summer. *L. atlantica* is common at the inshore platforms P01 and P02 in the summer, but rare at P03 and P04. It is common at the secondary platforms S06, S10 and S15 and absent at S05, S13, S17 and S19. It is rare at the other secondary platforms. In winter samples from P03, *L. atlantica* is generally abundant.

For the primary platforms and control sites, the fewest living specimens were found in the samples from the shallow stations at PO2 and C21. Most of the specimens came from water depths greater than 13 meters.

Remarks.--*L. atlantica* is not represented in the live/total slides with the same frequency with which it occurs in the wet samples, as the cement in many specimens is not sufficiently strong to withstand drying.

LAGENAMMINA DIFLUGIFORMIS (H. B. Brady, 1879)

Reophax diflugiformis H. B. BRADY, 1879, p. 51, Pl. 4, figs. 3a, b; BOCK, 1971, p. 5, Pl. 1, fig. 7.

Proteonina diflugiformis (H. B. Brady). PHLEGER & PARKER, 1951, p. 2, Pl. 1, figs. 4, 5; PARKER, 1954, p. 481, Pl. 1, fig. 2.

Diagnosis.--A species of Lagenammina consisting of a single oval chamber with a distinct neck. Test agglutinated; aperture small, circular, at end of pronounced, elongate neck.

Material.--81 living specimens.

Distribution.--Lagenammina diflugiformis is a rare species in the study area. L. diflugiformis was not found at PO2 in any of the samples, nor at control sites C21 and C24. It occurs most frequently at PO4 where it is common at several of the sampling stations.

All living specimens are from water depths greater than 13 meters.

Superfamily LITUOLACEA de Blainville, 1825

Family HORMOSINIDAE Haeckel, 1894

Subfamily REOPHACINAE Cushman, 1910

Genus REOPHAX Montfort, 1808

REOPHAX SCOTTII Chaster, 1892

Reophax scottii CHASTER, 1892, p. 314, Pl. 1, fig. 1; PHLEGER, 1960, Pl. 6, fig. 14; Pl. 7, fig. 33.

Diagnosis.--An extremely flexible, very finely agglutinated species of *Reophax*, with pyriform chambers.

Material.--420 living specimens.

Distribution.--*Reophax scottii* comprises only 0.77% of the total live foraminiferal population in the study area. It is most abundant in the spring samples where it makes up 1.02% of the total live count. *R. scottii* is found most frequently at PO4 where it may be common in the spring and summer samples.

R. scottii apparently prefers the deeper water stations, although a few individuals were collected at the shallow stations around PO2 and C21.

Remarks.--The lack of specimens of *R. scotti* at PO3 in the spring samples is probably because they were not recognized to be foraminifera until somewhat later in the picking stage, and not because they were totally absent. Their absence in the live/total slides is due to the failure of the delicate tests to survive drying.

Superfamily LITUOLACEA de Blainville, 1825

Family LITUOLIDAE de Blainville, 1825

Subfamily LITUOLINAE de Blainville, 1825

Genus AMMOSCALARIA Hoglund, 1947

AMMOSCALARIA PSEUDOSPIRALIS (Williamson, 1858)

Proteonia pseudospiralis WILLIAMSON, 1858, p. 2, Pl. 1, figs. 2, 3; LANKFORD, 1959, p. 2097, Pl. 1, figs. 5, 6, 7.

Ammoscalaria pseudospiralis (Williamson). HOGLUND, 1947, p. 159-162; PARKER, 1954, p. 488, Pl. 2, figs. 3, 4; PHLEGER, 1954, p. 636, Pl. 1, fig. 10; PHLEGER, 1956, p. 112; LANKFORD, 1959, p. 2097, Pl. 1, figs. 5, 6, 7; PHLEGER, 1960, Pl. 1, fig. 2.

Diagnosis.--A broad, rounded, somewhat compressed species of Ammoscalaria, with medium grained agglutinated exterior wall and somewhat distinct surface sutures.

Material.--118 living specimens.

Distribution.--Ammoscalaria pseudospiralis is a rare species in the study area. It occurs most frequently in the spring at the shallow stations around P01 and P02, and is a common species in some of the samples. However, it is absent from samples from the shallow control site C21.

Remarks.--This species is generally better represented in the live/total slides than other agglutinated species. It tends to be quite firmly cemented.

Turbellarian cocoons were found as parasites on several of the A. pseudospiralis specimens from both spring and summer samples. In the spring collection, one large specimen from PO2 E500 had three cocoons attached to it. In the summer collections, a specimen from PO2 W500 was noticeably deformed, possibly caused by the attachment of a turbellarian cocoon. An individual found at S10 had incorporated a cocoon as part of its test by cementing sand grains around it. The test had a noticeable swelling near the aperture.

Family LOFTSUIIDAE Brady, 1884

Subfamily CYCLAMMININAE Marie, 1941

Genus ALVEOLOPHRAGMIUM Shchedrina, 1936

ALVEOLOPHRAGMIUM sp.

Labrospira sp. PHLEGER & PARKER, 1951, p. 3, Pl. 1, fig. 14.

Alveolophragmium sp. PARKER, 1954, p. 488, Pl. 1, fig. 22.

Diagnosis.--A small, planispiral, involute species of *Alveolophragmium* with very finely agglutinated wall and wide aperture with small bordering lips.

Material.--2 living specimens.

Distribution.--*Alveolophragmium* sp. is extremely rare in the collections from the study area. Both specimens came from the spring samples at C23.

Family TEXTULARIIDAE Ehrenberg, 1838

Subfamily TEXTULARIINAE Ehrenberg, 1838

Genus BIGENERINA d'Orbigny, 1826

BIGENERINA IRREGULARIS Phleger & Parker, 1951

Bigenerina irregularis PHLEGER & PARKER, 1951, p. 4, Pl. 1, figs. 16-21; PARKER, 1954, p. 492, Pl. 3, figs. 1-3; PHLEGER, 1954, p. 636, Pl. 1, figs. 16, 17; PHLEGER, 1956, p. 113; BANDY, 1956, p. 193; LANKFORD, 1959, p. 2097, Pl. 1, fig. 12; PHLEGER, 1960, Pl. 1, fig. 1, Pl. 7, figs. 1, 2; ANDERSEN, 1961, p. 25, Pl. 2, figs. 8a, b; BOCK, 1971, p. 9, Pl. 2, fig. 5.

Bigenerina sp. cf. *B. irregularis* Phleger & Parker. WARREN, 1956, Pl. 11, fig. 1; WARREN, 1957, p. 34.

Diagnosis.--A species of *Bigenerina* with compressed initial biserial portion of approximately 4 pairs of distinct chambers comprising almost one quarter of total test length, and uniserial portion of up to 6 round, uniformly sized chambers, with a terminal rounded aperture at the end of a short neck.

Material.--82 living specimens.

Distribution.--*Bigenerina irregularis* is a rare species in the study area. It occurs most frequently in the winter samples and is common at C24 for the winter collecting season. In the summer, it is common at secondary platforms S10 and S11.

Remarks.--Juveniles of *B. irregularis* resemble

Textularia in the initial biserial portion, and may be extremely difficult to identify unless a population including several growth stages is present.

Genus *TEXTULARIA* Defrance in de Blainville, 1824

TEXTULARIA CONICA d'Orbigny, 1939

Textularia conica D'ORBIGNY, 1839, p. 143, Pl. 1, figs. 19, 20; CUSHMAN, 1922, p. 22, Pl. 5, figs. 5-7; PHLEGER & PARKER, 1951, p. 5, Pl. 1, fig. 27; PARKER, 1954, p. 490, Pl. 2, fig. 13; BANDY, 1956, p. 197, Pl. 30, figs. 6a, b; LEHMANN, 1957, p. 346; ANDERSEN, 1961, p. 22, Pl. 2, figs. 2a, b; BOCK, 1971, p. 8, Pl. 2, fig. 3.

Diagnosis.--An extremely low and broad species of *Textularia* with relatively few chambers.

Material.--11 living specimens.

Distribution.--*Textularia conica* is a very rare species in the study area. All of the 11 individuals of *T. conica* were found at the primary platforms PO3 and PO4 and the control sites C23 and C24 in the spring samples. All were from water depths greater than 18 meters.

TEXTULARIA EARLANDI Parker, 1952

Textularia earlandi PARKER, 1952, p. 458; PARKER, 1954,

p. 490, Pl. 2, fig. 12; LEHMANN, 1957, p. 346; LANKFORD, 1959, p. 2099, Pl. 1, fig. 10; PHLEGER, 1960, Pl. 8, fig. 10; BROOKS, 1973, Pl. 1, fig. 7-9.

Diagnosis.--A minute, dainty species of *Textularia* with very fine, smooth agglutinated walls, distinct sutures, and a distinct, curved, apertural slit on the inner edge of the terminal chamber.

Material.--34 living specimens.

Distribution.--*Textularia earlandi* is a rare species in the study area. *T. earlandi* occurs most frequently in the spring samples at P01. Specimens were found at all stations at PO1 except N500. Individuals were also found at PO2, PO3, PO4 and C21. In the summer, *T. earlandi* was absent at PO1, and specimens were found at PO3, C21, C24 and SO9. In the winter, a single specimen came from PO3 N500 and C21.

The specimens were collected from depths of 12 to 85 meters, with the greatest frequency of occurrence at 16 meters.

TEXTULARIA MEXICANA Cushman, 1922

Textularia mexicana CUSHMAN, 1922, p. 17, Pl. 2, fig. 9; CUSHMAN & TODD, 1945, p. 1, Pl. 1, fig. 1a, b; PHLEGER & PARKER, 1951, p. 5, Pl. 2, figs. 6, 7; ANDERSEN, 1961, p. 23, Pl. 1, figs. 4a, b.

Diagnosis.--A much compressed species of *Textularia*, only 1½ times as long as broad, with sharp periphery, well-defined, depressed sutures, and wall roughened and raised over sutures, forming a definite high ridge in later half of test.

Material.--22 living specimens.

Distribution.--*Textularia mexicana* is a rare species in the study area. With the exception of one specimen of *T. mexicana* found in the winter samples from PO2, all of the specimens collected at the primary platforms came from PO3 and PO4. The highest frequency of occurrence was in the summer and winter samples. No specimens were collected at the control sites. *T. mexicana* also occurred at the secondary platforms SO7, SO8, S10 and S14 in the summer. Most specimens came from water deeper than 25 meters.

Family ATAXOPHARGMIIDAE Schwater, 1877

Subfamily GLOBOTEXTULARIINAE Cushman, 1927

Genus *EGGERELLA* Cushman, 1911

EGGERELLA ADVENA (Cushman, 1922)

Verneuilina advena CUSHMAN, 1922, p. 57, Pl. 9, figs. 7-9.

Eggerella advena (Cushman). CUSHMAN, 1931, p. 51, Pl. 5, figs. 12-15; PHLEGER, 1960, Pl. 5, fig. 7; MURRAY, 1973, Pl. 5, figs. 7, 8.

Diagnosis.--A small, slender species of *Eggerella* with early chambers low and broad, later chambers increasing in size and becoming globular.

Material.--183 living specimens.

Distribution.--*Eggerella advena* comprises 0.28% of the total live foraminiferal population in the study area. It is most abundant in the spring samples from the primary platforms and control sites, but it represents less than 1.00% of the total live foraminiferal population for all collecting seasons.

E. advena was collected at most of the primary platform stations in the spring, and at all control sites except C23. In the summer samples from the primary platforms and control sites, it occurs most frequently at PO3 and is absent at PO2 and C23. It occurs most frequently at the secondary platforms SO8 and S11, where it is a common species. In the winter, *E. advena* is found only at PO1, PO3, and C24. The majority of the living specimens were collected from water depths between 12 and 45 meters.

Suborder MILIOLINA Delage & Herouard, 1896

Superfamily MILIOLACEA Ehrenberg, 1839

Family MILIOLIDAE Ehrenberg, 1839

Subfamily QUINQUELOCULININAE Cushman, 1917

Genus *PYRGO* Defrance, 1824

PYRGO NASUTA Cushman, 1935

Pyrgo nasutus CUSHMAN, 1935, p. 7, Pl. 3, figs. 1a, b, 2-4; PHLEGER & PARKER, 1951, p. 7, Pl. 3, figs. 12-14; PARKER, 1954, p. 501, Pl. 5, fig. 4; PHLEGER, 1956, p. 117; BANDY, 1956, p. 196.

Pyrgo nasuta ANDERSEN, 1961, p. 38, Pl. 9, figs. 2a-c.

Diagnosis.--A species of *Pyrgo* with a strongly keeled and serrate periphery, a much compressed neck on the apertural end; somewhat convex on the dorsal outer side, flattened or concave on the inner side, and without a distinct bifid tooth.

Material.--10 living specimens.

Distribution.--*Pyrgo nasuta* is an extremely rare species in the study area. Seven of the 10 living specimens of *P. nasuta* were from the spring samples, 6 specimens from PO3 and 1 from PO4. In the summer samples, single specimens were found at PO3, PO4 and C23.

Although not enough specimens were collected for verification, the species apparently prefers water depths of from 30 to 45 meters.

PYRGO OBLONGA (d'Orbigny, 1839)

Biloculina oblonga D'ORBIGNY, 1839, p. 164, Pl. 8, figs. 21-23.

Pyrgo cf. *P. oblonga* (d'Orbigny). ANDERSEN, 1961, p. 39, Pl. 9, figs. 3a-c.

Diagnosis.-- A species of Pyrgo with an extremely inflated and rounded bottom portion and only slightly rounded top portion, and a narrow, somewhat curved elongate aperture extending slightly over the bottom chamber.

Material.--5 living specimens.

Distribution.--*Pyrgo oblonga* is an extremely rare species in the study area. All of the living specimens of *P. oblonga* were collected at PO3 in the spring.

Genus QUINQUELOCULINA d'Orbigny, 1826

QUINQUELOCULINA COMPTA Cushman, 1947

Quinqueloculina compta CUSHMAN, 1947, p. 87, Pl. 19, figs. 2a-c; PHLEGER & PARKER, 1951, p. 7, Pl. 3, figs. 16a, b; 17a, b; PARKER, 1954, p. 496, Pl. 3, figs. 20, 21; PHLEGER, 1956, p. 117; BANDY, 1956, p. 196, Pl. 29, figs. 5a-c; LANKFORD, 1959, p. 2099, Pl. 1, fig. 14; PHLEGER, 1960, Pl. 1, fig. 16; Pl. 7, figs. 30, 31; ANDERSEN, 1961, p. 29, Pl. 4, figs. 2a-c, 3a-c.

Quinqueloculina cf. *compta* Cushman. PHLEGER, 1954, p. 45, Pl. 2, fig. 36; Pl. 9, figs. 19, 20.

Diagnosis.--A species of *Quinqueloculina* with medium-sized test, generally triangular in transverse section, with acute angles, a short but distinct neck bending back slightly from the elongate axis of the apertural chamber, aperture with a slightly flaring lip and a small simple tooth, and with a largely calcareous, smooth wall with fine sand grains in the exterior.

Material.--50 living specimens.

Distribution.--*Quinqueloculina compta* is a rare species in the study area. In the spring, all of the specimens were collected at PO2 and PO3 and C22 and C23. The 2 specimens from C23 were found in the macrofauna samples. In the summer, *Q. compta* was found at PO1, PO3, and PO4. No specimens were collected at the secondary platforms. Only 4 specimens of *Q. compta* were found in the winter samples and these came from PO2 and PO3.

Remarks.--The sediment grains attached to the tests of *Q. compta* are generally silt-sized and give the tests a slightly dirty appearance. The tests are not as porcelaneous in appearance as those of *Q. lamarckiana* and *Q. vulgaris*.

QUINQUELOCULINA LAMARCKINA d'Orbigny, 1839

Quinqueloculina lamarckina D'ORBIGNY, 1839, p. 189, Pl. 11, figs. 14, 15; PHLEGER & PARKER, 1951, p. 7, Pl. 4, figs. 1a, b; PARKER, 1954, p. 497, Pl. 4, figs. 5, 6; PHLEGER, 1956, p. 118; BANDY, 1956, p. 196; LEHMAN, 1957, p. 347, Pl. 1, figs. 28-30; ANDERSEN, 1961, p. 31, Pl. 5, figs. 3a-c, 4a-c; BOCK, 1971, p. 19, Pl. 6, figs. 7-9.

Quinqueloculina cf. *lamarckina* d'Orbigny. CUSHMAN & TODD, 1945, p. 10.

Diagnosis.--A broad species of *Quinqueloculina* with smooth, slightly striated wall, sub-rounded to sub-angular chambers, and slight apertural neck with lip.

Material.--2 living specimens.

Distribution.--*Quinqueloculina lamarckina* is an extremely rare species in the study area. Both specimens were collected in the spring samples from PO3.

QUINQUELOCULINA SABULOSA Cushman, 1947

Quinqueloculina sabulosa CUSHMAN, 1947, p. 87, Pl. 18, figs. 22a-c; PARKER, 1954, p. 497, PL. 4, figs. 9-10; ANDERSEN, 1961, p. 31, Pl. 4, figs. 1a-c; BOCK, 1971, p. 20, Pl. 7, figs. 4-6.

Diagnosis.--A small species of *Quinqueloculina*, almost twice as long as broad, angles subacute in transverse section; wall rather coarsely agglutinate; aperture with short, broad tooth.

Material.--2 living specimens.

Distribution.--*Quinqueloculina sabulosa* is an extremely rare species in the study area. One specimen of *Q. sabulosa* was found in the spring samples from PO2, the other in the winter samples from PO3.

QUINQUELOCULINA VULGARIS d'Orbigny, 1826

Quinqueloculina vulgaris D'ORBIGNY, 1826, p. 302, no. 33.

Quinqueloculina cf. *vulgaris* d'Orbigny. PHLEGER & PARKER, 1951, p. 8, PL. 4, figs. 2a, b; BOCK, 1971, p. 22.

Diagnosis.--A species of *Quinqueloculina* with a shiny, smooth wall, test almost as broad as long, subrounded, somewhat triangular in transverse section, and a very slightly extended apertural chamber with elliptical neck and simple tooth.

Material.--123 living specimens.

Distribution.--*Quinqueloculina vulgaris* comprises 0.19% of the total live foraminiferal population in the study area. All but one of the specimens were collected in the spring samples.

Q. vulgaris is a rare to abundant species at PO2 in the spring. It is abundant at stations N500, N2000, E500, S500; rare at E2000 and S2000; and absent at W500 and W2000. One specimen came from PO3 and two each from C21 and C22. A single specimen of *Q. vulgaris* was collected at PO3 in the summer samples.

Q. vulgaris appears to prefer shallow water. No specimens were found living at deeper depths than 30 meters.

Genus TRILOCULINA d'Orbigny, 1826

TRILOCULINA TRICARINATA d'Orbigny, 1826

Triloculina tricarinata D'ORBIGNY, 1826, p. 299, no. 7; PARKER, 1954, p. 500, Pl. 4, fig. 22; ANDERSEN, 1961, p. 36, Pl. 7, figs. la-c; BOCK, 1971; p. 28, Pl. 12, figs. 1-2.

Diagnosis.--A species of Triloculina with test almost as broad as long, three visible chambers with acute peripheral angles, a smooth shiny wall, and a small bifid tooth.

Material.--4 living specimens.

Distribution.--Triloculina tricarinata is an extremely rare species in the study area. All of the specimens of T. tricarinata were found in the spring samples from PO3.

MILIOLID JUVENILES

Material.--205 living specimens.

Distribution.--Unidentified miliolid juveniles account for only 0.32% of the total live foraminiferal population in the study area. They occur in the greatest numbers in the spring samples.

Most of the unidentified miliolid juveniles were found at PO2 in the spring samples. Specimens were found at all collecting sites except C21 and C24. In the summer samples, only rare specimens of miliolid juveniles were found at the primary platforms and control sites, and they were absent at P01 and C22. They were common at the secondary platform S11, rare at S08, S10, S15, and S20, and absent at all other secondary platforms. In the winter samples, unidentified miliolid juveniles occurred rarely at P03 and P04 and were absent at all other primary platforms and control sites.

