Distribution and Systematics of Foraminifera in the Indian River, Florida

MARTIN A. BUZAS
and
KENNETH P. SEVERIN
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Martin A. Buzas
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ABSTRACT

Buzas, Martin A., and Kenneth P. Severin. Distribution and Systematics of Foraminifera in the Indian River, Florida. Smithsonian Contributions to the Marine Sciences, number 16, 73 pages, 25 figures, 6 tables, 11 plates, 1982.—The Indian River, a shallow, 195 km long estuary, is bounded on the east by a barrier island. Three inlets divide the barrier island, providing exchange with the Atlantic Ocean. Twelve areas covering the length of the estuary were sampled for living foraminifera. Altogether, 17,348 individuals belonging to 94 species were identified. The mean number of individuals and the number of species generally increase from north to south.

The densities of the 15 most abundant species, comprising 95% of the total number of living individuals, were analyzed by canonical variate analysis. The first canonical axis discriminated the inlets and the northernmost (Haulover) area from the rest. On the second canonical axis, the 12 areas were arranged in a north-to-south series. Examination of the data confirms that the analysis succinctly summarizes foraminiferal distribution in the Indian River.

Taxonomic notes are given for each species, and almost all species are illustrated. Ishamella apertura, new genus and species, is described and illustrated.
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Distribution and Systematics of Foraminifera in the Indian River, Florida

Martin A. Buzas and Kenneth P. Severin

Introduction

The Indian River, a shallow, 195 km long body of water on the east-central coast of Florida (Figure 1), is a euryhaline and eurythermal estuary. Bounded on the east by a barrier island, the southern half of the estuary is connected with the Atlantic Ocean by three inlets: Sebastian, Fort Pierce (Jim's Flat of this study), and St. Lucie. All the inlets are maintained artificially. The northern end of the estuary is connected to the ocean via Haulover Canal, which links the estuary to the Mosquito Lagoon and the Ponce de Leon Inlet 40 km farther north.

The average depth of the Indian River is about 1.5 m; the greatest depths, about 3.5 m, occur in the Intracoastal Waterway and other dredged boat channels. The substrate is quartz sand with a low percentage of silt and clay. Because of the shallow depths, the waters of the estuary are influenced by a combination of tidal flushing, surface drainage, rainfall, and wind conditions.

Near the inlets, estuarine water is exchanged with the Atlantic Ocean on a semidiurnal basis and has little variation in salinity and only seasonal differences in temperature (Table 1). In the portions of the river away from the inlets, however, the tidal influence is almost negligible, and conditions are determined by nontidal effects. In general, the range of variation in temperature and salinity decreases from north to south (Table 1), whereas the average increases. An overall gradient of decreasing environmental variability from north to south was pointed out by Young et al. (1976), Young and Young (1977), and Nelson et al. (1982).

Although the foraminifera of the bays and estuaries of the northeastern continental margin of North America are relatively well studied, very little information exists from the shallower waters of the southeastern portion of the continent (Culver and Buzas, 1980). The purpose of the present investigation is to document the distribution and systematics of the foraminifera from the major estuary in east-central Florida.

Acknowledgments.—We thank M. Abrams, R. Bronson, K. Carle, M. Cavanaugh, G. Heim, A. Lanham, C. Leibhauser, C. McClay, and S. Pohanka for help in the laboratory. The samples were collected by K. Carle, D. Mook, and D. Young. The foraminifera and figures were drawn by Lawrence Isham. J. Piraino operated the SEM, and T. Smoyer assisted greatly in the darkroom. D. Dean prepared specimens for sectioning.

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C. G. Adams and J. Whittaker provided access to several specimens in the British Museum (NH). D. Dance and H. Marshall assisted in the computer analysis. S. J. Culver provided helpful criticisms of the manuscript, and, finally, we thank June Jones for typing it.

This is contribution number 234 from the Harbor Branch Foundation.
Table 1.—Ranges of temperature and salinity in the Indian River (except where noted, all data are from Nelson et al., 1982)

<table>
<thead>
<tr>
<th>Location</th>
<th>Temperature (°C)</th>
<th>Salinity (%&lt;sup&gt;o&lt;/sup&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haulover</td>
<td>11-34</td>
<td>20-46</td>
</tr>
<tr>
<td>Banana</td>
<td>15-35</td>
<td>18-40</td>
</tr>
<tr>
<td>Sebastian (Inlet)</td>
<td>14-30</td>
<td>25-36</td>
</tr>
<tr>
<td>Vero Beach</td>
<td>15-30</td>
<td>25-35</td>
</tr>
<tr>
<td>(Mook, 1980)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Link Port</td>
<td>12-32</td>
<td>20-38</td>
</tr>
<tr>
<td>Ft. Pierce (Inlet)</td>
<td>17-28</td>
<td>33-34</td>
</tr>
<tr>
<td>(Mook, 1980)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Herman’s Bay</td>
<td>14-29</td>
<td>22-32</td>
</tr>
<tr>
<td>(Wilcox and Gilmore, 1977)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>St. Lucie (Inlet)</td>
<td>18-32</td>
<td>28-36</td>
</tr>
</tbody>
</table>

Methods

Sampling Plan.—The samples for this study were taken in 1975 and 1976. The sampling program consisted of either single stations or stations located along a transect (Figure 1). At each transect station, two replicate cores were taken. One replicate from the John’s Island transect was lost. The inlets (Sebastian, Jim’s Flat at Fort Pierce, and St. Lucie) and Haulover and Banana consisted of single stations with four replicates. A replicate from the Banana station was lost. Table 2 lists the locations, the number of replicates (or observations), the date of sampling, and the latitude and longitude of each locality.

Field Methods.—Samples were taken by inserting 3.5 cm diameter plastic core liners into the sediment by hand or, in deeper water, by attaching them to a long pole. Upon recovery the samples were fixed with neutralized formalin.

Laboratory Methods.—On return to the laboratory, the top 20 ml of sediment was removed from the cores, washed over a 63 μm sieve, and stored in 95% ethanol. Before examination, the sample was stained for about 24 hours with rose bengal, washed once more over a 63 μm sieve, rinsed with acetone, and dried. The sample then was floated twice in a mixture of bromoform and acetone (specific gravity 2.4). The floated portion of the sample was re-wet, and the stained foraminifera was picked out and placed on a micropaleontologic slide for sorting, identification, and enumeration.

Statistical Methods.—The sampling plan was designed so that replicates were taken at all locations. This allows the data to be analyzed by canonical variate analysis, also called multiple discriminant analysis. The use of this method for faunal analysis was described by Buzas (1967). The computer program used for the analysis is part of the Statistical Package for the Social Sciences (SPSS). All densities were transformed to ln (x+1) before analysis to insure stability of variances and to increase Normality.

For each sampling location, the information function and a measure of equitability were cal-
culated. The information function was calculated from the formula
\[ H = -\sum p_i \ln p_i, \]
and equability from the formula
\[ E = \frac{e^H}{S}, \]
where \( e \) is the base of the natural logarithms, and \( S \) is the number of species (Buzas and Gibson, 1969).

**Distribution of Abundant Foraminifera**

Of the 94 species recorded in the Indian River, few were abundant. We arbitrarily chose the 15 most abundant species for canonical variate analysis. These 15 species represent about 95% of the total living population. The first analysis was made using each station as a separate group. The results were difficult to interpret, and so we decided on a simpler scheme. Inspection of the data showed little difference among stations in transects; consequently, all stations within transects were treated as a single group. This divided the samples into the 12 groups shown in Figure 1 and Table 2. The number of replicates varies from area to area and also is shown in Table 2. In all, there are \( N = 83 \) observations, \( h = 12 \) areas, and \( p = 15 \) species.