Suborder ROTALIINA Delage & Herouard, 1896

Superfamily NODOSARIACEA Ehrenberg, 1838

Family NODOSARIIDAE Ehrenberg, 1838

Genus NODOSARIA Lamarck, 1812

NODOSARIA FUSTA Cushman & Todd, 1945

Nodosaria fusta CUSHMAN & TODD, 1945, p. 28, Pl. 4, figs. 20a, b, 21, 22; ANDERSEN, 1961, p. 70, Pl. 17, fig. 12.

Diagnosis.--A species of Nodosaria with a slender test and a wall ornamented by 6 to 8 high, sharp, longitudinal costae.

Material.--5 living specimens.

Distribution.--Nodosaria fusta is an extremely rare species in the study area. N. fusta was found living only in the summer macrofauna samples from the secondary platforms

P15 and P17. These platforms are in deep water between 70 and 100 meters.

Genus DENTALINA Risso, 1826

DENTALINA ALBATROSSI (Cushman, 1923)

Nodosaria vertebralis (Batsch), var. albatrossi CUSHMAN, 1923, p. 87, Pl. 15, fig. 1; CUSHMAN & JARVIS, 1930, p. 360.

Dentalina vertebralis (Batsch), var. albatrossi (Cushman). CUSHMAN & TODD, 1945, p. 22, Pl. 3, fig. 21.

Nodosaria albatrossi Cushman. BARKER, 1960, p. 87, Pl. 15, fig. 1; ANDERSEN, 1961, p. 70, Pl. 17, fig. 11; BOCK, 1971, p. 37, Pl. 14, figs. 8-9.

Diagnosis.--A species of Dentalina with a long, slender test, apical spine, and a wall ornamented by 15 to 18 longitudinal costae.

Material.--14 living specimens.

Distribution.--Dentalina albatrossi is a very rare species in the study area. All of the 14 living specimens of D. albatrossi came from the summer macrofauna samples from S15 N2000. At 98 meters water depth, this is the deepest collecting site in this study.

Genus LAGENA Walker & Jacob in Kanmacher, 1798

LAGENA SPICATA Cushman & McCulloch, 1950

<u>Lagena</u> <u>sulcata</u> (Walker & Jones) var. <u>spicata</u> CUSHMAN & McCULLOCH, 1950, p. 360, Pl. 48, figs. 3-7.

<u>Lagena</u> <u>spicata</u> Cushman & McCulloch. ANDERSEN, 1961, p. 77, Pl. 16, fig. 16.

<u>Diagnosis</u>.--A species of <u>Lagena</u> with a round to ovate test with surface ornamented with numerous fine costae and a single hollow spine extending from base; aperture on elongate neck with phialine lip, apertural neck ornamented with small circles of blunt spinose material, especially near end of neck.

<u>Material</u>.--3 living specimens.

<u>Distribution</u>.--<u>Lagena</u> <u>spicata</u> is an extremely rare species in the study area. All of the specimens of <u>L</u>. <u>spicata</u> are from the spring samples, 2 from PO3 E500 and the other from PO4 W2000.

<u>LAGENA</u> <u>STRIATA</u> (d'Orbigny), 1839

<u>Oolina</u> <u>striata</u> d'ORBIGNY, 1839, p. 21, Pl. 5, fig. 12.

<u>Lagena</u> <u>striata</u> (d'Orbigny). CUSHMAN & TODD, 1945, p. 34. Pl. 5, fig. 16; ANDERSEN, 1961, p. 78, Pl. 16, fig. 15; BOCK, 1971, p. 39, Pl. 15, fig. 3.

<u>Diagnosis</u>.--A species of <u>Lagena</u> with an ovate test, with surface ornamented with numerous fine costae which continue onto long neck in a spiral ornamentation; base of test

covered with numerous fine, short, spinose projections; aperture on elongate neck, only slight hint of lip.

Material.--4 living specimens.

Distribution.--*Lagena striata* is an extremely rare species in the study area. All of the specimens of *L. striata* were found in the samples from PO4, three in the summer and one in the winter.

Family VAGINULINIDAE Reuss, 1860

Subfamily LENTICULININAE Chapman, Parr & Collins, 1934

Genus *LENTICULINA* Lamarck, 1804

LENTICULINA BOWDENENSIS (Cushman) 1919

Cristellaria bowdenensis CUSHMAN, 1919, p. 37, Pl. 8, fig. 2.

Cristellaria antillea CUSHMAN, 1923, p. 116, Pl. 31, fig. 1; Pl. 32, fig. 1; Pl. 33, fig. 1; Pl. 34, fig. 1.

Robulus bowdenensis (Cushman). ANDERSEN, 1961, p. 47, Pl. 12, figs. 4a, b.

Diagnosis.--A species of *Lenticulina* with periphery acute and keeled; early stages with flat, triangular-shaped acicular spines placed at irregular intervals along the keel, later stages with the keel uninterrupted; sides of the keel may be beaded; generally an overall reduction in the amount of surface ornamentation in the later stages of development. Aperture is roughly circular in outline, projecting slightly above periphery, filled with spongy material with numerous irregularly shaped cribrate openings. Test large, with close involute coiling in early stages, becoming evolute in later stages; sutures curved, limbate, raised and beaded in early stages, often depressed and unornamented in the adult. Sides of chambers with variable quantity of beading on the surface between the sutures.

Material.--17 living specimens.

Distribution.--Lenticulina bowdenensis is a very rare species in the study area. All of the living specimens of L. bowdenensis were found in the summer macrofauna samples from S15. At 98 meters of water depth, this is the deepest collecting site in this study.

LENTICULINA CALCAR (Linnaeus, 1767)

Nautilus calcar LINNAEUS, 1767, P. 1162, no. 272.

Robulus calcar (Linnaeus). CUSHMAN & JARVIS, 1930, p. 358, Pl. 32, fig. 9; CUSHMAN & TODD, 1945, p. 12, Pl. 2, fig. 6; BANDY, 1956, p. 197, Pl. 30, figs. 11a, b; ANDERSEN, 1961, p. 48, Pl. 11, figs. 1a, b, 2a, b.

Lenticulina calcar (Linnaeus). BARKER, 1960, p. 146, Pl. 70, figs. 9-12; BOCK, 1971, p. 39, Pl. 15, fig. 6.

Diagnosis.--Test small to medium size, biconvex; 4 to 6 chambers in the last formed whorl; keel ornamented with a spine projecting outward from each chamber except the last formed chamber; sutures limbate, very slightly curved, and radiate tangental from a clear spot in the umbilicus. The apertural face is small, depressed and flat, with aperture small, rounded, and slightly produced above the periphery with radiations distinct and converging at the center of the apertural opening; median slit concealed by two inward curved plates of shell material which enlarge at their inner margins to form an elliptical shaped opening directed downward. The inner margins of these plates bear numerous irregular spiny projections.

Material.--19 living specimens.

Distribution.--*Lenticulina calcar* is a very rare species in the study area. The 19 living specimens of *L. calcar* came from the summer macrofauna samples from secondary platforms S15 and S17. At 75 and 98 meters water depth, these are two of the deepest collecting sites in the study area.

LENTICULINA IOTA (Cushman), 1923

Cristellaria iota CUSHMAN, 1923, p. 111, Pl. 29, fig. 2.

Robulus iotus (Cushman). ANDERSEN, 1961, p. 51, Pl. 13, figs. 4a, b.

Lenticulina iota (Cushman), BOCK, 1971, p. 40, Pl. 15, fig. 7.

Diagnosis.--A species of *Lenticulina* with a large, thin test; sutures curved, limbate, slightly depressed in large specimens; aperture roughly circular in outline, projecting above periphery at apical angle of the test, apertural radiations distinct, joining in center of the aperture with 4 openings on each side of test formed between radiations.

Material.--13 living specimens.

Distribution.--*Lenticulina iota* is a very rare species in the study area. All of the living specimens of *L. iota* except one were found in the summer macrofauna samples from S15. The last specimen was found in the winter macrofauna samples from PO4 N500. All of the specimens came from water depths of 45 to 98 meters.

LENTICULINA sp.

Robulus sp. "F" ANDERSEN, 1961, p. 47, Pl. 11, Figs. 4a, b.

Diagnosis.--A small species of *Lenticulina* with completely involute manner of coiling, arched sutures radiating from a common center, very slightly depressed, not limbate; apertural face convex with elongate aperture with radiations distinct and confined to the sides of the test. Peripheral keel continues through the aperture to the outer margin of the median slit. Median slit narrow, elongate, flanked on each side by a thin blade of shell material which projects forward perpendicular to apertural face.

Material.--56 living specimens.

Distribution.--Only 8 of the *Lenticulina* sp. specimens were found in the microfauna samples. The rest of the specimens were found in the macrofauna samples. *Lenticulina* sp. is rare in the study area, but more numerous than other species of *Lenticulina*.

All of the *Lenticulina* sp. individuals found in the spring microfauna samples were collected at PO3 and PO4. A single specimen of *Lenticulina* sp. was found in the summer microfauna samples at PO4.

In the macrofauna samples, all specimens of *Lenticulina* sp. collected in the spring were from PO3 and PO4. Summer specimens came from PO4, SO9, S15 and S17. A single specimen was found in the winter macrofauna samples from PO4.

No specimens of *Lenticulina* sp. were found at depths shallower than 30 meters.

Subfamily MARGINULININAE Wedekind, 1937

Genus *MARGINULINA* d'Orbigny, 1826

MARGINULINA OBESA Cushman, 1923

Marginulina glabra d'Orbigny var. *obesa* CUSHMAN, 1923, p. 128, Pl. 37, fig. 1.

Marginulina obesa Cushman. BARKER, 1960, p. 136, Pl. 15, figs. 5, 6a, b; ANDERSEN, 1961, p. 63, Pl. 15, figs. 1a, b; 2a, b.

Diagnosis.--A short, broad species of *Marginulina* with smooth surface; sutures in earlier part rather obscure, later ones depressed; aperture terminal, protruding, radiate.

Material.--2 living specimens.

Distribution.--*Marginulina obesa* is an extremely rare species in the study area. One specimen of *M. obesa* was found in the spring samples from PO3 N500. A second specimen was found in the summer samples from PO3 N2000.

Genus *MARGINULINOPSIS* A. Silvestri, 1904

MARGINULINOPSIS MARGINULINOIDES (Goes), 1896

Cristellaria aculeata d'Orbigny var. *marginulinoides* GOES, 1896, p. 56, Pl. 5, figs. 15, 16.

Marginulina marginulinoides (Goes). PHLEGER & PARKER, 1951, p. 9, Pl. 4, figs. 17, 18; PARKER, 1954, p. 504, Pl. 5, fig. 21.

Marginulinopsis marginulinoides (Goes). ANDERSEN, 1961, p. 62, Pl. 15, figs. 9a, b.

Diagonosis.--A species of *Marginulinopsis* with a large test and broad, slightly inflated chambers; initial part enrolled, keeled with short spines on keel, becoming rectilinear without pronounced keel; septa strong, raised, beaded, sometimes the beads growing to short spines particularly on early segments; aperture terminal, protruding, radiate.

Material.--1 living specimen.

Distribution.--*Marginulinopsis marginulinoides* was found in the summer macrofauna samples from S15, the deepest collecting site in this study.

Superfamily BULIMINACEA Jones, 1875

Family TURRILINIDAE Cushman, 1927

Subfamily BULIMINELLINAE Hofker, 1951

Genus *BULIMINELLA* Cushman, 1911

BULIMINELLA ELEGANTISSIMA (d'Orbigny, 1839)

Bulimina elegantissima D'ORBIGNY, 1839, p. 51, Pl. 7, figs. 13, 14.

Buliminella elegantissima (d'Orbigny). PHLEGER & PARKER, 1951, p. 17, Pl. 8, figs. 3, 4; PHLEGER, 1954, p. 637, Pl. 1, figs. 24, 25; PHLEGER, 1956, p. 114; BANDY, 1956, p. 193; LANKFORD, 1959, p. 2097, Pl. 2, fig. 16; PHLEGER, 1960, Pl. 5, fig. 3; Pl. 7, fig. 8; ANDERSEN, 1961, p. 86, Pl. 19, fig. 5; BOCK, 1971, p. 44, Pl. 16, fig. 9; MURRAY, 1973, Pl. 10, fig. 10.

Diagnosis.--A small, elongate species of *Buliminella*, with high close spiral formed by numerous very high, narrow chambers, and relatively broad upper end and loop-shaped aperture with internal tooth plate.

Material.--266 living specimens.

Distribution.--*Buliminella elegantissima* comprises 0.41% of the total live foraminiferal population in the study area. It occurs most frequently in the spring samples from the primary platforms and control sites, but is rare for all collecting seasons.

B. elegantissima was found in the spring samples from most of the stations at P01 and P02. It is a common species at P02. Only one specimen was found at P03, none at P04. It was also found in the samples from C21 and C24, but none were found at C22 or C23. In the summer samples, *B. elegantissima* is absent at P01, common at the three stations at P02 where it is found, and rare at P03 and P04. It is rare at all control sites except C23, where it is absent. At the secondary platforms, *B. elegantissima* is abundant at S05, common at S06 and S11, and rare or absent at the other secondary platform stations. In the winter samples, 96.00% of the specimens of *B. elegantissima* were found at P01 and P02. One specimen was found at P03 and one at C24.

The greatest number of living individuals of *B. elegantissima* were from the shallow water stations with water depths of up to 16 meters.

BULIMINELLA BASSENDORFENSIS Cushman & Parker, 1937

Buliminella bassendorfensis CUSHMAN & PARKER, 1937, p. 40, Pl. 4, figs. 13a, b.

Buliminella cf. bassendorfensis Cushman & Parker. PHLEGER & PARKER, 1951, p. 17, Pl. 8, figs. 1, 2; PARKER, 1954, p. 509, Pl. 6, fig. 13; PHLEGER, 1954, p. 637, Pl. 1, figs. 22, 23; PHLEGER, 1956, p. 114; WARREN, 1956, Pl. 111, fig. 26; WARREN, 1957, p. 38; LANKFORD, 1959, p. 2097, Pl. 2, fig. 15; PHLEGER, 1960, Pl. 1, fig. 8; Pl. 7, fig. 7; Pl. 9, fig. 8.

Diagnosis.--A small, slender species of Buliminella, commonly with 5 to 6 sets of inflated, somewhat elliptical chambers essentially in 3 vertical rows, roughly parallel to the long axis of the test.

Material.--20,157 living specimens.

Distribution.--Buliminella bassendorfensis comprises 31.34% of the total live foraminiferal population in the study area. It is most abundant in the spring and summer samples at the primary platforms and control sites, less abundant in the winter samples.

B. bassendorfensis was found at all of the collecting stations at the primary platforms and control sites in the spring except PO2 W2000. It is abundant at all of the primary platforms and control sites. However, it may be common at individual collecting stations at some of the primary platforms. In the summer samples, B. bassendorfensis is is abundant at all of the collecting stations from the primary platforms and control sites except PO2 S500 and W2000, where it is common. It is abundant at most of the collecting stations at the secondary platforms except SO5 N500, S13 N500, S15 N500, S17 N2000, and S19 N500 and N2000, where it is absent. In the winter samples, *B. bassendorfensis* is present in samples from all of the collecting stations except N500 and E500 at PO2. It is a common species at PO2 and C24, abundant at all of the other primary platforms and control sites.

Most specimens of *B. bassendorfensis* came from water depths deeper than 12 meters.

Remarks.--*B. bassendorfensis* apparently prefers finer grained sediments to coarser grained ones. Comparison of total counts of *B. bassendorfensis* with trace metal data shows a high correlation of cadmium, chromium, iron, lead, and zinc with total numbers of *B. bassendorfensis*. At the same time, the total organic carbon content of the sediment increased. Large numbers of *B. bassendorfensis* were found in the silts around PO4 in the spring. These fine-grained sediments are the sediments that trap and hold the trace metals and organic carbon.

Family BOLIVINITIDAE Cushman, 1927

Genus BOLIVINA d'Orbigny, 1839

BOLIVINA LOWMANI Phleger & Parker, 1951

Bolivina lowmani PHLEGER & PARKER, 1951, p. 13-14, Pl. 6, figs. 20a, b, 21; PARKER, 1954, p. 515, Pl. 7, fig. 21; PHLEGER, 1954, p. 637, Pl. 1, figs. 18, 19; PHLEGER, 1956, p. 113; WARREN, 1956, Pl. 111, fig. 29; WARREN, 1957, p. 38; LANKFORD, 1959, p. 2097, Pl. 3, fig. 4; PHLEGER, 1960, Pl. 7, fig. 3; Pl. 9, fig. 10; BOCK, 1971, p. 46, Pl. 16, fig. 14.

Diagnosis.--A small, slightly compressed, sometimes slightly twisted species of Bolivina, with initial somewhat rounded to subacute end, numerous chambers, distinct sutures, and smooth wall with pores; loop shaped aperture.

Material.--3619 living specimens.

Distribution.--Bolivina lowmani is a common species in the study area and comprises 5.63% of the total live foraminiferal population. It is most abundant in the spring and summer samples at the primary platforms and control sites, somewhat less abundant in the winter samples, although its total percentage is higher in the winter samples.

B. lowmani was found living in the samples from all collecting stations at the primary platforms and control sites in the spring except PO2 W2000. It is an abundant species at PO2 and C21, common at the other primary platforms and control sites, although it may be rare at individual stations. In the samples collected during the summer, B. lowmani was found alive at all collecting stations except PO2 S500. It is abundant at C21 and PO2, common at PO3 and PO4 and the other control sites, and generally rare at PO1. It is abundant at the secondary platforms S10 and S11, absent at S17 N500 and N2000, S15 N500 and S19 N2000, and common at most of the other platforms. It is the only species found in samples from S13 N500 and S19 N500. In the winter samples, B. lowmani is abundant at all of the primary platforms and all control sites except C24, where it is common. Specimens of B. lowmani were found at every collecting station during the winter collecting season.

BOLIVINA ORDINARIA Phleger & Parker, 1952

Bolivina simplex Phleger & Parker, 1951, p. 14, Pl. 7, figs. 4, 5a, b, 6.

Bolivina ordinaria Phleger & Parker, 1952, p. 14; PARKER, 1954, p. 515, Pl. 7, fig. 24; Phleger, 1960, Pl. 3, fig. 4.

Diagnosis.--A small, compressed species of Bolivina with broad, opaque, slightly curved sutures; wall smooth, perforate, thin, except at sutures where it is thickened so that sutures appear very white as compared to rest of test.

Material.--9 living specimens.

Distribution.--*Bolivina ordinaria* is an extremely rare species in the study area. Specimens of *B. ordinaria* were collected at PO1, PO2, PO3, PO4 and C23 in the spring. A single specimen of *B. ordinaria* was found at PO3 in the summer samples, and at PO3 in the winter samples.

BOLIVINA STRIATULA Cushman, 1922

Bolivina striatula CUSHMAN, 1922, p. 27, Pl. 2, fig. 9; CUSHMAN & TODD, 1945, p. 43, Pl. 7, fig. 2; PHLEGER, 1954, p. 637; PHLEGER, 1956, p. 113; BANDY, 1956, p. 193; WARREN, 1956, Pl. 30, fig. 30; WARREN, 1957, p. 38; LEHMANN, 1957, p. 348; LANKFORD, 1959, p. 2097, Pl. 3, fig. 6; BOCK, 1971, p. 46, Pl. 17, fig. 2.

Diagnosis.--An elongate, tapering species of *Bolivina* with numerous, slightly inflated chambers, very slightly depressed sutures, and early portion of test with numerous longitudinal striations occupying about half the length of the test, final chambers being smooth, hardly punctate.

Material.--269 living specimens.

Distribution.--*Bolivina striatula* is a rare species in the study area, comprising only 0.42% of the total live foraminiferal population. It occurs with the same frequency in the spring and summer samples from the primary platforms and control sites, but the winter samples from these sites show a lower frequency of occurrence.