Canonical variate, or multiple discriminant, analysis emphasizes the difference between mean vectors in a \( p \)-dimensional space. The first canonical axis is placed as close as possible to the ends of the mean vectors, the second at right angles to the first, and so on. When \( p > h \), there are only \( h - 1 \) possible canonical variates. While this reduction in the number of dimensions is advantageous, an even greater advantage is that the first canonical variate will account for most of the variability, the second much less, and so on. In addition, each canonical variate is statistically independent and of unit variance, which greatly facilitates comparison of the results.

In the grouping used, there are \( h - 1 = 11 \) possible eigenvalues. Of these, the first six were significant at the 95% level, using the criterion provided by the SPSS program used for the analysis. These eigenvalues, the percent of variability accounted for, and their cumulative percent are shown in Table 3.

The first six mean canonical variates are shown in Table 4. Mean canonical variate 1 contrasts Haulover, Sebastian, Jim's Flat, and St. Lucie Inlet against the other areas. In other words, the first mean canonical variate, accounting for 37% of the total variability, indicates that Haulover and the inlets are quite distinct from the other areas. The second canonical variate, accounting for 17% of the total variability, contrasts the northern areas against the southern areas (Table 4). A plot of mean canonical variate 1 vs. mean canonical variate 2 (with 95% confidence circles) is shown in Figure 2. The inlets and Haulover are discriminated clearly from the remaining stations and from one another. The inlets and other areas are also arranged in a north-south pattern, with some areas slightly out of place (Figures 1, 2).

Figures 3 through 17 plot the mean densities of the 15 most abundant species at the 12 areas, and Table 5 lists the mean number of individuals per replicate (20 ml of sediment) plus some other useful statistics. We recall the first canonical variate contrasted Haulover, Sebastian, Jim's Flat, St. Lucie Inlet, and the remaining areas. By examining the canonical discriminate function coefficients (Table 6), we can determine the species mainly responsible for this contrast. In order of importance, these species are: *Gaudryina exilis* (Figure 12), *Cyclogyra planorbis* (Figure 7), *Elphidi um gunteri* (Figure 9), *Bolivina striatula* (Figure 5), *Nonionella auricula* (Figure 13), *Rosalina floridana*.

**Table 3.—The first six eigenvalues arranged in decreasing order with the percentage of variability accounted for**

<table>
<thead>
<tr>
<th>Eigenvalue</th>
<th>Percent of variability</th>
<th>Cumulative percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.44</td>
<td>37.36</td>
<td>37.36</td>
</tr>
<tr>
<td>2.04</td>
<td>17.20</td>
<td>54.56</td>
</tr>
<tr>
<td>1.35</td>
<td>11.37</td>
<td>65.93</td>
</tr>
<tr>
<td>1.08</td>
<td>9.06</td>
<td>74.99</td>
</tr>
<tr>
<td>1.05</td>
<td>8.87</td>
<td>83.86</td>
</tr>
<tr>
<td>0.82</td>
<td>6.93</td>
<td>90.79</td>
</tr>
</tbody>
</table>
Table 4.—Mean canonical variates for the first six variates (localities listed from north to south)

<table>
<thead>
<tr>
<th>Area</th>
<th>CV 1</th>
<th>CV 2</th>
<th>CV 3</th>
<th>CV 4</th>
<th>CV 5</th>
<th>CV 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haulover</td>
<td>4.03</td>
<td>-1.32</td>
<td>0.56</td>
<td>-0.89</td>
<td>-1.69</td>
<td>0.14</td>
</tr>
<tr>
<td>Banana</td>
<td>-1.00</td>
<td>-2.50</td>
<td>-0.13</td>
<td>0.32</td>
<td>-0.32</td>
<td>1.06</td>
</tr>
<tr>
<td>Sebastian</td>
<td>2.01</td>
<td>-1.57</td>
<td>-2.64</td>
<td>1.47</td>
<td>-0.80</td>
<td>-1.00</td>
</tr>
<tr>
<td>John's Island</td>
<td>-0.52</td>
<td>-2.04</td>
<td>-0.25</td>
<td>0.95</td>
<td>0.35</td>
<td>0.09</td>
</tr>
<tr>
<td>Vero Beach</td>
<td>-1.45</td>
<td>-1.20</td>
<td>0.09</td>
<td>-1.69</td>
<td>0.62</td>
<td>0.60</td>
</tr>
<tr>
<td>Link Port</td>
<td>-1.86</td>
<td>0.02</td>
<td>-0.35</td>
<td>-0.74</td>
<td>0.87</td>
<td>-1.80</td>
</tr>
<tr>
<td>Jim's Flat</td>
<td>5.15</td>
<td>0.30</td>
<td>1.26</td>
<td>-0.17</td>
<td>0.84</td>
<td>1.08</td>
</tr>
<tr>
<td>Buoy 195</td>
<td>-1.49</td>
<td>1.22</td>
<td>-0.17</td>
<td>1.22</td>
<td>0.61</td>
<td>1.13</td>
</tr>
<tr>
<td>Herman's Bay</td>
<td>-0.01</td>
<td>0.20</td>
<td>2.12</td>
<td>0.73</td>
<td>0.03</td>
<td>-0.99</td>
</tr>
<tr>
<td>Jensen Beach</td>
<td>-0.81</td>
<td>0.87</td>
<td>0.02</td>
<td>-0.02</td>
<td>-1.13</td>
<td>0.05</td>
</tr>
<tr>
<td>St. Lucie transect</td>
<td>-0.31</td>
<td>1.63</td>
<td>-0.67</td>
<td>-0.66</td>
<td>-1.07</td>
<td>0.06</td>
</tr>
<tr>
<td>St. Lucie Inlet</td>
<td>3.58</td>
<td>1.73</td>
<td>-1.52</td>
<td>-0.40</td>
<td>2.25</td>
<td>-0.52</td>
</tr>
</tbody>
</table>

Table 5.—Mean number of living individuals at Indian River localities

<p>| Table 5. Mean number of living individuals at Indian River localities |
|-------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th>Area</th>
<th>CV 1</th>
<th>CV 2</th>
<th>CV 3</th>
<th>CV 4</th>
<th>CV 5</th>
<th>CV 6</th>
</tr>
</thead>
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<tr>
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</tr>
<tr>
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<td>-2.50</td>
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<td>0.32</td>
<td>-0.32</td>
<td>1.06</td>
</tr>
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<td>1.47</td>
<td>-0.80</td>
<td>-1.00</td>
</tr>
<tr>
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<td>-0.25</td>
<td>0.95</td>
<td>0.35</td>
<td>0.09</td>
</tr>
<tr>
<td>Vero Beach</td>
<td>-1.45</td>
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<td>0.09</td>
<td>-1.69</td>
<td>0.62</td>
<td>0.60</td>
</tr>
<tr>
<td>Link Port</td>
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<td>0.02</td>
<td>-0.35</td>
<td>-0.74</td>
<td>0.87</td>
<td>-1.80</td>
</tr>
<tr>
<td>Jim's Flat</td>
<td>5.15</td>
<td>0.30</td>
<td>1.26</td>
<td>-0.17</td>
<td>0.84</td>
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</tr>
<tr>
<td>Buoy 195</td>
<td>-1.49</td>
<td>1.22</td>
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<td>1.13</td>
</tr>
<tr>
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<td>0.73</td>
<td>0.03</td>
<td>-0.99</td>
</tr>
<tr>
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<td>0.02</td>
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<td>-1.13</td>
<td>0.05</td>
</tr>
<tr>
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</tr>
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<td>1.73</td>
<td>-1.52</td>
<td>-0.40</td>
<td>2.25</td>
<td>-0.52</td>
</tr>
</tbody>
</table>