B. striatula, when it occurs in the spring samples, is a rare species except at PO2, where it is generally common. It was absent from the control sites C22, C23, and C24, and from all of the collecting stations at PO1 except N500. It was also absent from PO3 S2000 and W2000, and PO4 E500, S500 and W500. In the summer samples from the primary platforms and control sites, *B. striatula* was absent at C21 and C22, and was generally rare at the collecting stations from the primary platforms and other control sites. It was found in the samples from all of the primary platforms but was not found at all stations at these platforms except at PO4. At the secondary platforms, *B. striatula* was found only at S07, S10, S12, S16 and S20, where it was generally rare. *B. striatula* was not found in the samples collected during the winter at any of the control sites, and was found in only the S2000 samples from PO1. It occurs at N500 and S500 at PO2, and N2000 and E2000 at PO4, where it is rare. At PO3 it occurs at all stations except N2000, and is common at N500 and E500, rare at the other stations.

B. striatula is a shallow water species and generally does not occur deeper than 45 meters.

Family BULIMINIDAE Jones, 1875

Subfamily BULIMININAE Jones, 1875

Genus *BULIMINA* d'Orbigny, 1826

BULIMINA *MARGINATA* d'Orbigny, 1826

Bulimina *marginata* D'ORBIGNY, 1826, p. 269, no. 4, Pl. 12, figs. 10-12; CUSHMAN, 1922, p. 91, Pl. 21, figs. 4, 5; CUSHMAN & TODD, 1945, p. 39, Pl. 6, fig. 8; PHLEGER & PARKER, 1951, p. 16, Pl. 7, figs. 27, 28; PARKER, 1954, p. 510, Pl. 6, fig. 20; PHLEGER, 1956, p. 113; BANDY, 1956, p. 193; WARREN, 1956, Pl. 111, fig. 27; WARREN, 1957, p. 38; LANKFORD, 1959, p. 2097, Pl. 2, fig. 14; PHLEGER, 1960, Pl. 2, fig. 5; ANDERSEN, 1961, p. 88, Pl. 19, figs. 14-16.

Diagnosis.--A species of *Bulimina* with inflated chambers and basal margin undercut at a sharp angle; free edges of chambers with numerous short spines.

Material.--139 living specimens.

Distribution.--*Bulimina* *marginata* is a rare species in the study area, comprising only 0.22% of the total live foraminiferal population. It occurs most frequently in the spring samples from the primary platforms and control sites but is found in the summer and winter samples also.

B. *marginata* is rare in the spring samples from the collecting stations where it is found. It is absent at all control sites except C22 and is found at only half the collecting stations of PO1, PO2, and PO3, but occurs at all stations at PO4. *B. marginata* is a rare species in the summer samples from the primary platforms and control sites, occurring at all control sites except C23 and at only the W2000 station at PO1 and the E2000 station at PO2. It is found at half of the stations at PO3 and PO4. It is absent in the samples from the secondary platforms SO5, SO6, SO7, SO9, S13, S17, and S19, and rare at the other platforms. In the winter samples, *B. marginata* is absent at the control sites C23 and C24, and occurs in only the N500 and N2000 samples at PO1, the S2000 samples at PO2, and the N500, N2000, and S2000 samples at PO4. It occurs at over half of the collecting stations at PO3 and is common in the N500 and E500 samples, rare in the others.

The majority of the live specimens of *B. marginata* were found between depths of 12 and 45 meters. Only one specimen was found deeper than 45 meters.

Family UVIGERINIDAE Haeckel, 1894

Genus *UVIGERINA* d'Orbigny, 1826

UVIGERINA PARVULA Cushman, 1923

Uvigerina peregrina Cushman var. *parvula* CUSHMAN, 1923,
p. 168, Pl. 42, fig. 11; CUSHMAN & JARVIS, 1930,

p. 363, Pl. 33, fig. 11; PHLEGER & PARKER, 1951, p. 18, Pl. 8.

Uvigerina parvula Cushman. PARKER, 1954, p. 521, Pl. 8, fig. 6; PHLEGER, 1956, p. 120; LANKFORD, 1959, p. 2099, Pl. 3, fig. 12; PHLEGER, 1960, Pl. 2, fig. 23; ANDERSEN, 1961, p. 89, Pl. 20, fig. 16; BOCK, 1971, p. 49, Pl. 17, fig. 12; BROOKS, 1973, Pl. 4, figs. 11-12.

Diagnosis.--A small, elongate, costate, spinose species of *Uvigerina* with distinct, slightly inflated chambers, perforate test. Chambers triserially arranged, sutures depressed; circular aperture at end of neck with simple, straight, narrow tooth plate.

Material.--12 living specimens.

Distribution.--*Uvigerina parvula* is an extremely rare species in the study area. It is found in samples from the spring and summer collections, but no specimens were found in the winter samples. Specimens of *U. parvula* came from the spring samples at PO3 and PO4 and from the summer samples at PO3, SO7, S11 and S20.

All specimens of *U. parvula* were collected from waters 18 meters and deeper.

Genus *TRIFARINA* Cushman, 1923

TRIFARINA BELLA (Phleger & Parker, 1951)

Angulogerina bella PHLEGER & PARKER, 1951, p. 12, Pl. 6, figs. 7, 8; PARKER, 1954, p. 521, Pl. 8, fig. 7; PHLEGER, 1956, p. 113; BANDY, 1956, p. 192; LANKFORD, 1959, p. 2097, Pl. 3, fig. 8; PHLEGER, 1960, Pl. 1, fig. 4; ANDERSEN, 1961, p. 91, Pl. 20, fig. 13; BOCK, 1971, p. 49, Pl. 17, fig. 13; TRESSLAR, 1974, p. 72, Pl. 3, fig. 2.

Diagnosis.--An elongate species of Trifarina with indistinct costate early chambers and smooth, irregular, triangular later chambers.

Material.--41 living specimens.

Distribution.--Trifarina bella is a very rare species in the study area for all collecting seasons. It occurs most frequently in the winter samples from the primary platforms and control sites.

Specimens of T. bella found in the spring samples came from PO3 and C23. In the summer samples, specimens of T. bella were found at PO3, PO4, and the secondary platform S16. T. bella was rare to common in the winter samples from PO3 where it was found at all stations except N2000 and S2000. It was also found as a rare species at PO4 and C23.

All living specimens of T. bella were found in water depths from 30 to 45 meters.

Superfamily DISCORBACEA Ehrenberg, 1838

Family DISCORBIDAE Ehrenberg, 1838

Subfamily BAGGININAE Cushman, 1927

Genus CANCRIS de Montfort, 1808

CANCRIS SAGRA (d'Orbigny, 1839)

Rotalina sagra D'ORBIGNY, 1839, p. 77, Pl. 5, figs. 13-15.

Rotalina oblonga WILLIAMSON, 1858, p. 51, Pl. 4, figs. 98-100.

Pulvinulina sagra (d'Orbigny). CUSHMAN, 1918, p. 65, Pl. 22, figs. 3a-c; Pl. 23, figs. 1a-c.

Cancris sagra (d'Orbigny). CUSHMAN, 1931, p. 74, Pl. 15, fig. 2; PARKER, 1954, p. 532, Pl. 10, figs. 15, 21; BANDY, 1956, p. 193; ANDERSEN, 1961, p. 104, Pl. 24, figs. 4a-c; BOCK, 1971, p. 5, Pl. 19, figs. 6-7; BROOKS, 1973, P. 10, figs. 11, 16; TRESSLER, 1974, p. 73, P. 4, figs. 5, 6.

Cancris oblonga (Williamson). PHLEGER & PARKER, 1951, p. 20, Pl. 9, figs. 17a, b, 18, 19; PARKER, 1954, p. 532, Pl. 10, figs. 13, 14; PHLEGER, 1956, p. 114; BROOKS, 1973, Pl. 9, figs. 13, 14.

Cancris sp. cf. C. cagra (d'Orbigny). WARREN, 1956, Pl. 4, figs. 17, 18; WARREN, 1957, p. 38.

Diagnosis.--A small, compressed species of Cancris with area of transparent, non-perforate test material near umbilicus.

Material.--64 living specimens.

Distribution.--*Cancris sagra* is a rare species in the study area and comprises only 0.10% of the total live foraminiferal population. It is found in samples from all of the collecting seasons.

C. sagra is a rare species in the spring collections and is found only at stations at P03 and P04 and at control site C23. In the summer samples, *C. sagra* was found at P03 and P04, but was absent at all of the control sites. Rare specimens were found at the secondary platforms S07, S09, S10, S16, and S20. In the winter samples, *C. sagra* is again found in samples from the collecting stations at P03 and P04, where it is generally rare, with a single specimen coming from C21.

The majority of the *C. sagra* specimens were collected in water depths of 30 to 45 meters, with a single specimen coming from 12 meters water depth at the shallow control site C21.

Subfamily DISCORBINAE Ehrenberg, 1838

Genus *DISCORBIS* Lamarck, 1804

DISCORBIS NITIDA (Williamson, 1858)

Rotalina nitida WILLIAMSON, 1858, p. 54, Pl. 4, figs. 106-108.

Discorbis cf. *nitida* (Williamson). PHLEGER & PARKER, 1951, p. 20, Pl. 10, figs. 8a, b.

Diagnosis.--A very small species of *Discorbis* with a high-spired conical test and very finely perforate walls. Live specimens have two-colored test, a dark reddish-brown lower part, and light yellow upper chambers.

Material.--19 living specimens.

Distribution.--*Discorbis nitida* is an extremely rare species in the study area. It is found in samples from all of the collecting seasons. In the spring samples, *D. nitida* was found only at P02 and P03. In the summer samples, it was found living at P03 and at the secondary platforms S10, S11, S12, and S20. All of the live winter specimens were found at P03.

All living specimens of *D. nitida* were collected from water depths of 17 to 30 meters.

Subfamily ROSALININAE Reiss, 1963

Genus *ROSALINA* d'Orbigny, 1826

ROSALINA FLORIDENSIS (Cushman), 1931

Discorbis bertheloti (d'Orbigny) var. *floridensis* CUSHMAN, 1931, p. 364, Pl. 33, fig. 13; CUSHMAN & JARVIS, 1930, p. 364, Pl. 33, figs. 13a-c; CUSHMAN & TODD, 1945, p. 56, Pl. 8, figs. 15a, b, 16a-c; BOCK, 1971, p. 52, Pl. 18, figs. 11-12.

Discorbis floridensis Cushman. PHLEGER & PARKER, 1951, p. 20, Pl. 10, figs. 5a, b, 6a, b, 7a, b; BANDY, 1956, p. 193, Pl. 31, figs. 5a-c.

Rosalina floridensis (Cushman). PARKER, 1954, p. 525, Pl. 8, figs. 28, 29.

Neoconorbina floridensis (Cushman). ANDERSEN, 1961, p. 101, Pl. 21, figs. 6a-c.

Diagnosis.--A rounded, conical species of *Rosalina* with broad narrow chambers and limbate sutures on spiral side.

Material.-- 2 living specimens.

Distribution.--*Rosalina floridensis* is an extremely rare species in the study area and was found only in the spring samples. One of the specimens of *R. floridensis* came from the microfauna samples at P02, and the second specimen was found in the P03 macrofauna samples.

Family EPONIDIDAE Hofker, 1951

Genus *EPONIDES* de Montfort, 1808

EPONIDES ANTILLARUM (d'Orbigny, 1839)

Rosalina antillarum D'ORBIGNY, 1839, p. 75, Pl. 5, figs. 4-6.

Eponides antillarum CUSHMAN & JARVIS, 1930, p. 364, Pl. 33, figs. 14a-e; Pl. 34, fig. 2; CUSHMAN, 1931, p. 4, Pl. 9, fig. 2; PHLEGER & PARKER, 1951, p. 20, Pl. 10, figs. 9a, b, 10a, b; PARKER, 1954, p. 528, Pl. 9, figs. 14, 15; PHLEGER, 1956, p. 116; BANDY, 1956, p. 194; PHLEGER, 1960, Pl. 1, fig. 11; BOCK, 1971, p. 57, Pl. 21, figs. 4-5; BROOKS, 1973, Pl. 5, figs. 3-5.

Neoeponides _antillarum_ (d'Orbigny). ANDERSEN, 1961, p. 102, Pl. 23, figs. 4a-c, 5a-c.

Diagnosis.--A species of _Eponides_ with test unequally biconvex, dorsal side somewhat more convex than ventral; periphery subacute; chambers numerous, 7 to 8 in the last formed whorl; sutures oblique, rather indistinct and slightly depressed on the dorsal side, nearly radiate and ending in raised area about the umbilicus on the ventral side. Wall is fairly thick, finely perforate, otherwise smooth, with clear, conspicuous boss on dorsal side, obliterating chambers in larger specimens. Aperture is at the margin of the ventral face between the periphery and umbilucus. Diameter up to 1 mm or more.

Material.--148 living specimens.

Distribution.--_Eponides_ _antillarum_ is a rare species in the study area, comprising only 0.23% of the total live foraminiferal population. It occurs with the greatest frequency in the microfauna samples from the primary platforms and control sites in the summer and winter, but is most abundant in the macrofauna samples from these sites in the spring.

E. antillarum was found only in the samples from P03 P04 in the spring. The majority of the specimens came from the macrofauna samples at P03. In the summer samples specimens were found at P03, P04 and C23. A single specimen was found in the macrofauna samples at the secondary platform S15. In the winter samples, *E. antillarum* occurs only rarely at P03, P04 and C23.

No specimens of *E. antillarum* were found at any of the stations shallower than 30 meters.

Family PSEUDOPARRELLIDAE Voloshinova, 1952

Genus *EPISTOMINELLA* Husezima & Maruhasi, 1944

EPISTOMINELLA VITREA Parker, 1953

Epistominella vitrea PARKER, 1953, p. 9, Pl. 4, figs. 34-36, 40, 41; PARKER, 1954, p. 534, Pl. 10, figs. 20, 26; PHLEGER, 1954, p. 40, Pl. 2, figs. 11, 12; PHLEGER, 1956, p. 116; WARREN, 1956, Pl. 4, figs. 25, 26; WARREN, 1957, p. 39; LANKFORD, 1959, p. 2098, Pl. 3, figs. 14a, b; PHLEGER, 1960, Pl. 1, fig. 6; Pl. 9, fig. 9; ANDERSEN, 1961, p. 104, Pl. 24, figs. 1a-c.

Diagnosis.--A small species of *Epistominella*. Test trochospiral, all chambers visible on umbilical side, final chamber somewhat larger than other three. Sutures oblique on spiral side, nearly radial on umbilical side. Wall finely perforate. Aperture an elongate vertical slit in face, near and parallel to peripheral keel. Diameter commonly only 1/4 mm.

Material.--285 living specimens.

Distribution.--*Epistominella vitrea* is a common species in the spring samples, where it accounts for 1.05% of the total live foraminiferal population. It is absent in the summer samples, and only one specimen was found in the winter samples.

Remarks.--*Epistominella vitrea* may be the juvenile form of *Eponides antillarum*. It is abundant in the spring, when specimens of *E. antillarum* are found mainly in the macrofauna samples, and it is virtually absent in the summer and winter, when specimens of *E. antillarum* are more common in the microfauna samples and absent from macrofauna samples. However, differences in construction of apertures of the two species have been difficult to understand. Breaking intermediate sized specimens of *E. antillarum* in order to see preceding chambers always results in damage to the chamber wall.

Family CIBICIDIDAE Cushman, 1927

Subfamily CIBICIDINAE Cushman, 1927

Genus <u>CIBICIDES</u> de Montfort, 1808

<u>CIBICIDES</u> <u>CONCENTRICUS</u> (Cushman, 1918)

Truncatulina concentrica CUSHMAN, 1918, p. 64, Pl. 21, figs. 3a-c.

Cibicides concentricus (Cushman). PHLEGER & PARKER, 1951, p. 29, Pl. 15, figs. 14a, b, 15a, b; MURRAY, 1973, Pl. 7, figs. 1, 2.

Hanzawaia concentrica (Cushman). BANDY, 1956, p. 195; PHLEGER, 1960, Pl. 1, fig. 10; ANDERSEN, 1961, p. 124, Pl. 28, figs. 5a-c.

<u>Diagnosis</u>.--A species of *Cibicides* with peripheral margin rounded to subcarinate, sutures deep, with chambers on the dorsal side forming a concentric circle about the umbilical region. Test shape is variable due to attaching habit.

<u>Material</u>.--1700 living specimens.

<u>Distribution</u>.--*Cibicides concentricus* is a common species in the study area and accounts for 2.64% of the total live foraminiferal population. It occurs with the greatest frequency in the microfauna samples at the primary platforms and control sites in the winter, but is more commonly found in the macrofauna samples from these sites in the spring. No live specimens of *C. concentricus* were found in the spring samples from control sites C21 and C24. It

is a common species in the microfauna samples at P03 and P04, occurs only in the N500 samples at P01, and is rare at P02 and C23. Only one specimen was recovered at C22. *C. concentricus* is abundant at the macrofauna samples from P03, P04 and P02. In the summer samples, *C. concentricus* is rare in the macrofauna samples and was only found at P03 and P04. In the microfauna samples, *C. concentricus* is common at P03, absent at C24, and rare at the other primary platforms and control sites. It is absent at the secondary platforms S05, S07, S09, S13, S15, S17 and S19, and common to rare at the other secondary platforms. In the winter samples, *C. concentricus* is common at P02, P03, P04 and control sites, and rare at P01.

The majority of *C. concentricus* specimens came from water depths between 15 and 45 meters.

Superfamily ROTALIACEA Ehrenberg, 1839

Family ROTALIIDAE Ehrenberg, 1839

Subfamily ROTALIINAE Ehrenberg, 1839

Genus *AMMONIA* Brunnich, 1772

AMMONIA BECCARII (Linne, 1758)

Nautilus beccarii Linne, 1758, p. 710.

Rosalina parkinsoniana D'ORBIGNY, 1839, p. 99, Pl. 4, figs. 25-27.

Rotalia beccarii (Linnaeus) d'Orbigny. CUSHMAN, 1918, p. 18, Pl. 5, figs. 1a, b; Pl. 6, figs. 1a, b; p. 66, Pl. 23, figs. 3a-c; Pl. 24, figs. 1a-c, 2a-c; Pl. 25, figs. 1a-c.

Rotalia beccarii (Linnaeus) var. tepida CUSHMAN, 1926, p. 79, Pl. 1, figs. 1a-c.

"Rotalia" beccarii (Linne) var. parkinsoniana (d'Orbigny). PHLEGER & PARKER, 1951, p. 23, Pl. 12, figs. 6a, b; KORNFELD, 1931, p. 90, Pl. 13, figs. 1a-c; BOCK, 1971, p. 55, Pl. 20, figs. 5, 6.

"Rotalia" beccarii (Linne) var. tepida Cushman. KORNFELD, 1931, p. 91, Pl. 13, figs. 3a-c; PHLEGER & PARKER, 1951, p. 23, Pl. 12, figs. 7a, b.

"Rotalia" beccarii parkinsoniana (d'Orbigny). WARREN, 1956, Pl. 4, figs. 7, 8; WARREN, 1957, p. 39.

"Rotalia" beccarii tepida Cushman. WARREN, 1956, Pl. 4, figs. 9, 10; WARREN, 1957, p. 39.

"Rotalia" beccarii (Linne) variants. PARKER, 1954, p. 531, Pl. 10, figs. 1, 2, 5, 6; PHLEGER, 1956, p. 118.

Streblus beccarii (Linne) variants. LEHMANN, 1957, p. 349, Pl. 3, figs. 29-31; LANKFORD, 1959, p. 2099, Pl. 3, figs. 10, 13; PHLEGER, 1960, Pl. 1, figs. 18, 19; Pl. 7, fig. 28; Pl. 9, figs. 5, 23.

Streblus tepidus Cushman. BANDY, 1956, p. 197, Pl. 31, figs. 2a-c.