Table 6.—Standardized canonical discriminant function coefficients

<table>
<thead>
<tr>
<th>Species</th>
<th>Function 1</th>
<th>Function 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia beccarii</td>
<td>-0.02</td>
<td>-0.38</td>
</tr>
<tr>
<td>Bolivina striatula</td>
<td>0.63</td>
<td>-0.64</td>
</tr>
<tr>
<td>Quinqueloculina seminula</td>
<td>0.37</td>
<td>0.13</td>
</tr>
<tr>
<td>Quinqueloculina impressa</td>
<td>-0.09</td>
<td>-0.58</td>
</tr>
<tr>
<td>Bulimina elegantissima</td>
<td>0.13</td>
<td>0.78</td>
</tr>
<tr>
<td>Elphidium mexicanum</td>
<td>0.47</td>
<td>-0.17</td>
</tr>
<tr>
<td>Elphidium excavatum</td>
<td>-0.12</td>
<td>-0.45</td>
</tr>
<tr>
<td>Nonionella auricula</td>
<td>-0.58</td>
<td>0.16</td>
</tr>
<tr>
<td>Elphidium gunteri</td>
<td>-0.75</td>
<td>-0.11</td>
</tr>
<tr>
<td>Cyclogyra planorbis</td>
<td>0.85</td>
<td>0.20</td>
</tr>
<tr>
<td>Rosalina floridana</td>
<td>-0.51</td>
<td>0.37</td>
</tr>
<tr>
<td>Rosalina globularis</td>
<td>-0.10</td>
<td>0.39</td>
</tr>
<tr>
<td>Gaudryina exilis</td>
<td>-0.87</td>
<td>0.57</td>
</tr>
<tr>
<td>Elphidium CG2</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>Ammobaculites exilis</td>
<td>0.28</td>
<td>-0.16</td>
</tr>
</tbody>
</table>

(Figure 16), and Elphidium mexicanum (Figure 11). Some of these species have higher than average densities at Haulover and the inlets, whereas others have lower than average densities. In particular, the species *C. planorbis* and *E. mexicanum* have higher than average densities at Haulover and the inlets.

We recall that the second canonical variate contrasts northern and southern areas. The canonical discriminate function coefficients (Table 6) indicate that, in order of importance, the most important species are *Bulimina elegantissima* (Figure 6), *Bolivina striatula*, *Quinqueloculina impressa* (Figure 14), and *Gaudryina exilis* (Figure 12). *Quinqueloculina impressa* increases in density northward, whereas the other species increase southward.

Tables 3 and 6 show that the canonical variate
Figure 2.—Plot of mean canonical variates 1 and 2.

Figure 3.—Mean densities of *Ammobaculites exilis* at Indian River sampling sites.
**Figure 4.**—Mean densities of *Ammonia beccarii* at Indian River sampling sites.

**Figure 5.**—Mean densities of *Bolivina striatula* at Indian River sampling sites.
Figure 6.—Mean densities of *Buliminella elegantissima* at Indian River sampling sites.

Figure 7.—Mean densities of *Cyclogyra planorbis* at Indian River sampling sites.
**Figure 8.**—Mean densities of *Elphidium excavatum* at Indian River sampling sites.

**Figure 9.**—Mean densities of *Elphidium gunteri* at Indian River sampling sites.
**Figure 10.** Mean densities of *Elphidium kugleri* at Indian River sampling sites.

**Figure 11.** Mean densities of *Elphidium mexicanum* at Indian River sampling sites.
Figure 12.—Mean densities of *Gaudryina exilis* at Indian River sampling sites.

Figure 13.—Mean densities of *Nonionella auricula* at Indian River sampling sites.
**Figure 14.**—Mean densities of *Quinqueloculina impressa* at Indian River sampling sites.

**Figure 15.**—Mean densities of *Quinqueloculina seminula* at Indian River sampling sites.
Figure 16.—Mean densities of *Rosalina floridana* at Indian River sampling sites.

![Graph showing mean densities of Rosalina floridana](image)

Figure 17.—Mean densities of *Rosalina globularis* at Indian River sampling sites.