Streblus beccarii tepida (Cushman). ANDERSEN, 1961, p. 99, Pl. 22, figs. 2a, b.

Ammonia beccarii (Linne). WANTLAND, 1969, p. 109, Pl. 3, figs. 1-3; MURRAY, 1973, Pl. 2, figs. 1, 2; Pl. 8, figs. 1, 2; BROOKS, 1973, Pl. 10, figs. 5, 10.

Diagnosis.--A nearly equally biconvex species of Ammonia with inflated chambers, rounded periphery, and deep, open umbilicus.

Material.--2170 living specimens.

Distribution.--Ammonia beccarii comprises 3.37% of the total live foraminiferal population collected from the study area. It is common in all sampling seasons, with a somewhat higher frequency of occurrence in the spring and summer samples, although it accounts for a much higher percentage of the total live population in the winter samples.

A. beccarii is abundant only at P02 in the spring samples, where it makes up almost 20.00% of the total live population. It is common at P01, C22 and C24, and rare at the rest of the primary platforms and control sites. The summer sampling at the primary platforms and control sites follows this same pattern, with the exception that A. beccarii is also abundant at C24. It is also abundant at the secondary platform S05, absent at S13, S15, S17, S18, S19, and common to rare at the rest of the secondary platforms. In the winter, _A_. _beccarii_ is abundant at P01, P02, C21, C22 and C24, absent at C23 and rare at P03 and P04.

The majority of A. beccarii specimens were found in water depths between 9 and 50 meters, with the greatest number coming from P02 with a water depth of 12 meters.

Remarks.--It does not appear that there are two distinct species of _Ammonia_ in the samples. Variations seem to be within the normal range of a single species and are treated here as specimens of _Ammonia_ _beccarii_.

A twinned specimen of a juvenile _A_. _beccarii_ was found in the P02 W500 1.A winter sample.

Family ELPHIDIIDAE Galloway, 1933

Subfamily ELPHIDIINAE Galloway, 1933

Genus _ELPHIDIUM_ de Montfort, 1808

ELPHIDIUM _GUNTERI_ Cole, 1931

Elphidium _gunteri_ COLE, 1931, p. 34, Pl. 4, figs. 9, 10; PARKER, 1954, p. 508, Pl. 6, fig. 16; PHLEGER, 1954, p. 39, Pl. 2, figs. 3, 4; PHLEGER, 1956, p. 115; BANDY, 1956, p. 194, Pl. 30, figs. 19a, b; WARREN, 1957, p. 37; LEHMANN, 1957, p. 348, Pl. 3, figs. 1-4; PHLEGER, 1960, Pl. 7, fig. 18; Pl. 9, figs. 1, 17.

Elphidium _gunteri_ Cole var. _galvestonense_ KORNFIELD, 1931,

p. 87, Pl. 15, figs. 1a, b, 2a, b, 3a, b; PHLEGER & PARKER, 1951, p. 10, Pl. 5, figs. 13, 14.

Cellanthus gunteri Cole. WANTLAND, 1969, p. 109, Pl. 3, fig. 5.

Diagnosis.--A medium sized species of *Elphidium* with slightly depressed sutures, bridged by a double row of small, closely-spaced transverse crenulations, and umbilicus covered with granulations.

Material.--72 living specimens.

Distribution.--*Elphidium gunteri* is a rare species in the study area. It occurs in the greatest numbers in the spring samples from the primary platforms and control sites.

E. gunteri occurs only rarely in the spring samples except at P02 S2000 where it is a common species. It is absent at C21, C22, and C23.

E. gunteri was found only in the samples from P02, P03, and C24 of the primary platforms and control sites in the summer, and at the secondary platforms S08, S10, S12 and S20. It was common only at P02 W2000, rare at the other collecting stations. In the winter samples, *E. gunteri* was absent at C24, but present in samples from all other primary platforms and control sites. It is generally rare, but at the collecting stations P02 W500,P03 N2000 and C23, where foraminiferal counts are very low, one or two specimens will cause it to be a common species in the samples.

E. gunteri is a fairly shallow water species, and no specimens were found deeper than 45 meters.

Superfamily CASSIDULINACEA d'Orbigny, 1939

Family CAUCASINIDAE N. K. Bykova, 1959

Subfamily FURSENKOININAE Loeblich & Tappan, 1961

Genus *FURSENKOINA* Loeblich & Tappan, 1961

FURSENKOINA COMPLANATA (Egger, 1893)

Virgulina schreibersiana Czjzek var. *complanata* EGGER, 1893, p. 292, Pl. 18, figs. 91, 92.

Virgulina complanata Egger. CUSHMAN & TODD, 1945, p. 41, Pl. 6, fig. 22; PHLEGER & PARKER, 1951, p. 19, Pl. 9, figs. 1a, b, 2a, b, 3a, b; PARKER, 1954, p. 512, Pl. 7, fig. 6; LANKFORD, 1959, p. 2099, Pl. 3, fig. 1; PHLEGER, 1960, Pl. 5, fig. 23; ANDERSEN, 1961, p. 91, Pl. 20, figs. 2a, b.

Fursenkoina complanata (Egger). BOCK, 1971, p. 62, Pl. 23, fig. 6.

Diagnosis.--A slender, compressed, species of *Fursenkoina*, with somewhat overhanging earlier chambers, inflated later ones, and distinct, depressed sutures.

Material.--3600 living specimens.

Distribution.--*Fursenkoina complanata* is a common species in the study area, comprising 5.60% of the total live foraminiferal population. It occurs with a slightly greater frequency in the summer samples from the primary platforms and control sites than in the spring samples from those same sites, but is greatly reduced in the winter samples.

F. complanata is an abundant species at P04 in the spring, common at P03, and rare at the rest of the primary platforms and control sites. In the summer samples, F. complanata is again abundant at P04, common at P02 and P03, and rare at the rest of the primary platforms and control sites. At the secondary platforms, it was common at S07, S10, S11, S18 and S20, rare at the rest of the secondary platforms. In the winter samples, F. complanata was common at P03, rare at P01, P04, C21 and C24, and absent at P02, C22, and C23.

The majority of F. complanata specimens were found in water depths greater than 25 meters.

FURSENKOINA PONTONI (Cushman, 1932)

Virgulina pontoni CUSHMAN, 1932, p. 17, Pl. 3, fig. 7; CUSHMAN & TODD, 1945, p. 42, Pl. 6, fig. 23; PHLEGER & PARKER, 1951, p. 19, Pl. 9, figs. 9a, b, 10a, b; PARKER, 1954, p. 513, Pl. 7, fig. 9; PHLEGER, 1956, p. 120; WARREN, 1956, Pl. 3, fig. 32; WARREN, 1957,

p. 38; LANKFORD, 1959, p. 2099, Pl. 2, fig. 17; PHLEGER, 1960, Pl. 7, fig. 37; ANDERSEN, 1961, p. 92, Pl. 20, fig. 3.

Fursenkoina pontoni (Cushman), 1932. BOCK, 1971, p. 63, Pl. 23, fig. 9; BROOK 1973, Pl. 4, figs. 22-23.

Diagnosis.--A large species of Fursenkoina with long narrow chambers and distinct, only slightly depressed sutures.

Material.--155 living specimens.

Distribution.--Fursenkoina pontoni is a rare species in the study area and comprises only 0.24% of the total live foraminiferal population. It occurs with equal frequency in the spring and winter samples from the primary platforms and control sites, and with approximately half that frequency in the summer samples from those sites.

F. pontoni was absent at C21 and C24 in the spring samples, rare at all other collecting stations. In the summer samples, F. pontoni is absent at P01, P02, C21 and C22, rare at other primary platforms and control sites. It is found rarely at the secondary platforms S07, S09, S15 and S16, and is absent at the other secondary platforms. In the winter samples F. pontoni is absent at C22 and C23, and rare at the other collecting sites.

The majority of F. pontoni specimens were found living deeper than 12 meters.

FURSENKOINA sp.

Virgulina sp. LANKFORD, 1959, p. 2099, Pl. 3, fig. 2

Diagnosis.--A small dainty species of Fursenkoina. Chambers in early twisted biserial part of test somewhat inflated, becoming more elongate in latter, straighter chambers. Sutures distinct, depressed. Aperture slightly extended above and at an angle to last formed chamber. Size commonly 1/4 to 1/2 mm.

Material.--90 living specimens.

Distribution.--*Fursenkoina* sp. is rare in the study area and comprises only 0.14% of the total live formaminiferal population. It occurs most frequently in the spring samples.

Fursenkoina sp. is absent at PO3, PO4, C22, C23, and C24 in the spring. It is rare at PO1, PO2 and C21. In the summer, *Fursenkoina* sp. is absent at PO4, C22, and C23, rare at the other primary platforms and control sites. It also occurs with rare frequency at the secondary platforms S10, S11, S12, and S20, and is absent at the other secondary platforms. In the winter samples, *Fursenkoina* sp. was found only at PO1, PO2, and C24, where it is rare.

Fursenkoina sp. is a fairly shallow water species, not found deeper than 30 meters. The majority of the specimens were found between 12 and 20 meters.

Genus *VIRGULINELLA* Cushman, 1932

VIRGULINELLA PERTUSA (Reuss, 1861)

Virgulina pertusa REUSS, 1861, p. 362, Pl. 2, fig. 16.

Virgulina (*Virgulinella*) *pertusa* Reuss. CUSHMAN, 1932, p. 8, Pl. 3, figs. 16a, b; CUSHMAN, 1937, p. 31, Pl. 5, figs. 6-9; LANKFORD, 1959, p. 2099, Pl. 3, fig. 3.

Diagnosis.--A slender species of *Virgulinella* with deep, rather large, sutural openings outlining chambers.

Material.--8 living specimens.

Distribution.--*Virgulinella pertusa* is an extremely rare species in the study area. It was found only in the spring samples from the shallow stations at PO1 and PO2.

Family CASSIDULINIDAE d'Orbigny, 1839

Genus CASSIDULINA d'Orbigny, 1826

CASSIDULINA CRASSA d'Orbigny, 1839

Cassidulina crassa D'ORBIGNY, 1839, p. 56, Pl. 7, figs. 18-20; CUSHMAN, 1922, p. 124, Pl. 26, fig. 7; PHLEGER & PARKER, 1951, p. 26, Pl. 14, figs. 4a, b.

Cassidulina aff. crassa d'Orbigny. PARKER, 1954, p. 535, Pl. 10, fig. 31.

Diagnosis.--A small species of Cassidulina with few inflated and rounded chambers.

Material.--1 living specimen.

Distribution.--An extremely rare species in the study area, a single specimen of Cassidulina crassa was found in the spring samples from P02.

Superfamily NONIONACEA Schultze, 1854

Family NONIONIDAE Schultze, 1854

Subfamily NONIONINAE Schultze, 1854

Genus FLORILUS de Montfort, 1808

FLORILUS ATLANTICUS (Cushman, 1947)

Nonionella atlantica CUSHMAN, 1947, p. 90, Pl. 20, figs. 4a-c, 5; PHLEGER & PARKER, 1951, p. 11, Pl. 5, figs. 21a, b, 22a, b, 23a, b; PARKER, 1954, p. 507, Pl. 6, figs. 6, 7; PHLEGER, 1954, p. 642, Pl. 2, figs. 25, 26; PHLEGER, 1956, p. 117; BANDY, 1956, p. 195; WARREN, 1956, Pl. 3, figs. 23, 24; WARREN, 1957, p. 36; LANKFORD, 1959, p. 2098, Pl. 2, figs. 13a, b.

Pseudononion atlanticus (Cushman). ANDERSEN, 1961, p. 84, Pl. 18, figs. 1a, b, 2a-c.

Diagnosis.--A species of Florilus with about 10 chambers that gradually increase in size in the adult whorl, and distinct depressed sutures.

Material.--271 living specimens.

Distribution.--*Florilus atlanticus* is a rare species in the study area and comprises only 0.40% of the total live foraminiferal population. It occurs with equal frequency in the spring and summer samples from the primary platforms and control sites, less frequency in the winter samples.

F. atlanticus was absent in the spring samples from P01, P02, C21 and C22, common to rare at the individual collecting stations at P03, P04, C23 and C24. In the summer samples, *F. atlanticus* was a common species at P04, rare at P03, C23 and C24, and absent at the other primary platforms and control sites. It was rare in occurrence at the secondary platforms S14, S15, S16 and S18, and was absent at all other secondary platforms. In the winter samples, *F. atlanticus* was a common to rare species at individual collecting stations around the primary platforms P03 and P04, and 3 specimens were discovered in the samples from C21. It was absent at P01, P02, C22, C23 and C24.

F. atlanticus is a fairly deep water species and seems to prefer water depths between 30 and 45 meters.

Genus NONIONELLA Cushman, 1926

NONIONELLA BASILOBA Cushman and McCulloch, 1940

Nonionella basiloba CUSHMAN & McCULLOCH, 1940, p. 162, Pl. 18, figs. 3a-c; ANDERSEN, 1961, p. 85, Pl. 18, figs. 5a-c.

Nonionella opima CUSHMAN, 1947, p. 90, Pl. 20, figs. 1-3; PARKER, 1954, p. 501, Pl. 6, figs. 10-12; PHLEGER, 1954, p. 642, Pl. 2, figs. 27-29; PHLEGER, 1956, p. 117; LANKFORD, 1959, p. 2098, Pl. 2, figs. 10-12.

Nonionella cf. opima Cushman. PHLEGER & PARKER, 1951, p. 11, Pl. 6, figs. 1a, b, 2a, b; PHLEGER, 1960, Pl. 1, fig. 12; Pl. 9, figs. 6, 7.

Nonionella cf. *N. basiloba* Cushman & McCulloch. ANDERSEN, 1961, p. 85, Pl. 18, figs. 4a-c.

Diagnosis.--A small species of *Nonionella* with large, inflated, basal lobe developed on final chamber, comprising a large part of the test in ventral view; low peripheral aperture extends under the basal lobe on both sides.

Material.--28,778 living specimens.

Distributions.--*Nonionella basiloba* is the most abundant species in the study area, comprising 44.74% of the total live foraminiferal population. It occurs with the greatest frequency in the spring samples, is less frequent in the summer samples, and has the least frequency of occurrence in the winter samples. *N. basiloba* comprises 51.07% of the total live foraminiferal population in the spring samples. It is generally abundant at all collecting stations in the spring, except P02E500 and C24, where it is common. In the summer samples, *N. basiloba* accounts for 40.79% of the total live foraminiferal population. It is abundant at the collecting stations at P03 and P04 and at control sites C21, C22, and C23. It is common or rare when it is found at individual collecting stations at P01, P02 and C24. It is absent at N2000 and W2000 stations at P02. It is absent at the secondary platform S19, common at S05 and S18, and abundant at all other secondary platforms. In the winter samples, *N. basiloba* comprises 34.20% of the total live foraminiferal population. It occurs as an abundant species at all collecting stations at P03, and at the control sites C21, C23 and C24. It is common to abundant at P04 and C22. At P01 and P02, *N. basiloba* is absent at a few stations, and rare, common, or abundant at others.

N. basiloba is an abundant species at all water depths in the study area.

Remarks.--*N. basiloba* apparently prefers coarse-grained sediments to finer grained ones. Comparisons of *N. basiloba* with mean grain size show high correlations for the winter season. The numbers of *N. basiloba* increase as mean grain size increases. At the same time, the total organic carbon content of the sediment decreases. The only trace metal to show a significant correlation with *N. basiloba* was nickel. Large numbers of *N. basiloba* are correlated with the lowest amounts of nickel at the secondary platforms in the summer. Shallower waters and coarser grained sediments trap and hold lesser amounts of trace metals and organic carbon, and these are the stations where generally the highest counts of *N. basiloba* are found.

Family ANOMALINIDAE Cushman, 1927

Subfamily ANOMALININAE Cushman, 1927

Genus *MELONIS* de Montfort, 1808

MELONIS BARLEEANUM (Williamson, 1858)

Nonionina barleeana WILLIAMSON, 1858, p. 32, Pl. 3, figs. 68-69.

"*Nonion*" cf. *pompilioides* (Fichtel & Moll). PHLEGER & PARKER, 1951, p. 11, Pl. 5, fig. 20.

Gavelinonion barleeanum (Williamson). BARKER, 1960, p. 224, Pl. 109, figs. 8, 9.

"Nonion" barleeanus (Williamson). ANDERSEN, 1961, p. 82, Pl. 18, fig. 6.

Diagnosis.--A small, compressed and flattened species of Melonis, with straight, slightly depressed sutures and finely perforate test.

Material.--13 living specimens.

Distribution.--Melonis barleeanum is a very rare species in the study area. Specimens were found only in the spring and summer samples. M. barleeanum was found only at P02 and C21 in both the spring and summer samples.

M. barleeanum is probably a very shallow water species, but not enough specimens are available for verification. Specimens were found only in water depths up to 12 meters.

Remarks.--M. barleeanum resembles M. pompilioides Fichtel & Moll quite closely. However, M. pompilioides has been reported in very deep waters (2000 meters and deeper) in the Gulf of Mexico and Parker (1948) and Phleger & Parker (1951) believe this somewhat compressed, shallow water form to be M. barleeanum.

REFERENCES

*References not seen are marked with an asterisk.

Andersen, H. V., 1961. Foraminifera of the mudlumps, lower Mississippi River Delta: Louisiana Geological Survey, Geological Bulletin, no. 35, pt. 2, p. 1-208.

Anepohl, J. K., 1976. Seasonal distribution of living benthonic foraminifera of the South Texas outer continental shelf: unpublished Master's Thesis, University of Texas at Austin, 130 p.

Bandy, O. L., 1954. Distribution of some shallow-water foraminifera in the Gulf of Mexico: United States Geological Survey Professional Paper 254-F, p. 125-141.

____, 1956. Ecology of foraminifera in northeastern Gulf of Mexico: United States Geological Survey Professional Paper 274-G, p. 179-204.

Bandy, O. L., J. C. Ingleside and J. M. Resig, 1964a. Foraminifera, Los Angeles County outfall area, California: Limnology and Oceanography, v. 9, p. 124-137.

____, 1964b. Foraminiferal trends, Laguna Beach outfall area, California: Limnology and Oceanography, v. 9, p. 112-123.

____, 1965a, Foraminiferal trends, Hyperion outfall, California: Limnology and Oceanography, v. 10, p. 312-332.

____, 1965b. Modification of foraminiferal distribution by the Orange County outfall, California: Ocean Science and Ocean Engineering, p. 55-76.

Barker, R. W., 1960. Taxonomic notes on the species figured by H. B. Brady in his report on the foraminifera dredged by H.M.S. Challenger during the years 1873-1876: Society of Economic Paleontologists and Mineralogists, Special Publication no. 9, 280 p.

Bartlett, G. A., 1972. International Symposium on the identification and measurement of environmental pollutants: National Research Council of Canada, 277 p.

Bates, J.M., and R. S. Spencer, 1959. Modification of foraminiferal trends by the Chesapeake-Elizabeth sewage outfall, Virginia Beach, Virginia: Journal of Foraminiferal Research, v. 9, p. 125-140.

Bock, W. D., 1971. A handbook of the benthonic foraminifera of Florida Bay and adjacent waters: in, A symposium of Recent South Florida foraminifera: Miami Geological Society, Memoir 1, p. 1-72.

____, 1974. M. S., Distribution and significance of foraminifera in the MAFLA area: unpublished report to the Bureau of Land Management on results of spring-summer sampling, 1974, Outer Continental Shelf Environmental Benchmark, MAFLA.

____, 1976. Distribution and significance of foraminifera in the MAFLA area: in First International Symposium on Benthonic Foraminifera of Continental Margins, Part A. Ecology and Biology, C. T. Schafer and B. R. Pelletier eds.: Maritime Sediments, Special Publication 1, p. 221-237.

Boltovskoy, E., 1963. The littoral foraminiferal biocoenosis of Puerto Deseado (Patagonia, Argentina): Cushman Foundation for Foraminiferal Research Contributions, v. 2, p. 58-70.

____, 1966. Depth at which foraminifera can survive in sediments: Cushman Foundation for Foraminiferal Research Contributions, v. 17, p. 43-45.

____ and A. Boltovskoy, 1970. Additional note on unrecorded foraminifera from littoral of Puerto Deseado (Patagonia, Argentina): Cushman Foundation for Foraminiferal Research Contributions, v. 21, p. 148-155.

____ and R. Wright, 1976. Recent foraminifera: Junk, The Hague, 515 p.

Bradshaw, J. S., 1957. Laboratory studies on the rate of growth of the foraminifer Streblus beccarii (Linne) var. tepida (Cushman): Journal of Paleontology, v. 31, no. 6, p. 1138-1147.

*Brady, H. B., 1879. Notes on some of the reticularian rhizopoda of the Challenger Expedition: Part I, On new or little-known arenaceous types: Quarterly Journal of Micropaleontology Science, new ser., v. 19, p. 20-63.

Brasier, M. D., 1975. Ecology of Recent sediment-dwelling and phytal foraminifera from the lagoons of Barbuda, West Indies: Journal of Foraminiferal Research, v. 5, p. 42-622.

Buckley, D. E., E. H. Owens and C. T. Schafer, 1974. Canso Strait and Chedabucto Bay: a multidisciplinary study of the impact of man on the marine environment: in, Offshore Geology of Eastern Canada, v. 1, Concepts and Applications of Environmental Geology: Canada Geological Survey Paper no. 74-30, p. 133-160.

Bureau of Land Management, 1977. Request For Proposal No. AA550-RP8-2, Ecological Investigations of Petroleum Production Platforms in the Central Gulf of Mexico.

*Chaster, G. W., 1892. Report upon the foraminifera of the Southport Society of Natural Science District: Southport Society of Natural Science, Report, Southport, England, 1st Rept. (1890-91), Append.

Christiansen, J. H. J. and R. L. Ellison, 1965. Distribution of foraminifera in the Patuxent Estuary, Maryland (abst.): Virginia Academy of Science Annual Meeting for 1965.

Clark, D. F., 1971. Effects of aquaculture outfall on benthonic foraminifera in Clam Bay, Nova Scotia: Maritime Sediments, v. 7, p. 76-81.

Cole, W. S., 1931. The Pliocene and Pleistocene foraminifera of Florida: Florida State Geological Survey Bulletin 6, 79 p.

Cushman, J. A., 1918. Some Miocene foraminifera of the coastal plain of the United States: United States Geological Survey Bulletin 676, 100 p.

____, 1919. Fossil foraminifera from the West Indies: in Vaughan, T. W., Contributions to the geology and paleontology of the West Indies: Carnegie Institute, Washington, Publication 291, p. 1-100.

____, 1922. Shallow-water foraminifera of the Tortugas region: Carnegie Institute, Washington, Publication 311 (Department of Marine Biology, Papers, v. 17), Washington, D. C., p. 3-85.

____, 1922. The foraminifera of the Atlantic Ocean: Part 3. Textulariidae: United States National Museum, Bulletin 104, pt. 3, 143 p.

____, 1923. The foraminifera of the Atlantic Ocean: Part 4. Lagenidae: United States National Museum, Bulletin 104, pt. 4, 228 p.

____, 1931. The foraminifera of the Atlantic Ocean: Part 8. Rotaliidae, Amphisteginidae, Calcarinidae, Cymbaloporettidae, Globorotaliidae, Anomalinidae, Planorbulinidae, Rupertiidae, and Homotremidae: United States National Museum, Bulletin 104, 79 p.

____, 1932. Notes on the genus Virgulina: Contributions from the Cushman Laboratory for Foraminiferal Research, v. 8, pt. 1, p. 7-23.

____, 1935. Fourteen new species of foraminifera: Smithsonian Institute Miscellaneous Collection, v. 91, no. 21, p. 1-9.

____, 1937. A monograph of the subfamily Virgulininae of the foraminiferal family Buliminidae: Cushman Laboratory for Foraminiferal Research, Special Publication 9, 228 p.

____, 1944. Foraminifera from the shallow water of the New England coast: Cushman Laboratory for Foraminiferal Research, Special Publication No. 12, 37 p.

____, 1947. New species and varieties of foraminifera from off the southeastern coast of the United States: Contributions from the Cushman Laboratory for Foraminiferal Research, v. 23, pt. 4.

____ and P. W. Jarvis, 1930. Miocene foraminifera from Buff Bay, Jamaica: Journal of Paleontology, v. 4, p. 353-368.

____ and R. Todd, 1945. Miocene foraminifera from Buff Bay, Jamaica: Cushman Laboratory for Foraminiferal Research, Special Publication No. 15, p. 1-73.

____ and F. L. Parker, 1937. Notes on some Pliocene and Pleistocene Species of Bulmina and Buliminella: Contributions from the Cushman Laboratory for Foraminiferal Research, v. 30, p. 40-53.

____ and I. McCulloch, 1950. Some Lagenidae in the collections of the Allan Hancock Foundation: Allan Hancock Pacific Expeditions, v. 6, no. 6, p. 295-364.

Davis, J. C., 1973. Statistics and data analysis in geology: John Wiley & Sons, Inc., New York, 550 p.

Dhillon, D. S., 1969. An abnormal Astacolus from the Holocene, Gantheaume Bay, Western Australia: Cushman Foundation for Foraminiferal Research Contributions, v. 20, p. 99.

____, 1970. An abnormal Ammotium from the Holocene, West Malaysia: Micropaleontology, v. 16, no. 1, p. 59-60.

*d'Orbigny, A. D., 1826. Tableau methodique de la classe des Cephalopodes: Annes Science Natura Paris, v. 7, p. 245-314.

*____, 1839. Foraminiferes in Sagra, Ramon de la, Histoire physique, ploitique et naturelle de l'ile de Cuba, p. 1-224.

*____, 1839. Voyage dans l'Amerique Meridionale-Foraminiferes: v. 5, pt. 5, "Foraminiferes", p. 1-86.

Douglas, R. G., 1972. Paleozoography of Late Cretaceous planktonic foraminifera in North America: Journal of Foraminiferal Research, v. 2, p. 14-34.

Earland, A., 1933. Foraminifera, Part II. South Georgia: Discovery Reports, v. 7, p. 27-138.

Earland, 1934. Foraminifera, Part 3, The Falklands sector of the Antarctic (excluding South Georgia): Discovery Reports, v. 10, p. 1-208.

____, 1936. Foraminifera, Part 4, Additional Records from the Weddell Sea sector from material obtained by the S. Y. Scotia: Discovery Reports, v. 13, p. 1-59.

*Egger, J. G., 1893. Foraminiferen aus Meeresgrundproben, gelothet von 1874 bis 1876 von S. M. Sch. Gzelle: K. Bayer, Akademie Wissen Munchen, Mathematics-Physics Cl., Abhandl., v. 18, p. 193-458.

Ellison, S., 1953. An abnormal Uvigerina from the Upper Eocene, Mississippi: Cushman Foundation for Foraminiferal Research Contributions, v. 4, p. 66-67.

Fish, A. G., L. L. Massey, J. R. Inabet, & P. L. Lewis, 1974: A study of the effects of environmental factors upon the distribution of the selected sandy beach organisms of Timbalier Bay, Louisiana: M. S. Final Report submitted to Gulf University Research Consortium, Petroleum & Allied Industry Sponsored offshore Ecologic Investigations, 84 p.

Fisher, R. A., A. S. Corbett and C. B. Williams, 1943. The relationship between the number of species and the number of individuals in a random sample of an animal population: Journal of Animal Ecology, v. 12, p. 42-58.

Frerichs, W. E., 1969. Recent arenaceous foraminifera from the Gulf of Mexico: University of Kansas Paleontology Contributions, Paper 46, p. 1-2.

Galloway, B. J., 1978. Report on biofouling activities: Southwest Research Institute. Second quarterly report of ecological investigations of petroleum production platforms in the central Gulf of Mexico.

Gibson, L. B., 1966. Some unifying characteristics of species diversity: Contr. Cushman Foundation for Foraminiferal Research Contributions, v. 17, p. 117-124.

*Goes, A., 1896. The Foraminifera, in Reports on the dredging operations off the west coast of Central America to the Galapagos, to the west coast of Mexico, and in the Gulf of California, in charge of Alexander Agassiz, carried on by the U. S. Fish Commission Steamer "Albatross," during 1891, Lieut. Commander Z. L. Tanner, U. S. N., Commanding: Harvard College, Museum of Comparative Zoology, Bulletin, v. 29, p. 1-103.

Hoglund, H., 1947. Foraminifera in the Gullmar Fjord and the Skagerak: Zoologiska Bidrag Uppsala 16:1-328.

Hueni, C. D., 1979. Living benthonic foraminifera of the South Texas shelf: temporal variations and associated ecologic and paleoecologic implications: M. S. Thesis, Rice University, 154 p.

Imbrie, J. and E. G. Purdy, 1962. Classification of modern Bahamian carbonate sediments, in Classification of carbonate rocks, a symposium: American Association of Petroleum Geologists, Memoir 1. 279 p.

Koch, G. S., Jr. and R. F. Link, 1971. Statistical Analysis of Geological Data: John Wiley and Sons, New York, 438 p.

Kornfeld, M. M., 1931. Recent littoral foraminifera from Texas and Louisiana: Contributions, Department of Geology, Stanford University, v. 1, p. 75-101.

Lankford, R. R., 1959. Distribution and ecology of the foraminifera from East Mississippi Delta margin: American Association of Petroleum Geologists, v. 43, p. 2068-2099.

Le Campion, L. E., 1970. Contribution a l'etude des Foraminiferes du bassin d'Arcachon et du proche ocean: Bulletin Institute Geologie Bassin Aquitaine, v. 8, p. 1-98.

Le Furgey, A. and J. St. Jean, Jr., 1976. Foraminifera in brackish-water ponds designed for waste control and aquaculture studies in North Carolina: Journal of Foraminiferal Research, v. 6, p. 274-294.

Lidz, L., 2965. Sedimentary environment and foraminiferal parameters--Nantucket Bay, Massachusetts. Limnology and Oceanography, v. 10, p. 392-402.

*Linne, C., 1767. Systema Natura 12.

Loeblich, A. R., Jr. and H. Tappan, 1964. Treatise on invertebrate paleontology: Part C Protista: Geological Society of America and University of Kansas Press. 900 p.

____, 1974. Recent advances in the classification of the foraminiferida, in Foraminifera: R. H. Hedley & C. G. Adams, eds., v. 1, Academic Press, Inc., London, p. 1-53.

Loep, K. J., 1965. A study of ecology and distribution of recent foraminifera in the northwest Gulf of Mexico: Gulf Coast Association of Geological Societies, Transactions, v. 15, p. 167-177.

Lowman, S. W., 1949. Sedimentary facies in Gulf Coast: Bulletin of the American Association of Petroleum Geologists, v. 33, p. 1939-1997.

Lynts, G. W., 1962. Distribution of recent foraminifera in upper Florida Bay and associated sounds: Cushman Foundation for Foraminiferal Research Contributions, v. 13, p. 127-144.

____, 1965. Observations on some Recent Florida Bay foraminifera: Cushman Foundation for Foraminiferal Research Contributions, v. 16, p. 67-69.

____, 1966. Variation of foraminiferal standing crop over short distances in Buttonwood Sound, Florida Bay: Limnology and Oceanography, v. 11, p. 562-566.

____, 1971. Distribution and model studies on foraminifera living in Buttonwood Sound, Florida Bay: A Symposium of Recent South Florida Foraminifera, Miami Geological Society, Memoir 1, p. 73-115.

Lutze, G. F. and R. Wolf, 1976. Persian Gulf Foraminifera, depth distribution and sea level change: In, First International Symposium on Benthonic Foraminifera of Continental Margins, Part B. Paleoecology and Biostratigraphy: Maritime Sediments Special Publication No. 1, p. 425-430.

Matoba, Y., 1976. Recent foraminiferal assemblages off Sendai, northeast Japan: In, First International Symposium on Benthonic Foraminifera of Continental Margins, Part A. Ecology and Biology: Maritime Sediments Special Publication No. 1, p. 205-220.

Moore, W. E., 1957. Ecology of Recent Foraminifera in northern Florida Keys: Bulletin of the American Association of Petroleum Geologists, v. 41, p. 727-741.

Myers, E. H., 1943. Life activities of foraminifera in relation to marine ecology: American Philosophical Society, Proceedings, v. 86, p. 439-458.

Murray, J. W., 1968: Living foraminifers of lagoons and estuaries: Micropaleontology, v. 14, p. 435-455.

____, 1970. The foraminifera of the hypersaline Abu Dhabi Lagoon, Persian Gulf: Lethaia, v. 3, p. 51-68.

____, 1971. Living foraminiferids of tidal marshes: A review: Journal of Foraminiferal Research, v. 1, p. 153-161.

____, 1973. Distribution and ecology of living benthic foraminiferids: Crane, Russak & Co., Inc., New York, 174 p.

____, 1976. Comparative Studies of living and dead benthic foraminiferal distributions: In, Foraminifera, v. 2, R. H. Hedley & C. G. Adams, eds.: Academic Press, London, p. 63-84.

____, 1979. Recent benthic foraminiferids of the Celtic Sea: Journal of Foraminiferal Research, v. 9, p. 193-209.

Parker, F. L., 1948. Foraminifera of the Continental Shelf from the Gulf of Maine to Maryland: Harvard College, Museum of Comparative Zoology Bulletin, v. 106, p. 391-423.

____, 1952. Foraminiferal distribution in the Long Island Sound - Buzzards Bay area: Harvard College, Museum of Comparative Zoology Bulletin, v. 106, p. 395-415.

____, 1954. Distribution of the foraminifera in the northeastern Gulf of Mexico: Harvard College, Museum of Comparative Zoology, Bulletin 111, p. 453-588.

Phleger, F. B., 1951. Ecology of foraminifera northwest Gulf of Mexico, Part I. Foraminifera distribution: Geological Society of America, Memoir 46, p. 1-88.

____, 1954. Ecology of foraminifera and associated microorganisms from Mississippi Sound and environs: American Association of Petroleum Geologists, Bulletin, v. 38, p. 584-647.

____, 1955. Ecology of foraminifera in southeastern Mississippi Delta area: American Association of Petroleum Geologists, Bulletin, v. 39, p. 712-759.

____, 1956. Significance of living foraminiferal populations along the central Texas coast: Cushman Foundation for Foraminiferal Research Contributions, v. 7, p. 106-151.

____, 1960a. Sedimentary patterns of microfaunas in northern Gulf of Mexico: in Recent sediments, Northwest Gulf of Mexico. F. B. Shepard, F. B. Phleger, and T. H. Van Andel, eds. American Association of Petroleum Geologists, p. 267-301.

____, 1960b. Ecology and distribution of recent foraminifera: Johns Hopkins Press, Baltimore, 297 p.

____, 1976. Benthic foraminiferids as indicators of organic production in marginal marine areas: in, First International Symposium on Benthonic Foraminifera of Continental Margins, Part A. Ecology and Biology, C. T. Schafer and B. R. Pelletier eds.: Maritime Sediments, Special Publication 1, p. 107-118.

____ and F. L. Parker, 1951. Ecology of foraminifera, northwestern Gulf of Mexico: Geological Society of America, Memoir 46, 64 p.

*Reuss, A. E., 1861. Beitrage zur Kenntniss der tertiaren Foraminiferen-Fauna (Zweite Folge): K. Akad. Wiss. Wien, math.-naturwiss. Cl., Sitzungsber 44:355-396.

Schafer, C. F. and F. E. Cole, 1974. Distributions of benthonic foraminifera: in, Offshore Geology of Eastern Canada, v. 1, Concepts and Applications of Environmental Geology: Canada, Geological Survey, Paper 74-30, p. 103-108.

____, F. J. Wagner and C. Ferguson. 1975. Occurrence of foraminifera, molluscs and ostracods adjacent to the industrialized shoreline of Canso Strait, Nova Scotia: Water, Air and Soil Pollution, v. 5, p. 79-96.

Scott, D. B., C. T. Schafer, and E. S. Medioli, 1980. Eastern Canadian Estuarine foraminifera: A framework for comparison: Journal of Foraminiferal Research, v. 10, p. 205-234.

Sen Gupta, B. K., 1979. Foraminifera of South Atlantic/Georgia Right: in, Results of studies of Georgia Right of South Atlantic Ocean, South Atlantic Benchmark Program (OCS) Environmental Studies. 51 p.

Sen Gupta, B. K., R. F. Lee, and M. S. May, III, 1981. Upwelling and an unusual assemblage of benthic foraminifera on the northern Florida Continental slope: Journal of Paleontology, v. 5, p. 853-857.

Sieglie, G. A., 1975. Foraminifera of Guayanilla Bay and their use as environmental indicators: Revista Espanola di Micropaleontologia, v. 7, p. 453-587.

Smith, R. N., 1971. Survey of marine waste deposits, New York metropolitan region: Marine Science Research Center, State University of New York, Stony Brook, Technical Report 8, p. 8.

Smith, S. L., 1971. Distribution of Recent foraminifera in lower Florida Bay: in A symposium of Recent South Florida Bay Foraminifera: Miami Geological Society, Memoir 1, p. 116-130.

Southwest Research Institute proposal for ecological investigations of petroleum production platforms in the central Gulf of Mexico, in response to RFP No. AA550-RP8-2, to Bureau of Land Management, New Orleans, OCS, 1977.

Southwest Research Institute, 1978. First Quarterly Report, Ecological Investigations of petroleum production platforms in the central Gulf of Mexico, to Bureau of Land Management, New Orleans, OCS.

____, 1978. Second Quarterly Report, Ecological investigations of petroleum production platforms in the central Gulf of Mexico, to Bureau of Land Management, New Orleans, OCS.

____, 1980. Final Report, Ecological investigations of petroleum production platforms in the central Gulf of Mexico, to Bureau of Land Management, New Orleans, OCS.

Tresslar, R. C., 1974a. The living benthonic foraminiferal fauna of the West Flower Garden Bank coral reef and biostrome: M. S. Thesis, Texas A. & M. University, College Station, Tx. 205 p.

____, 1974b. Foraminifera: in, Biota of the West Flower Garden Bank, T. J. Bright and L. H. Pequegnat eds., Gulf Pub. Co., p. 68-91.

Valentine, J. W., 1973. Evolutionary Paleoecology of the Marine Biosphere: Prentice-Hall Inc., Englewood Cliffs, N. J. 498 p.

Walton, W. R., 1952. Techniques for recognition of living foraminifera: Cushman Foundation for Foraminiferal Research Contributions, v. 3, p. 56-60.

____, 1964. Recent foraminiferal ecology and paleoecology: in, Approaches to Paleoecology, John Imbrie and Norman Newell, eds. John Wiley & Sons, Inc., p. 151-237.

Wantland, K. F., 1969. Distribution of modern brackish-water foraminifera in Trinity Bay: in, Galveston Bay Geology, R. R. Lankford and J. W. Rodgers, eds., Houston Geological Society Special Publication, 141 p.

Warren, A. D., 1956. Ecology of foraminifera of the Buras-Scofield Bayou region, Southeast Louisiana: Gulf Coast Association of Geological Societies, Transactions, v. 6, p. 131-151.

____, 1957. Foraminifera of the Buras-Scofield Bayou region, southeast Louisiana: Cushman Foundation for Foraminiferal Research Contributions v. 8, p. 29-40.

Watkins, J. G., 1961. Foraminiferal ecology around the Orange County, California, ocean sewer outfall: Micropaleontology, v. 7, p. 199-206.

*Williamson, W. C., 1858. On the recent foraminifera of Great Britain: Royal Socient 4to, London, p. 1-107.

Wright, R. C. and W. W. Hay, 1971. The abundance and distribution of foraminifers in a back-reef environment, Molasses Reef, Florida: Miami Geological Society, Memoir 1, p. 121-174.

Wright, C. A. & J. W. Murray, 1972. Comparison of modern and paleogene foraminiferal distributions and their environmental implications: Extrait du Mars du B.R.G.M. 79:89-96.