![Graph showing mean densities of Rosalina globularis](image)
analysis used a combination of some of the more abundant species, such as *Bolivina striatula* and *Buliminella elegantissima*, as well as some of the less abundant ones, such as *Gaudryina exilis* and *Elphidium gunteri*, for discriminating the various areas. The most abundant species, *Ammonia beccarii*, is of little importance in the analysis as it occurs abundantly everywhere (Figure 4).

The third, fourth, fifth and sixth canonical variates are statistically significant (Table 3) and together account for about 36% of the total variance. They do not, however, provide any particularly interpretable contrasts. Perhaps the only information that can be gleaned from them is that the Indian River is extremely variable, a fact confirmed by the canonical analysis attempted on the individual stations.

We will briefly review where each species has its maximum or peak density relative to other areas. For standardization, we define a peak density as one exceeding twice the average density of the species over the entire area.

At the Haulover station, *Cyclogyra planorbis* and *Quinqueloculina seminula* (Figure 15) exhibit peak densities. The Banana station has a maximum density achieved by *Q. impressa*, five times its average density. At Sebastian Inlet, *Elphidium mexicanum* attains its maximum density, four times greater than average. The John’s Island transect has peak densities for *E. excavatum* (Figure 8) and *E. gunteri*. At the Vero Beach transect, *E. gunteri* and *Rosalina floridana* reach their maximum densities of four to five times their average densities. The Link Port transect also has a peak density for *R. floridana*. Jim’s Flat has maximum densities for *E. excavatum* (Figure 8) and *E. gunteri*. At the Vero Beach transect, *E. gunteri* and *Rosalina floridana* reach their maximum densities of four to five times their average densities. The Link Port transect also has a peak density for *R. floridana*. Jim’s Flat has maximum densities for *E. excavatum*, *E. gunteri*, and *Rosalina floridana*. The Buoy 195 transect has a maximum density for *Ammonia beccarii* (Figure 4), by far the most abundant species in the Indian River (Table 5). *Ammobaculites exilis*, *Bolivina striatula*, *Buliminella elegantissima*, *E. kugleri*, and *G. exilis* also have high densities at the Buoy 195 transect. The Herman’s Bay transect has maximum densities for *Bolivina striatula*, the second most abundant species in the Indian River, and *Nonionella auricula*. At Jensen Beach all species have densities below their average, except for *G. exilis*, which maintains its average density. The St. Lucie transect has maximum densities for *G. exilis* and *R. globularis* (Figure 17). *Nonionella auricula* and *Q. seminula* are also abundant. The St. Lucie Inlet has maximum densities for *Buliminella elegantissima* and *E. excavatum*. The species *C. plan-
orbis, E. kugleri, and R. globularis also have high densities at the St. Lucie Inlet.

This brief review indicates that various areas in the Indian River are characterized or discriminated by different abundances of the 15 most common species. The trend of increasing density southward is shown clearly in Figure 18, which plots the mean number of total living individuals per 20-ml replicate. With the exception of the Jensen Beach transect, the density of foraminifera clearly increases in a southerly direction.

**Species Diversity**

The number of species found at the 12 areas is plotted on Figure 19 and listed in Table 5. In general there is an increase in the number of species encountered to the south. The greatest number of species was found at Buoy 195, Herman’s Bay, Jensen Beach, and St. Lucie transect. In the northern half of the Indian River, Vero Beach had the greatest number of species encountered.

Table 5 lists the values for the information function $H$ at the 12 areas, and Figure 20 is a plot of them. The same trend of increasing species diversity to the south is evident. Because the information function gives less weight to rare species, the amplitude of the curve is diminished. Some other differences are also notable. Maxima for the information function occur at Jim’s Flat and Jensen Beach, and an increase rather than a decrease occurs from St. Lucie transect to St. Lucie Inlet. This happens because the value of information function depends not only on the number of species but also upon their equitability (Gibson and Buzas, 1973).