APPENDIX A--Data used for correlation coefficients. (Total foraminifera counts; total *Buliminella bassendorfensis* counts; total *Nonionella basiloba* counts; weight percent of total organic carbon; barium, cadmium, chromium, copper, iron, lead, nickel, vanadium, and zinc in ppm; and mean sediment grain size.) Except for the trace elements, which were measured in the spring at the primary platforms and control sites and in the summer at the secondary platforms, the data are for all collecting seasons. All data except foraminifera counts were furnished by SwRI.

SPRING

Station	Total Foraminifera	*Buliminella bassendorfensis*	*Nonionella basiloba*	Total Organic Carbon	Barium	Cadmium
P01 N500	467	123	250	0.52	61.6	0.4
P01 N2000	652	213	343	0.77	60.8	0.3
P01 E500	686	207	439	0.79	17.2	0.2
P01 E2000	474	157	247	0.68	26.4	0.2
P01 S500	212	144	49	0.66	45.2	0.4
P01 S2000	852	242	553	0.74	44.4	0.3
P01 W500	1227	243	909	0.71	36.1	0.2
P01 W2000	1200	268	874	0.72	42.2	0.4
P02 N500	49	4	12	0.64	81.8	0.3
P02 N2000	440	6	86	0.71	117.6	0.4
P02 E500	170	4	16	0.61	43.4	0.2
P02 E2000	296	16	178	0.43	92.8	0.3
P02 S500	383	12	129	0.58	55.4	0.3
P02 S2000	638	23	452	0.72	87.2	0.3
P02 W500	28	2	15	0.38	68.6	0.2
P02 W2000	35	0	18	0.67	89.4	0.3

SPRING

Station	Chromium	Copper	Iron	Lead	Nickel	Vanadium	Zinc	Mean Grain Size
P01 N500	6.9	9.3	0.6	9.5	13.4	8.9	51.6	5.30
P01 N2000	10.2	13.5	0.9	11.4	18.9	7.2	48.3	6.49
P01 E500	9.6	14.5	0.8	10.0	14.0	7.0	35.2	6.69
P01 E2000	7.7	11.8	0.7	8.5	11.1	4.3	32.7	5.47
P01 S500	7.8	13.2	0.7	11.1	14.0	9.2	42.1	6.03
P01 S2000	10.7	13.7	1.0	12.3	15.5	13.3	42.7	6.29
P01 W500	11.0	12.7	0.9	11.3	14.0	6.7	39.4	5.81
P01 W2000	7.9	12.2	0.6	10.3	14.4	7.1	43.1	5.69
P02 N500	6.1	13.9	0.7	12.1	8.2	12.0	30.8	5.70
P02 N2000	4.8	10.3	0.5	9.7	8.6	7.7	27.5	5.42
P02 E500	6.3	10.1	0.7	10.5	8.0	7.9	25.0	5.17
P02 E2000	4.8	9.7	0.5	9.3	8.2	4.5	25.7	5.31
P02 S500	5.8	9.3	0.6	10.1	10.6	5.6	26.8	5.49
P02 S2000	5.5	11.7	0.5	10.4	11.1	25.4	30.8	6.26
P02 W500	5.7	6.4	0.6	8.8	13.0	6.0	29.1	4.82
P02 W2000	8.4	16.1	1.0	12.8	12.0	13.6	33.6	7.21

SPRING

Station	Total Foraminifera	*Buliminella bassendorfensis*	*Nonionella basiloba*	Total Organic Carbon	Barium	Cadmium
P03 N500	306	45	234	0.33	34.6	0.1
P03 N2000	96	7	67	0.17	33.2	0.2
P03 E500	653	31	317	0.26	78.4	0.1
P03 E2000	366	68	256	0.18	44.2	0.1
P03 S500	520	121	350	0.26	61.4	0.1
P03 S2000	942	269	620	0.69	52.2	0.1
P03 W500	843	109	640	0.28	64.6	0.1
P03 W2000	1001	127	846	0.72	35.0	0.2
P04 N500	579	209	258	0.73	76.8	0.1
P04 N2000	763	206	341	0.74	48.6	0.1
P04 E500	1040	299	352	0.76	77.8	0.1
P04 E2000	1147	411	402	0.75	97.4	0.1
P04 S500	832	403	210	0.67	132.4	0.1
P04 S2000	1054	358	407	0.85	84.6	0.3
P04 W500	938	438	298	0.62	75.6	0.1
P04 W2000	964	332	315	0.75	80.0	0.1

SPRING Station	Chromium	Copper	Iron	Lead	Nickel	Vanadium	Zinc	Mean Grain Size
P03 N500	4.3	3.2	0.4	5.0	6.5	2.9	18.6	3.42
P03 N2000	6.8	10.1	0.6	10.5	7.5	7.9	24.0	2.83
P03 E500	5.4	4.1	0.4	6.0	7.8	4.8	20.0	3.80
P03 E2000	4.2	2.4	0.4	4.5	7.1	3.1	19.2	3.64
P03 S500	5.3	2.6	0.4	6.5	6.0	4.7	18.2	3.54
P03 S2000	7.2	8.0	0.6	6.8	19.5	8.1	32.0	5.40
P03 W500	5.4	3.6	0.5	6.2	7.7	6.1	25.0	3.74
P03 W2000	5.6	7.8	0.5	8.5	7.8	13.1	25.7	4.67
P04 N500	9.5	10.2	0.8	9.6	17.0	10.6	33.6	6.16
P04 N2000	9.2	9.6	0.8	9.4	15.0	8.6	33.6	6.12
P04 E500	10.1	10.7	0.7	8.1	18.2	8.8	31.8	6.16
P04 E2000	7.1	10.0	0.6	9.6	19.8	10.9	35.9	6.24
P04 S500	9.6	10.9	0.9	11.4	20.7	10.8	43.0	5.93
P04 S2000	9.7	10.6	0.9	10.0	21.6	12.8	41.6	5.99
P04 W500	9.0	11.0	0.7	8.2	17.7	14.5	33.9	5.60
P04 W2000	11.0	10.5	2.0	10.9	17.3	15.7	37.0	6.35

SPRING

Station	Total Foraminifera	*Buliminella bassendorfensis*	*Nonionella basiloba*	Total Organic Carbon	Barium	Cadmium
C21	1317	157	903	0.54	68.7	0.4
C22	1118	188	791	0.56	26.8	0.2
C23	422	183	165	0.69	47.5	0.1
C24	321	219	11	0.91	26.6	0.1

SUMMER

Station	Total Foraminifera	*Buliminella bassendorfensis*	*Nonionella basiloba*	Total Organic Carbon	Mean Grain Size
P01 N500	83	74	1	0.81	6.60
P01 N2000	55	38	10	0.74	6.34
P01 E500	187	134	25	0.83	5.84
P01 E2000	309	246	42	0.58	5.40
P01 S500	18	8	5	0.82	5.97
P01 S2000	143	99	39	0.71	6.10
P01 W500	95	73	4	0.79	6.24
P01 W2000	220	122	92	0.74	5.87

SUMMER

Station	Total Foraminifera	*Buliminella bassendorfensis*	*Nonionella basiloba*	Total Organic Carbon	Mean Grain Size
P02 N500	6	1	1	0.59	6.43
P02 N2000	20	3	0	0.55	5.80
P02 E500	20	3	1	0.27	4.41
P02 E2000	83	18	13	0.45	4.98
P02 S500	11	1	2	0.32	5.02
P02 S2000	54	12	21	0.42	6.24
P02 W500	17	4	1	0.27	4.41
P02 W2000	25	1	0	0.60	7.64
P03 N500	530	161	304	0.20	4.07
P03 N2000	682	129	500	0.19	2.55
P03 E500	1023	260	660	0.24	3.56
P03 E2000	303	103	177	0.19	3.49
P03 S500	126	36	68	0.26	3.68
P03 S2000	379	150	189	0.59	6.21
P03 W500	745	205	424	0.45	4.27
P03 W2000	907	220	548	0.43	4.69

SUMMER

Station	Total Foraminifera	*Buliminella bassendorfensis*	*Nonionella basiloba*	Total Organic Carbon	Mean Grain Size	
P04 N500	1008	271	498	0.64	6.27	
P04 N2000	800	242	413	0.64	6.74	
P04 E500	1004	302	440	0.67	6.38	
P04 E2000	862	229	359	0.75	6.51	
P04 S500	1121	353	443	0.61	5.81	
P04 S2000	1272	382	490	0.76	6.12	
P04 W500	1183	450	429	0.66	5.92	
P04 W2000	923	312	304	0.70	6.25	
C21	722	217	118	0.90	6.69	
C22	194	49	122	0.65	5.53	
C23	1102	611	304	0.64	6.68	
C24	772	575	14	0.71	6.81	
					Barium	Cadmium
S05 N500	7	0	2	0.62	0.6	5.5
S05 N2000	26	3	0	0.41	0.8	5.9
S06 N500	13	4	4	0.89	0.4	16.2
S06 N2000	35	9	6	0.94	0.5	15.4

SUMMER

Station	Total Foraminifera	*Buliminella bassendorfensis*	*Nonionella basiloba*	Total Organic Carbon	Barium	Cadmium
S07 N500	27	11	9	0.87	0.3	13.1
S07 N2000	346	195	106	0.96	0.4	13.0
S08 N500	980	587	337	0.70	0.3	9.4
S08 N2000	1024	631	333	0.61	0.2	11.1
S09 N500	521	362	79	0.87	0.3	9.4
S09 N2000	38	28	5	0.87	0.4	13.9
S10 N500	119	33	54	0.86	0.6	8.7
S10 N2000	470	126	206	0.84	0.4	8.2
S11 N500	37	6	9	0.56	0.2	7.4
S11 N2000	880	112	456	0.86	0.3	8.8
S12 N500	584	141	342	0.53	0.6	8.6
S12 N2000	293	80	155	0.61	0.4	5.7
S13 N500	1	0	0	1.05	0.6	15.0
S13 N2000	20	14	5	1.10	0.4	16.4
S14 N500	5	1	3	0.62	0.3	9.3
S14 N2000	137	106	19	0.67	0.2	9.6

SUMMER

Stations	Total Foraminifera	*Buliminella bassendorfensis*	*Nonionella basiloba*	Total Organic Carbon	Barium	Cadmium
S15 N500	1	0	1	0.68	0.3	14.2
S15 N2000	68	35	18	0.68	0.3	10.1
S16 N500	295	127	117	0.78	0.3	8.1
S16 N2000	280	151	73	0.76	0.4	14.0
S17 N500	2	1	1	0.72	0.2	14.5
S17 N2000	0	0	0	0.69	0.2	10.7
S18 N500	8	3	0	0.70	0.3	9.7
S18 N2000	105	81	5	0.64	0.1	9.4
S19 N500	2	0	0	0.15	0.0	3.2
S19 N2000	0	0	0	0.07	0.0	2.3
S20 N500	575	205	331	0.45	0.2	7.3
S20 N2000	337	94	197	0.48	0.2	6.3

SPRING

Station	Chromium	Copper	Iron	Lead	Nickel	Vanadium	Zinc	Mean Grain Size
C21	7.0	13.2	0.8	12.4	12.3	9.4	40.3	5.16
C22	7.0	10.9	0.7	8.9	14.2	6.8	33.7	5.07
C23	7.4	7.7	0.7	9.2	17.9	11.6	34.3	6.37
C24	9.5	10.7	0.9	9.9	21.3	7.5	37.2	6.67

SUMMER

Station	Chromium	Copper	Iron	Lead	Nickel	Vanadium	Zinc	Mean Grain Size
S05 N500	8.8	8.8	0.5	12.3	36.3	86.0	7.5	5.87
S05 N2000	17.4	12.5	0.6	13.6	42.4	123.8	9.6	5.37
S06 N500	15.6	15.2	0.9	29.5	65.0	18.4	14.4	8.12
S06 N2000	14.7	11.8	0.9	24.3	50.6	52.2	9.8	8.16
S07 N500	13.6	14.5	0.8	27.3	52.7	62.0	12.1	8.56
S07 N2000	12.1	10.6	0.8	22.2	45.8	60.8	15.2	7.12
S08 N500	14.2	13.5	0.7	15.1	49.9	46.6	10.2	6.94
S08 N2000	12.8	14.2	0.8	16.9	49.2	37.2	17.9	6.15
S09 N500	13.2	10.4	0.6	24.1	48.5	89.4	20.6	6.64
S09 N2000	13.4	13.5	1.0	23.6	47.5	15.4	14.5	6.75

SUMMER

Station	Chromium	Copper	Iron	Lead	Nickel	Vanadium	Zinc	Mean Grain Size
S10 N500	13.7	13.0	0.9	6.7	32.3	60.8	10.9	4.29
S10 N2000	9.9	12.4	0.7	9.2	40.1	60.8	12.6	4.13
S11 N500	7.0	11.1	0.6	7.0	32.5	35.2	6.5	4.06
S11 N2000	12.8	14.7	0.7	10.4	42.0	13.0	9.2	4.55
S12 N500	15.5	11.8	0.8	9.2	35.2	55.0	13.2	6.89
S12 N2000	12.2	10.0	0.5	10.2	36.3	72.8	7.7	6.14
S13 N500	14.7	12.1	0.9	24.3	57.1	32.4	2.3	7.44
S13 N2000	15.5	15.3	0.9	30.0	66.0	51.8	11.6	7.97
S14 N500	7.3	8.7	0.7	13.4	36.2	49.2	8.4	6.44
S14 N2000	7.5	9.9	0.7	10.7	34.7	79.4	11.8	6.96
S15 N500	8.7	14.0	0.8	42.5	71.0	493.4	12.5	6.54
S15 N2000	6.5	11.8	0.7	12.3	31.1	57.2	12.9	6.68
S16 N500	8.9	8.2	0.5	23.0	44.5	57.4	18.6	6.65
S16 N2000	7.5	11.4	0.7	20.1	71.4	50.6	19.8	6.49
S17 N500	7.9	11.7	0.7	59.3	64.6	193.4	12.1	6.54
S17 N2000	6.2	10.1	0.7	17.4	33.8	114.2	10.4	6.70

SUMMER

Station	Chromium	Copper	Iron	Lead	Nickel	Vanadium	Zinc	Mean Grain Size
S18 N500	7.5	9.1	0.7	11.5	13.7	87.6	9.2	6.79
S18 N2000	6.6	9.6	0.7	14.7	30.8	45.8	9.4	6.21
S19 N500	0.9	5.7	0.3	2.1	16.3	00.0	2.1	3.22
S19 N2000	1.1	4.4	0.2	2.1	17.5	00.0	3.2	3.25
S20 N500	4.8	9.2	0.5	7.9	31.2	97.8	8.5	4.58
S20 N2000	9.7	8.3	0.5	12.0	29.5	56.0	8.2	5.89

WINTER Stations	Total Foraminifera	*Buliminella bassendorfensis*	*Nonionella basiloba*	Total Organic Carbon	Mean Grain Size
P01 N500	27	6	1	0.71	6.64
P01 N2000	83	22	3	0.68	6.55
P01 E500	33	21	0	0.78	6.63
P01 E2000	67	15	9	0.64	5.37
P01 S500	61	19	5	0.64	5.98
P01 S2000	28	11	6	0.71	5.74
P01 W500	52	15	3	0.67	6.40
P01 W2000	85	18	26	0.71	6.23
P02 N500	25	0	1	0.56	6.59
P02 N2000	34	1	0	0.36	5.78
P02 E500	7	0	2	0.58	4.55
P02 E2000	134	5	2	0.35	5.39
P02 S500	98	2	1	0.43	4.79
P02 S2000	97	10	0	0.38	5.47
P02 W500	15	1	1	0.48	7.14
P02 W2000	55	1	0	0.54	7.46

WINTER Stations	Total Foraminifera	*Buliminella bassendorfensis*	*Nonionella basiloba*	Total Organic Carbon	Mean Grain Size
P03 N500	226	27	94	0.39	3.62
P03 N2000	41	2	22	0.44	2.55
P03 E500	299	17	169	0.39	3.82
P03 E2000	631	64	413	0.49	3.58
P03 S500	227	48	92	0.37	4.00
P03 S2000	326	106	124	0.61	6.11
P03 W500	511	57	308	0.26	3.41
P03 W2000	482	23	259	0.33	2.81
P04 N500	239	60	63	0.66	6.49
P04 N2000	142	68	28	0.60	6.29
P04 E500	76	9	2	0.62	6.68
P04 E2000	136	47	45	0.71	6.90
P04 S500	49	12	16	0.63	6.55
P04 S2000	29	10	7	0.70	6.52
P04 W500	144	37	53	0.65	6.61
P04 W2000	76	29	11	0.64	6.86

WINTER

Stations	Total Foraminifera	*Buliminella bassendorfensis*	*Nonionella basiloba*	Total Organic Carbon	Mean Grain Size
C21	93	15	14	0.51	5.94
C22	108	20	10	0.77	6.04
C23	20	6	2	0.82	6.89
C24	68	2	8	0.73	6.64

APPENDIX B--Numbers of live foraminifera found in the microfauna samples at each collecting station for each collecting season, by species.