A measure of species equitability, $E$ (Buzas and Gibson, 1969), is listed in Table 5 and plotted on Figure 21. At Haulover, Banana, and Sebastian, equitability is nearly constant, and the information function’s curve closely resembles the species number plot. At John’s Island, Vero Beach, and Link Port, the equitability values are again constant but at a lower level, and the plot of the information function still resembles the species number plot. The Jim’s Flat station has a rise in species equitability, whereas Buoy 195 has a decrease. The information function mimics this pattern and shows a higher value at Jim’s Flat than at Buoy 195, the opposite of the species number plot. The same situation occurs at the remaining southern stations so that the information function plot closely resembles that of species equitability. If the criterion for “species diversity” is the information function, then maxima occur at Jim’s Flat and Jensen Beach, areas with high equitabilities and number of species. If the criterion for “species diversity” is the number of species, then Buoy 195, Herman’s Bay, Jensen Beach, and St. Lucie transect would be chosen. In any case, a trend of increasing species diversity toward the south is observed.

Because the number of species is correlated with the number of individuals (Buzas et al., 1977), it is no surprise that the southern area has a higher number of species than the northern area. Figure 22 is a semilog plot of the number of individuals found in each area against the number of species. The areas with the greatest number of species, Herman’s Bay, St. Lucie transect, and Buoy 195, are also the areas with the greatest numbers of individuals. The Jensen Beach transect appears as an outlier in Figure 22. Although 10 replicates were collected in this transect, only 939 individuals were found, making Jensen Beach the area with the lowest mean density in the entire Indian River (Table 5). Nevertheless, 49 species were identified at Jensen Beach, and because the more abundant species occur there with low densities (Table 5), the equitability is higher than at adjacent stations. Consequently the information function reaches its maximum value at this transect.

We have not had an opportunity to investigate whether or not this anomalous pattern of low number of individuals and high number of species at Jensen Beach is due to some unique spatial pattern found only at that locality.

**Distribution of Rare Species**

The 15 most abundant species comprise 95% of the total living population for all areas except
Figure 19.—Number of species recorded at Indian River sampling sites.

Figure 20.—Values of information function at Indian River sampling sites.
Figure 21.—Values of equitability function at Indian River sampling sites.

Figure 22.—Semilog plot of individuals vs. species in the Indian River.

\[ S = -93.02 + 17.97 \ln N \]
Jim's Flat, Herman's Bay, and Jensen Beach (Table 5). At Jim's Flat the addition of 78 Ishamella apertura specimens brings the percentage from 88 to 96. *Ishamella apertura* could have been included with the most abundant species, as its grand total (79) is comparable to that of *Ammobaculites exilis* (83). Because this species is a very unusual foraminifer (see “Systematic Catalog”), and all specimens except one occur at Jim's Flat, we decided to exclude it from the analysis of the abundant species.

At Herman's Bay four rare species must be included to attain 95% of the total living population. These are *Ammobaculites* cf. *exilis* (53), *Hopkinsina pacifica* (22), *Quinqueloculina poeyana* (16), and *Bolivina* sp. B (13). The addition of *A. cf. exilis* alone brings the total to 95%, and it is possible that this species is merely a large grained form of *A. exilis* sensu stricto, which was included among the 15 most abundant species.

As pointed out earlier, Jensen Beach is very unusual because the total living population is low, and yet a large number of species was recorded there. At Jensen Beach eight species must be added to bring the total to 95%. These are: *Hopkinsina pacifica* (40), *Quinqueloculina poeyana* (9), *Elphidium advenum* (8), *Rosatina concinna* (8), *Fursenkoina fusiformis* (6), *Bolivina* sp. B (5), *Nonionella opima* (5), and *Quinqueloculina cf. akneriana* (5). This is the only area where more than 20 species are required to obtain 95% of the total living population.

The great disparity in densities among areas, the positive correlation between numbers of species and numbers of individuals, and the fact that 15 species almost always make up 95% of the total living population suggest that the use of rare species to discern meaningful spatial patterns is extremely hazardous. Because the probability of encountering a rare species is low, it is difficult to tell whether a species was not found because of chance or because it really wasn’t there. On the other hand, the relatively large number (78) of *Ishamella apertura* found at Jim's Flat while only one specimen was found elsewhere does suggest that this species may have a very restricted distribution. A similar, but more tenuous, pattern may exist for *Hopkinsina pacifica*, *Quinqueloculina poeyana*, and *Bolivina* sp. B. These species were found at the adjacent Herman's Bay and Jensen Beach stations and were members of those species that make up 95% of the total living population.