Primary Platform 1 - Spring Collections

	Stations							
Species	N500	N2000	E500	E2000	S500	S2000	W500	W2000
Lagenammina comprima	5	3	3	2	2		3	
Lagenammina diflugiformis	1							
Reophax scottii					2	11	11	6
Ammoscalaria pseudospiralis	10	3	8		1		5	1
Textularia earlandi		2	1	2	2	1	2	5
Eggerella advena	3	1		1		1	2	4
Buliminella elegantissima		4	3	8			2	2
Buliminella bassendorfensis	123	213	207	157	144	242	243	268
Bolivina lowmani	60	71	13	31	3	11	25	7
Bolivina ordinaria						1		
Bolivina striatula	2							
Bulimina marginata	2	2	2				2	
Epistominella vitrea				5			3	8
Cibicides concentricus	1							
Ammonia beccarii	8	9	8	6	9	5	6	6
Elphidium gunteri		1					1	1
Fursenkoina complanata				14		22	7	9

Primary Platform 1 - Spring Collections (continued)

Species	Stations N500	N2000	E500	E2000	S500	S2000	W500	W2000
Fursenkoina pontoni							3	2
Fursenkoina sp.	2		2			3	1	4
Virgulinella pertusa				1		1	1	3
Nonionella basiloba	250	343	439	247	49	553	909	874
Miliolid juveniles						1	1	

Primary Platform 2 - Spring Collections

Species	Stations N500	N2000	E500	E2000	S500	S2000	W500	W2000
Lagenammina comprima	1	1	1					
Reophax scottii	1		1	3	3	20	1	
Ammoscalaria pseudospiralis		5	2	3	5	11	1	
Bigenerina irregularis	1					1		
Textularia earlandi	1		1					
Eggerella advena		3	1			4		
Quinqueloculina compta		1		2		3		

Primary Platform 2 - Spring Collections (continued)

Species	Stations							
	N500	N2000	E500	E2000	S500	S2000	W500	W2000
Quinqueloculina sabulosa						1		
Quinqueloculina vulgaris	8	35	8	2	23	3		
Buliminella elegantissima	1	22	7	13	22	12	1	
Buliminella bassendorfensis	4	6	4	16	12	23	2	
Bolivina lowmani	9	51	66	34	75	10	2	
Bolivina ordinaria					1			
Bolivina striatula	1	21	2	1	10	2	1	1
Bulimina marginata		2	1		1	4		
Discorbis nitida		2			2			
Rosalina floridensis		1						
Cibicides concentricus		4	6	1		4		
Ammonia beccarii	8	161	38	36	65	65	3	3
Elphidium gunteri		4		1	3	8	1	
Fursenkoina complanata	1	2	1		1	3		
Fursenkoina pontoni	1							
Fursenkoina sp.		3	1	2	7	7	1	

Primary Platform 2 - Spring Collections (continued)

Species	Stations N500	N2000	E500	E2000	S500	S2000	W500	W2000
Virgulinella pertusa						2		
Cassidulina crassa		1						
Nonionella basiloba	12	86	16	178	129	452	15	18
Melonis pompilioides		3						
Miliolid juveniles	1	25	14	4	24	3		2

Primary Platform 3 - Spring Collections

Species	Stations N500	N2000	E500	E2000	S500	S2000	W500	W2000
Lagenammina comprima		1	1	3	2	2	6	4
Lagenammina diflugiformis				3		1		
Ammoscalaria pseudospiralis			3				5	
Bigenerina irregularis				1			1	
Textularia conica			1					
Textularia earlandi			2	1	1		1	
Eggerella advena	2			3	2	1	4	

Primary Platform 3 - Spring Collections (continued)

Species	N500	N2000	E500	E2000	S500	S2000	W500	W2000
	Stations							
Pyrgo nasutus	1			2			1	
Pyrgo oblonga				1	1		2	
Quinqueloculina compta			5	3	5	1	4	
Quinqueloculina lamarckina							2	
Quinqueloculina sabulosa		2						
Quinqueloculina vulgaris							1	
Triloculina tricarinata				3			1	
Lagena spicata			2					
Lenticulina		1			1		3	
Marginulina obesa	1							
Buliminella bassendorfensis	45	7	231	68	121	269	109	127
Bolivina lowmani	5	5	31	5	11	1	20	9
Bolivina ordinaria					1			
Bolivina striatula		2	1	3	1		1	
Bulimina marginata	1		3	1	3		3	

Primary Platform 3 - Spring Collections (continued)

	Stations							
Species	N500	N2000	E500	E2000	S500	S2000	W500	W2000
Uvigerina parvula						1	2	
Trifarina bella			2					
Cancris sagra	1	2	3			1	2	
Discorbis nitida	1							
Eponides antillarum							1	
Epistominella vitrea	9	4	23		7		15	
Cibicides concentricus			2					
Ammonia beccarii				3	2	6		4
Elphidium gunteri			6	2	1			1
Fursenkoina complanata	2	1	8		6	30	8	3
Fursenkoina pontoni	1		4	3	1	7	1	1
Florilus atlanticus	1		4	2	1	1	7	4
Nonionella basiloba	234	67	317	256	350	620	640	846
Miliolid juveniles	2	4	4	3	3	1	3	2

Primary Platform 4 - Spring Collections

Species	N500	N2000	E500	E2000	S500	S2000	W500	W2000
	Stations							
Lagenammina comprima	3	8	2	5	5	4	11	3
Lagenammina diflugiformis	1	2		1	5	2	3	11
Reophax scottii	18	5	32	22	21	10	13	33
Ammoscalaria pseudospiralis		2					1	2
Textularia conica		2				1	1	1
Textularia earlandi		1						
Textularia mexicana		2						
Eggerella advena		3		1				2
Pyrgo nasutus				1				
Lagena spicata								1
Lenticulina			1					
Buliminella bassendorfensis	209	206	299	411	403	358	438	332
Bolivina lowmani	13	27	50	18	10	17	20	41
Bolivina ordinaria		1				1		
Bolivina striatula	3	10		2		2		3
Bulimina marginata	1	2	2	1	1	3	2	3

Primary Platform 4 - Spring Collections (continued)

	Stations							
Species	N500	N2000	E500	E2000	S500	S2000	W500	W2000
Uvigerina parvula						1		
Cancris sagra								1
Eponides antillarum							3	
Epistominella vitrea		31	57	14	1	36	18	23
Cibicides concentricus	5	27	12	8	6	18	32	11
Ammonia beccarii	1	35	12					
Elphidium gunteri	4						6	1
Fursenkoina complanata	61	49	216	252	157	174	77	173
Fursenkoina pontoni			1	1		5	3	1
Florilus atlanticus	2	8	1	7	13	13	9	4
Nonionella basiloba	258	341	352	402	210	407	298	315
Miliolid juveniles		1	3	1		2	3	3

Control Sites - Spring Collections

Species	C21	C22	C23	C24
Lagenammina comprima		16	4	33
Lagenammina diflugiformis			2	
Reophax scottii	10	4	5	2
Ammoscalaria pseudospiralis		4		
Alveolophragmium sp.			1	
Bigenerina irregularis		1		
Textularia conica			2	1
Textularia earlandi	1			
Eggerella advena	1	15		4
Quinqueloculina compta		1		
Quinqueloculina vulgaris	2	2		
Buliminella elegantissima	10	1		7
Buliminella bassendorfensis	157	188	183	219
Bolivina lowmani	200	53	7	7
Bolivina ordinaria			1	
Bolivina striatula	2			

Control Sites - Spring Collections (continued)

Species	C21	C22	C23	C24
Bulimina marginata		4		
Trifarina bella			1	
Cancris sagra			2	
Epistominella vitrea		4		
Cibicides concentricus		1	5	
Ammonia beccarii	19	26	2	32
Elphidium gunteri				2
Fursenkoina complanata	1	5	22	2
Fursenkoina pontoni		1	7	
Fursenkoina sp.	9			
Florilus atlanticus			11	1
Nonionella basiloba	903	791	165	11
Melonis pompilioides	2			
Miliolid juveniles		1	2	

Primary Platform 1 - Summer Collections

Species	Stations							
	N500	N2000	E500	E2000	S500	S2000	W500	W2000
Lagenammina comprima	1	4	15	8	1	1	15	2
Lagenammina diflugiformis								1
Ammoscalaria pseudospiralis			2					
Eggerella advena			2					1
Quinqueloculina compta					1			
Buliminella bassendorfensis	74	38	134	246	8	99	73	122
Bolivina lowmani		1	1	4	1	1	2	2
Bolivina striatula			1					
Bulimina marginata								1
Ammonia beccarii	6	2	6	4	2	1	1	3
Fursenkoina complanata	1		1	5		2		1
Fursenkoina sp.								1
Nonionella basiloba	1	10	25	42	5	39	4	92

Primary Platform 2 - Summer Collections

	Stations							
Species	N500	N2000	E500	E2000	S500	S2000	W500	W2000
Lagenammina diflugiformis		1		3	2	2		
Ammoscalaria pseudospiralis		1					1	
Buliminella elegantissima			3	1		2		
Buliminella bassendenforsis	1	3	3	18	1	12	4	1
Bolivina lowmani	2	1	2	31		9	1	4
Bolivina striatula			1	1		1	1	
Bulimina marginata				2				
Cibicides concentricus		1	2	3		1		
Ammonia beccarii	2	12	7	8	5	4	7	17
Elphidium gunteri				1				2
Fursenkoina complanata			1	2				1
Fursenkoina sp.						1		
Nonionella basiloba	1		1	13	2	21	1	
Melonis pompilioides						1	1	
Miliolid juveniles		1			1		1	

Primary Platform 3 - Summer Collections

	Stations							
Species	N500	N2000	E500	E2000	S500	S2000	W500	W2000
Lagenammina comprima	5	2	2	1	1	1	11	2
Lagenammina diflugiformis	1							
Reophax scottii	1		3		1	3	1	
Ammoscalaria pseudospiralis							1	
Bigenerina irregularis							1	
Textularia earlandi			1				1	
Textularia mexicana		1		1			1	1
Eggerella advena	2		1		2		3	7
Pyrgo nasutus			1					
Quinqueloculina compta		3	2		1			1
Quinqueloculina vulgaris					1			
Marginulina obesa		1						
Buliminella elegantissima	1							
Buliminella bassendorfensis	161	129	260	103	36	150	205	220
Bolivina lowmani	12	12	24	2	5	3	40	71
Bolivina ordinaria							1	

Primary Platform 3 - Summer Collections (continued)

	Stations							
Species	N500	N2000	E500	E2000	S500	S2000	W500	W2000
Bolivina striatula	2	4	4	2				
Bulimina marginata		1	1				3	2
Uvigerina parvula						1		1
Trifarina bella			2		1	1		
Cancris sagra		1	1				1	1
Discorbis nitida				1			1	
Eponides antillarum	2		1	2	1		1	
Cibicides concentricus	24	3	29	3	5	1	24	23
Ammonia beccarii	1		3	3	3	1	3	6
Elphidium gunteri								1
Fursenkoina complanata	9	11	28	7	1	26	23	23
Fursenkoina pontoni	2					3		
Fursenkoina sp.	1							
Florilus atlanticus	1	14		1				
Nonionella basiloba	304	500	660	177	68	189	424	548
Miliolid juveniles	1							

Primary Platform 4 - Summer Collections

Species	Stations							
	N500	N2000	E500	E2000	S500	S2000	W500	W2000
Lagenammina comprima	13	6	11	7	10	8	8	
Lagenammina diflugiformis		2		1	1		1	
Reophax scottii	16	6	10	17	20	18	14	25
Ammoscalaria pseudospiralis	2	2	1					
Bigenerina irregularis				1			1	
Textularia mexicana	1	1				1		
Eggerella advena	1				2		1	
Pyrgo nasutus					1			
Quinqueloculina compta	1		2			1	1	
Lagena striata			1					1
Lenticulina					1			
Buliminella elegantissima			1	1				
Buliminella bassendorfensis	271	242	302	229	353	382	450	312
Bolivina lowmani	29	33	29	23	52	39	47	18
Bolivina striatula		21	3	4	9	5	7	2
Bulimina marginata		2			1	1		1

Primary Platform 4 - Summer Collections (continued)

Species	Stations N500	N2000	E500	E2000	S500	S2000	W500	W2000
Trifarina bella	1			1	2			
Cancris sagra			1		6	1	1	
Eponides antillarum			1	1	1			
Cibicides concentricus	4	6	9	2	24	6	19	2
Ammonia beccarii		4	3	2	5	3	9	1
Fursenkoina complanata	164	60	180	204	176	302	185	254
Fursenkoina pontoni				1	2	2	4	1
Florilus atlanticus	7	2	10	9	12	13	5	1
Nonionella basiloba	498	413	440	359	443	490	429	304
Miliolid juveniles							1	1

Control Sites - Summer Collections

Species	C21	C22	C23	C24
Lagenammina comprima	1		6	20
Lagenammina diflugiformis		1	8	
Reophax scottii			5	
Ammoscalaria pseudospiralis		1	1	
Bigenerina irregularis		2		2
Textularia earlandi	1			1
Eggerella advena	2	2		2
Pyrgo nasutus			1	
Buliminella elegantissima	2	1		4
Buliminella bassendorfensis	217	49	611	575
Bolivina lowmani	302	4	38	9
Bolivina striatula			11	1
Bulimina marginata	1	1		1
Eponides antillarum			2	
Cibicides concentricus		5	10	
Ammonia beccarii	67	4	7	135
Elphidium gunteri				1

Control Sites - Summer Collections (continued)

Species	C21	C22	C23	C24
Fursenkoina complanata		2	76	1
Fursenkoina pontoni			5	1
Fursenkoina sp.	6			2
Florilus atlanticus			16	2
Nonionella basiloba	118	122	304	14
Melonis pompilioides	4			
Miliolid juveniles	1		1	1

Secondary Platforms - Summer Collections

Species	S05 N500	S05 N2000	S06 N500	S06 N2000	S07 N500	S07 N2000	S08 N500	S08 N2000
Lagenammina comprima				1	1	2	6	
Lagenammina diflugiformis					1			
Reophax scottii					1	3	4	
Textularia mexicana					1		1	
Eggerella advena				1		2	13	7
Buliminella elegantissima		6	1	2				1
Buliminella bassendorfensis		3	4	9	11	195	587	631
Bolivina lowmani	1	5	3	12	2	2	15	26
Bolivina striatula				1		2		
Bulimina marginata							1	3
Uvigerina parvula						1		
Cancris sagra						1		
Cibicides concentricus			1				1	
Fursenkoina complanata						29	10	3
Fursenkoina pontoni						3		

Secondary Platforms - Summer Collections (continued)

	S05		S06		S07		S08	
Species	N500	N2000	N500	N2000	N500	N2000	N500	N2000
Nonionella basiloba	2		4	6	9	106	337	333
Miliolid juveniles							1	

	S09		S10		S11		S12	
Species	N500	N2000	N500	N2000	N500	N2000	N500	N2000
Lagenammina comprima		1	1	7	1	2	1	2
Ammoscalaria pseudospiralis				2		1		1
Bigenerina irregularis			1	5		14		
Textularia earlandi	1							
Textularia mexicana				2				
Eggerella advena			1	3	1	14	1	2
Buliminella elegantissima			1	3	1	13	3	2
Buliminella bassendorfensis	362	28	33	126	6	112	141	80
Bolivina lowmani	9	1	16	63	10	173	28	18
Bolivina striatula				9			10	3

Secondary Platforms - Summer Collections (continued)

	S09		S10		S11		S12	
Species	N500	N2000	N500	N2000	N500	N2000	N500	N2000
Bulimina marginata				4		3	3	1
Uvigerina parvula						3		
Cancris sagra	1							
Discorbis nitida				3		2	1	
Cibicides concentricus			5	16	2	45	2	1
Ammonia beccarii	2		7	13	6	22	35	21
Elphidium gunteri				1				1
Fursenkoina complanata	59	1		1		1	10	4
Fursenkoina pontoni	8	2						
Fursenkoina sp.				1		1	7	2
Nonionella basiloba	79	5	54	206	9	456	342	155
Miliolid juveniles				5	1	18		

Secondary Platforms - Summer Collections (continued)

Species	S13		S14		S15		S16	
	N500	N2000	N500	N2000	N500	N2000	N500	N2000
Lagenammina comprima				1		2		2
Reophax scottii							1	1
Ammoscalaria pseudospiralis						1		
Bigenerina irregularis				1		1		1
Eggerella advena				1				1
Buliminella elegantissima						1		1
Buliminella bassendorfensis		14	1	106		35	127	151
Bolivina lowmani	1	1	1	1		1	8	4
Bolivina striatula								4
Bulimina marginata				1		1		1
Trifarina bella								1
Cancris sagra								1
Cibicides concentricus				1			1	4
Ammonia beccarii				1			3	4
Fursenkoina complanata				2		1	32	25

Secondary Platforms - Summer Collections (continued)

Species	S13 N500	S13 N2000	S14 N500	S14 N2000	S15 N500	S15 N2000	S16 N500	S16 N2000
Fursenkoina pontoni						2	3	4
Florilus atlanticus				3		3	2	2
Nonionella basiloba		5	3	19	1	18	117	73
Miliolid juveniles						2	1	

Species	S17 N500	S17 N2000	S18 N500	S18 N2000	S19 N500	S19 N2000	S20 N500	S20 N2000
Lagenammina comprima				1			1	1
Bigenerina irregularis							1	2
Textularia mexicana			1					
Eggerella advena							1	1
Buliminella elegantissima							1	2
Buliminella bassendorfensis	1		3	81			205	94
Bolivina lowmani			2	4	2		16	5
Bolivina striatula								2
Bulimina marginata				2			1	2

Secondary Platforms - Summer Collections (continued)

	S17		S18		S19		S20	
Species	N500	N2000	N500	N2000	N500	N2000	N500	N2000
Uvigerina parvula							1	1
Cancris sagra								1
Discorbis nitida							1	
Cibicides concentricus			2	6			3	8
Ammonia beccarii							6	19
Elphidium gunteri							2	1
Fursenkoina complanata							1	
Fursenkoina sp.							2	1
Florilus atlanticus				6				
Nonionella basiloba	1			5			331	197
Miliolid juveniles							2	

Primary Platform 1 - Winter Collections

Species	Stations							
	N500	N2000	E500	E2000	S500	S2000	W500	W2000
Lagenammina comprima						1		
Lagenammina diflugiformis				1				
Reophax scottii								2
Ammoscalaria pseudospiralis		6						1
Bigenerina irregularis								1
Eggerella advena							1	1
Buliminella elegantissima		1		1	5	1		1
Buliminella bassendorfensis	6	22	21	15	19	11	15	18
Bolivina lowmani	9	35	8	25	21	5	21	13
Bolivina striatula								1
Bulimina marginata	1	1						
Cibicides concentricus	1			1		1	1	
Ammonia beccarii	9	15	4	13	10	2	10	15
Elphidium gunteri				1				1
Fursenkoina complanata								3

Primary Platform 1 - Winter Collections (continued)

	Stations							
Species	N500	N2000	E500	E2000	S500	S2000	W500	W2000
Fursenkoina pontoni						1		1
Fursenkoina sp.				1	1		1	1
Nonionella basiloba	1	3		9	5	6	3	26

Primary Platform 2 - Winter Collections

	Stations							
Species	N500	N2000	E500	E2000	S500	S2000	W500	W2000
Lagenammina comprima						6		
Textularia mexicana						1		
Quinqueloculina compta					2			
Buliminella elegantissima		1		4	12	1	1	2
Buliminella bassendorfensis		1		5	2	10	1	1
Bolivina lowmani	13	5	2	37	23	13	2	24
Bolivina striatula	1				7			
Bulimina marginata						1		
Cibicides concentricus				2	3		1	2
Ammonia beccarii	10	27	3	83	47	61	8	25
Elphidium gunteri					1		1	1

Primary Platform 2 - Winter Collections (continued)

Species	Stations							
	N500	N2000	E500	E2000	S500	S2000	W500	W2000
Fursenkoina sp.				1		4		
Nonionella basiloba	1		2	2	1		1	

Primary Platform 3 - Winter Collections

Species	Stations							
	N500	N2000	E500	E2000	S500	S2000	W500	W2000
Lagenammina comprima	28	3	53	36	46	73	35	11
Lagenammina diflugiformis	2		2					
Reophax scottii	1			2			1	1
Ammoscalaria pseudospiralis	1				1	1		1
Bigenerina irregularis	2							2
Textularia earlandi	1							
Textularia mexicana				2			2	
Eggerella advena	1		1	2			1	
Quinqueloculina compta		1						
Quinqueloculina sabulosa			1					

Primary Platform 3 - Winter Collections (continued)

Species	Stations							
	N500	N2000	E500	E2000	S500	S2000	W500	W2000
Buliminella elegantissima								1
Buliminella bassendorfensis	27	2	17	64	48	106	57	23
Bolivina lowmani	7	3	15	32	4	4	20	97
Bolivina ordinaria								1
Bolivina striatula	3		5	3	2	1		
Bulimina marginata	5		4	2			5	3
Trifarina bella	3		1	3	5		2	2
Cancris sagra	2		1		3	1	4	1
Discorbis nitida				1				2
Eponides antillarum	1	1	2	8	3	3	4	1
Epistominella vitrea	1							
Cibicides concentricus	40	4	29	22	14	5	60	58
Ammonia beccarii	1	2		1	1			1
Elphidium gunteri	1	1						1
Fursenkoina complanata	2	1	8	27	2	2	3	8

Primary Platform 3 - Winter Collections (continued)

Species	Stations							
	N500	N2000	E500	E2000	S500	S2000	W500	W2000
Fursenkoina pontoni				7	4	4	4	1
Florilus atlanticus	2	1		6	2	2	3	3
Nonionella basiloba	94	22	160	413	92	124	308	258
Miliolid juveniles	1						2	6

Primary Platform 4 - Winter Collections

Species	Stations							
	N500	N2000	E500	E2000	S500	S2000	W500	W2000
Lagenammina comprima	7	24	3	13	9	1	14	10
Lagenammina diflugiformis	3			3			2	2
Reophax scottii	1	1		1	1		2	1
Ammoscalaria pseudospiralis			1					
Bigenerina irregularis	1		2	1			1	
Textularia mexicana	1							
Legena striata	1							

Primary Platform 4 - Winter Collections (continued)

Species	Stations N500	N2000	E500	E2000	S500	S2000	W500	W2000
Buliminella bassendorfensis	60	68	9	47	12	10	37	29
Bolivina lowmani	36	12	9	4	1	6	4	1
Bolivina striatula		1		1				
Bulimina marginata	1	1						
Trifarina bella	2			1				1
Cancris sagra	3						6	1
Eponides antillarum	2			1	1	1	1	1
Cibicides concentricus	50	2	50	8	7	3	16	12
Ammonia beccarii	3	2		1				
Elphidium gunteri		1						
Fursenkoina complanata	2			1				1
Fursenkoina pontoni	2	1		7	2		2	2
Florilus atlanticus		1		2		1	6	4
Nonionella basiloba	63	28	2	45	16	7	53	11
Miliolid juveniles	1							

Control Sites - Winter Collections

Species	C21	C22	C23	C24
Lagenammina comprima	4	8	1	4
Reophax scottii	1			
Bigenerina irregularis	2	2		7
Textularia earlandi	1			
Eggerella advena				1
Buliminella elegantissima				1
Buliminella bassendorfensis	15	20	6	2
Bolivina lowmani	23	7	1	6
Bulimina marginata	1	1		
Trifarina bella			1	
Cancris sagra	1			
Eponides antillarum			1	
Cibicides concentricus	10	7	7	1
Ammonia beccarii	14	52		34
Elphidium gunteri	1	1	1	
Fursenkoina complanata	3			1

Control Sites - Winter Collections (continued)

Species	C21	C22	C23	C24
Fursenkoina pontoni	1			1
Fursenkoina sp.				2
Florilus atlanticus	2			
Nonionella basiloba	14	10	2	8

APPENDIX C--Numbers of live foraminifera found in the macrofauna samples at each collecting station for each collecting season, by species.

Macrofauna Samples - Spring Collections

	Stations							
	P02	P03						
Species	S500	N500	N2000	E500	E2000	S500	S2000	W500
Ammoscalaria pseudospiralis	1				1			
Lenticulina sp.				6	1	5		
Buliminella bassendorfensis			1					
Rosalina floridensis			1					
Eponides antillarum		2	1	26	50	5		3
Cibicides concentricus	1	8	11	152	271	10	1	7

	Stations					
	P04					
Species	N500	N2000	E2000	S500	W500	C23
Quinqueloculina compta						2
Lenticulina sp.				1	1	
Eponides antillarum					1	
Cibicides concentricus	3	1	1			

Macrofauna Samples - Summer Collections

	Stations			
	P04			
Species	N2000	N500	N2000	S2000
Lenticulina sp.			2	1
Cibicides concentricus	3	1		

	Stations						
	P09		P11	P15		P17	
Species	N500	N2000	N500	N500	N2000	N500	N2000
Lenticulina sp.	4	4		9	12		1
Nodosaria fusta				1	3		1
Dentalina albatrossi					14		
Lenticulina bowdenensis				6	11		
Lenticulina calcar					4	15	
Lenticulina iota				6	6		
Marginulinopsis marginulinoides				1			
Eponides antillarum				1			
Cibicides concentricus			1				

Macrofauna Samples - Winter Collections

	Stations	
	P04	
Species	N500	S500
Lenticulina sp.		1
Lenticulina iota	1	

APPENDIX D--Fisher Alpha Index of species Diversity Values for individual stations for all collecting seasons.

Fisher Alpha Index of Diversity Values - Spring Collection

Platforms	Stations							
	N500	N2000	E500	E2000	S500	S2000	W500	W2000
P01	2.3	1.8	1.7	2.0	1.7	2.1	2.6	2.1
P02	5.0	4.8	4.8	3.0	3.3	3.8	5.0	1.6
P03	3.0	3.1	3.8	4.2	3.7	2.4	4.8	1.6
P04	2.4	3.7	2.2	2.4	1.8	2.8	2.9	3.5
Control Sites	C21		C22		C23		C24	
	1.7		2.8		3.5		2.5	

Fisher Alpha Index of Diversity Values - Summer Collection

Platforms	Stations							
	N500	N2000	E500	E2000	S500	S2000	W500	W2000
P01	1.3	1.5	2.0	1.1	3.0	1.4	1.2	2.2
P02	3.0	4.0	5.0	2.4	5.0	3.6	5.4	1.9
P03	3.3	2.3	2.9	2.4	2.5	2.1	3.3	2.4
P04	2.1	2.5	2.7	2.8	2.9	2.0	2.5	2.2
Control Sites	C21		C22		C23		C24	
	2.0		3.5		2.5		3.1	

Fisher Alpha Index of Diversity Values - Summer Collection

	S05		S06		S07		S08	
Secondary Platforms	N500	N2000	N500	N2000	N500	N2000	N500	N2000
	1.0	1.5	3.5	3.0	3.7	2.3	1.8	1.4

	S09		S10		S11		S12	
	N500	N2000	N500	N2000	N500	N2000	N500	N2000
	1.4	1.9	2.2	3.7	3.8	2.8	2.4	3.0

	S13		S14		S15		S16	
	N500	N2000	N500	N2000	N500	N2000	N500	N2000
	0.0	1.3	1.3	2.8	0.0	4.0	2.0	3.9

	S17		S18		S19		S20	
	N500	N2000	N500	N2000	N500	N2000	N500	N2000
	0.0	0.0	2.0	1.7	0.0	0.0	3.0	3.3

Fisher Alpha Index of Diversity Values - Winter Collection

	Stations							
Platforms	N500	N2000	E500	E2000	S500	S2000	W500	W2000
P01	2.4	1.8	0.9	2.8	1.7	3.8	2.3	4.5
P02	1.5	1.3	2.0	1.6	2.5	2.0	5.1	1.6
P03	5.5	4.5	3.1	3.1	3.3	2.3	3.0	4.4
P04	4.4	3.1	1.8	4.2	2.9	2.9	3.0	4.1

Control Sites	C21	C22	C23	C24
	4.8	2.5	5.0	4.0

APPENDIX E--Results of analysis of variance tests on foraminiferal population.

Two-way analysis of variance for total observations of foraminiferal species for each collecting season.

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F-Test	P
Among Samples	21,876.13	45	486.14	14.3828	S.
Among Seasons	947.53	2	437.77	14.0169	S.
Error	3,041.80	90	33.80		
Total	25,865.46	137			

Two-way analysis of variance for total numbers of foraminifera for all collecting seasons.

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F-Test	P
Among Samples	6,895,245,676	45	153,227,681.7	5.340	S.
Among Seasons	147,572,860.8	2	73,786,430.4	2.241	S.
Error	2,739,575,366	90	30,439,726.3		
Total	9,782,393,902.8	137			

One-way analysis of variance for each foraminifera species for spring collecting season.

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F-Test	P
Lagenammina comprima					
Among Samples	6,762.65	22	307.39	2.9206	S.
Within Replications	7,262.25	69	105.25		
Total	14,024.90	91			

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F-Test	P
Lagenammina diflugiformis					
Among Samples	674.73	10	67.47	1.3427	N.S.
Within Replications	1658.25	33	50.25		
Total	2332.98	43			
Reophax scottii					
Among Samples	17184.46	21	818.31	3.7331	S.
Within Replications	14467.50	66	219.20		
Total	31651.96	87	-		
Textularia conica					
Among Samples	37.93	6	6.32	0.4328	N.S.
Within Replications	306.75	21	14.61		
Total	344.68	27			
Textularia earlandi					
Among Samples	243.81	12	20.32	1.1001	N.S.
Within Replications	720.25	39	18.47		
Total	964.86	51			
Bigenerina irregularis					
Among Samples	17.20	4	4.30	0.4674	N.S.
Within Replications	138.00	15	9.20		
Total	155.20	19			
Eggerella advena					
Among Samples	2267.31	20	113.37	3.0285	S.
Within Replications	2358.25	63	37.43		
Total	4625.56	83			

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F-Test	P
Miliolid juveniles					
Among Samples	4111.13	23	178.74	1.7011	N.S.
Within Replications	7565.50	72	105.08		
Total	11676.63	95			
Quinqueloculina compta					
Among Samples	143.13	9	15.90	0.4902	N.S.
Within Replications	973.25	30	32.44		
Total	1116.38	39			
Quinqueloculina vulgaris					
Among Samples	28.13	1	28.13	0.5294	N.S.
Within Replications	318.75	6	53.13		
Total	346.88	7			
Lenticulina sp.					
Among Samples	40.00	4	10.00	0.4781	N.S.
Within Replications	313.75	15	20.92		
Total	353.75	19			
Fursenkoina sp.					
Among Samples	5.33	5	1.07	0.1684	N.S.
Within Replications	114.00	16	6.33		
Total	119.33	23			
Lagena spicata					
Among Samples	4.50	1	4.50	0.3103	N.S.
Within Replications	87.00	6	14.50		
Total	91.50	7			

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F-Test	P
Buliminella elegantissima					
Among Samples	2584.33	14	184.60	1.5183	N.S.
Within Replications	5471.00	45	121.58		
Total	8055.33	59			
Buliminella bassendorfensis					
Among Samples	3499773.00	34	102934.50	3.7507	S.
Within Replications	2881595.00	105	27443.76		
Total	6381368.00	139			
Bolivina lowmani					
Among Samples	349546.13	34	10260.77	3.0085	S.
Within Replications	358805.75	105	3417.20		
Total	708351.88	139			
Bolivina striatula					
Among Samples	3330.33	16	185.00	1.1069	N.S.
Within Replications	9526.50	57	167.13		
Total	12856.52	75			
Bulimina marginata					
Among Samples	21087.14	19	1109.85	0.9114	N.S.
Within Replications	73066.19	60	1217.77		
Total	94153.38	79			
Fursenkoina sp.					
Among Samples	35.20	4	8.80	0.3145	N.S.
Within Replications	419.75	15	27.98		
Total	454.95	19			

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F-Test	P
Uvigerina parvula					
Among Samples	3.17	2	1.58	0.3285	N.S.
Within Replications	59.75	9	6.64		
Total	62.92	11			
Trifarina bella					
Among Samples	6.00	2	3.00	1.2273	N.S.
Within Replications	22.00	9	2.44		
Total	28.00	11			
Cancris sagra					
Among samples	16.21	6	2.70	0.4710	N.S.
Within Replications	120.50	21	5.74		
Total	136.71	27			
Rosalina floridensis					
Among Samples	2.19	3	0.73	0.1515	N.S.
Within Replications	57.75	12	4.81		
Total	59.94	15			
Epistominella vitrea					
Among Samples	7.17	2	3.58	0.2654	N.S.
Within Replications	121.50	9	13.50		
Total	128.67	11			
Elphidium gunteri					
Among Samples	10020.36	15	668.02	1.3300	N.S.
Within Replications	24109.75	48	502.29		
Total	34130.11	63			

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F-Test	P
Fursenkoina complanata					
Among Samples	339224.25	35	9692.12	1.1171	N.S.
Within Replications	936983.75	108	8675.77		
Total	1276208.00	143			
Fursenkoina pontoni					
Among Samples	301.94	15	20.13	0.6989	N.S.
Within Replications	1382.50	48	28.80		
Total	1684.44	63			
Cassidulina crassa					
Among Samples	10.67	2	5.33	0.7059	N.S.
Within Replications	68.00	9	7.56		
Total	78.67	11			
Florilus atlanticus					
Among Samples	1196663.00	28	42737.96	4.2521	S.
Within Replications	874429.00	87	10050.91		
Total	2071092.00	115			
Nonionella basiloba					
Among Samples	7952318.00	35	923527.31	4.1298	S.
Within Replications	9542376.00	108	223623.38		
Total	15237392.00	143			
Melonis barleanum					
Among Samples	22575.50	8	2821.94	1.7757	N.S.
Within Replications	42907.25	27	1589.16		
Total	65482.75	35			

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F-Test	P
Pyrgo nasuta					
Among Samples	3.50	3	1.17	0.2617	N.S.
Within Replications	53.50	12	4.46		
Total	57.00	15			

One-way analysis of variance for each foraminifera species for summer collecting season.

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F-Test	P
Lagenammina atlantica					
Among Samples	6037.55	46	131.25	1.2666	N.S.
Within Replications	14384.25	141	102.02		
Total	20421.80	187			
Lagenammina diflugiformis					
Among Samples	301.22	9	33.47	1.7409	N.S.
Within Replications	576.75	30	19.22		
Total	877.97	39			
Reophax scottii					
Among Samples	13434.29	18	746.35	3.2249	S.
Within Replications	13191.75	57	231.43		
Total	26626.04	75			
Ammoscalaria pseudospiralis					
Among Samples	23.50	10	2.35	0.5943	N.S.
Within Replications	130.50	33	3.95		
Total	154.00	43			

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F-Test	P
Textularia earlandi					
Among Samples	0.20	4	0.05	0.0112	N.S.
Within Replications	66.75	15	4.45		
Total	66.95	19			
Bigenerina irregularis					
Among Samples	662.56	11	60.23	2.4154	S.
Within Replications	897.75	36	24.94		
Total	1560.31	47			
Eggerella advena					
Among Samples	1364.45	28	48.73	1.4137	N.S.
Within Replications	2999.00	67	34.47		
Total	4363.45	115			
Miliolid juveniles					
Among Samples	1135.00	15	75.67	8.1071	S.
Within Replications	448.00	48	9.33		
Total	1583.00	63			
Quinqueloculina compta					
Among Samples	83.00	9	9.22	0.4733	N.S.
Within Replications	584.50	30	19.48		
Total	667.60	39			
Lagena striata					
Among Samples	6.13	1	6.13	0.3577	N.S.
Within Replications	102.75	6	17.13		
Total	108.88	7			

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F-Test	P
Buliminella elegantissima					
Among Samples	3103.94	24	129.33	1.2342	N.S.
Within Replications	9379.50	75	125.06		
Total	12483.44	99			
Buliminella bassendorfensis					
Among Samples	9934517.00	60	187404.31	5.6321	S.
Within Replications	4563284.00	183	33274.29		
Total	8567392.00	243			
Bolivina lowmani					
Among Samples	539509.31	62	8701.76	2.2424	S.
Within Replications	733414.69	189	3580.50		
Total	1272924.00	251			
Bolivina striatula					
Among Samples	3343.17	26	128.58	1.5386	N.S.
Within Replications	6769.50	81	83.57		
Total	7354.29	107			
Bulimina marginata					
Among Samples	148.96	24	6.21	0.4364	N.S.
Within Replications	1066.75	75	14.22		
Total	1215.71	99			
Cancris sagra					
Among Samples	305.27	12	25.44	2.0953	S.
Within Replications	473.50	39	12.14		
Total	778.77	51			

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F-Test	P
<u>Discorbis</u> <u>nitida</u>					
Among Samples	10.88	5	2.17	0.2863	N.S.
Within Replications	136.75	18	7.60		
Total	147.63	23			
<u>Eponides</u> <u>antillarum</u>					
Among Samples	17.72	6	2.22	0.3127	N.S.
Within Replications	191.25	27	7.08		
Total	208.97	35			
<u>Cibicides</u> <u>concentricus</u>					
Among Samples	18138.90	37	490.24	1.7579	S.
Within Replications	31791.50	114	278.87		
Total	49930.40	151			
<u>Ammonia</u> <u>beccarii</u>					
Among Samples	87402.81	51	1713.78	5.9258	S.
Within Replications	45116.25	146	289.21		
Total	132519.06	197			
<u>Elphidium</u> <u>gunteri</u>					
Among Samples	7.56	8	0.94	0.2351	N.S.
Within Replications	108.00	27	4.00		
Total	115.56	35			
<u>Fursenkoina</u> <u>complanata</u>					
Among Samples	3010061.00	40	75251.50	5.0113	S.
Within Replications	1846995.00	123	15016.22		
Total	4857056.30	163			

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F-Test	P
Fursenkoina pontoni					
Among Samples	21048.98	15	1403.27	0.9056	N.S.
Within Replications	74374.69	48	1549.47		
Total	95423.69	63			
Florilus atlanticus					
Among Samples	6243.45	17	368.26	1.9268	S.
Within Replications	10293.00	54	190.61		
Total	16536.45	71			
Nonionella basiloba					
Among Samples	6328451.00	59	301403.63	4.3495	S.
Within Replications	8563213.00	180	69296.06		
Total	14891664.00	239			
Melonis barleanum					
Among Samples	32.67	2	16.33	0.7424	N.S.
Within Replications	198.00	9	22.00		
Total	230.67	11			

One-way analysis of variance for each foraminifera species for winter collecting season.

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F-Test	P
Lagenammina atlantica					
Among Samples	38364.00	23	1654.96	1.4894	S.
Within Replications	80002.00	72	1111.14		
Total	118066.00	95			

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F-Test	P
Lagenammina diflugiformis					
Among Samples	27.71	6	4.62	0.2413	N.S.
Within Replications	402.00	21	19.14		
Total	429.71	27			
Reophax scottii					
Among Samples	18.92	12	1.58	0.2834	N.S.
Within Replications	217.00	39	5.56		
Total	235.92	51			
Ammoscalaria pseudospiralis					
Among Samples	72.86	6	12.14	0.6100	N.S.
Within Replications	418.00	21	19.90		
Total	490.86	27			
Textularia mexicana					
Among Samples	110.73	10	11.07	1.1039	N.S.
Within Replications	331.00	33	10.03		
Total	441.73	43			
Eggerella advena					
Among Samples	6.93	6	1.15	0.3201	N.S.
Within Replications	75.75	21	3.61		
Total	82.68	27			
Miliolid juveniles					
Among Samples	80.80	4	20.20	5.1356	S.
Within Replications	59.00	15	3.93		
Total	139.80	19			

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F-Test	P
Buliminella elegantissima					
Among Samples	490.31	12	48.86	1.6360	S.
Within Replications	974.00	39	24.97		
Total	1464.31	51			
Buliminella bassendorfensis					
Among Samples	101820.94	33	3065.48	3.4562	S.
Within Replications	91059.75	108	895.03		
Total	192880.69	141			
Bolivina lowmani					
Among Samples	47188.31	35	1348.24	1.5064	S.
Within Replications	96662.94	108	895.03		
Total	143851.25	143			
Bolivina striatula					
Among Samples	165.00	11	15.00	0.9000	N.S.
Within Replications	600.00	36	16.67		
Total	765.00	47			
Bulimina marginata					
Among Samples	115.31	12	9.61	0.6823	N.S.
Within Replications	424.75	39	10.89		
Total	540.06	51			
Uvigerina parvula					
Among Samples	2.00	1	2.00	0.2000	N.S.
Within Replications	60.00	6	10.00		
Total	62.00	7			

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F-Test	P
Fursenkoina sp.					
Among Samples	24.86	6	4.14	0.5241	N.S.
Within Replications	166.00	21	7.90		
Total	190.86	27			
Trifarina bella					
Among Samples	52.73	10	5.27	1.0357	S.
Within Replications	168.00	33	5.09		
Total	220.73	43			
Rosalina floridensis					
Among Samples	103.56	8	12.94	1.1238	S.
Within Replications	311.00	27	11.52		
Total	414.56	35			
Eponides antillarum					
Among Samples	302.93	14	21.64	1.3530	S.
Within Replications	717.00	45	15.93		
Total	1019.93	59			
Cibicides concentricus					
Among Samples	41708.91	26	1604.19	3.8145	S.
Within Replications	34064.71	81	420.55		
Total	75773.63	107			
Ammonia beccarii					
Among Samples	46781.02	26	1799.27	2.2751	S.
Within Replications	64060.48	81	790.87		
Total	110841.50	107			

Source of Variation	Sum of Squares	D.F.	Mean of Squares	F-Test	P
Elphidium gunteri					
Among Samples	2.25	11	0.20	0.1169	N.S.
Within Replications	63.00	36	1.75		
Total	65.25	47			
Fursenkoina complanata					
Among Samples	3844.86	13	295.76	1.1815	S.
Within Replications	10514.00	42	250.33		
Total	14358.86	55			
Fursenkoina pontoni					
Among Samples	240.43	14	17.17	0.7362	N.S.
Within Replications	1049.75	45	23.33		
Total	1290.18	59			
Florilus atlanticus					
Among Samples	163.69	12	13.64	0.7399	N.S.
Within Replications	719.00	39	18.44		
Total	882.69				
Nonionella basiloba					
Among Samples	1524803.00	30	50826.77	3.5224	S.
Within Replications	1341961.00	93	14429.69		
Total	2866764.00	123			