Finally, two species occur at St. Lucie Inlet and St. Lucie transect and nowhere else in the Indian River. *Peneroplis pertusus* and *Sorites marginalis* are well-known tropical species. They occur abundantly in Florida Bay (Bock, 1971) and are probably at the northernmost limits of their ranges.

**Discussion**

Ideally, studies concerned with the distribution of organisms would sample all areas simultaneously over a long period to average out seasonal fluctuations in density. Unfortunately, this is rarely feasible due to economic and time constraints. In the present study, samples were taken in February, March, April, June, September, and December (Table 2). Data from Link Port taken over a four-year period (Buzas, 1978; 1982; unpublished) indicate a substantial variation in density from month to month. In general the winter months (December, February, and March) have low densities, June a moderate density, and April a high density. If seasonality, or time, rather than location were responsible for the density pattern observed, we would expect moderate densities at Haulover, Banana, Sebastian, Jim's Flat, and St. Lucie Inlet (all sampled in June). We would expect low densities at John’s Island, Link Port, Buoy 195, Herman’s Bay, and St. Lucie transect (all sampled in winter). Finally, we would expect a high density at Jensen Beach (sampled in April). Figure 18 clearly shows this is not the case. Instead, there is an overall increase in density southward, with the exception of Jensen Beach, which has the lowest density of anywhere! Therefore, we believe that the observed density pattern is a consequence of the area sampled rather than time of sampling.

When studying the distribution of foraminifera, researchers usually divide the study area into faunal zones or biofacies (Boltovskoy and Wright, 1976). The biofacies are defined either on the
basis of examination of the data or by the use of some numerical or statistical technique (Buzas, 1979). Examination of data usually shows that boundaries between biofacies are rarely discrete. However, the use of some numerical techniques, such as cluster analysis, forces samples into one group or another, and the amount of overlap may not be apparent. The results of the canonical variate analysis performed on the 15 most abundant species in the Indian River (Figure 2) shows that the inlets and Haulover are distinct from other areas. They do not, however, form a homogeneous group themselves. Each is distinct and would have to be assigned its own biofacies. The second canonical axis shows a north-south trend or arrangement of areas. St. Lucie transect is clearly different from Banana or John’s Island, but the confidence circles from area to area overlap. At no point is there an indication of a simple break dividing, for example, the area into north and south biofacies. Consequently, we have decided not to designate any biofacies but to allow Figure 2 to stand as a representation of the foraminiferal distribution in the Indian River.

Young et al. (1976) reported an increase in density of decapods southward in the Indian River. In the adjacent ocean, Gore et al. (1978) found the same trend for the decapods inhabiting the sabellariid worm reefs that parallel the barrier island. On the other hand the macrobenthos, mostly polychaetes, exhibit a trend of decreasing density southward (Young et al., 1976; Young and Young, 1977). Amphipods inhabiting seagrass also have lower densities in southern areas as well as near inlets (Nelson et al., 1982). The decrease in density of macrobenthos and amphipods was attributed to predation by decapods on the former (Young et al., 1976; Young and Young, 1977) and by decapods and fish on the latter (Nelson et al., 1982).

Predation of foraminifera is common (Lipps and Valentine, 1970), and experiments indicate that foraminiferal densities in the Indian River are regulated by predation (Buzas, 1978; 1982). Buzas and Carle (1979) found foraminifera in the guts of deposit feeders, among them polychaetes and decapods. Unfortunately we do not know whether one group is more important in regulating foraminiferal density than the other. Consequently we cannot speculate with confidence as to whether or not the increase in foraminiferal densities southward is due to a change in predation pressure. The increase in density does correlate positively with increasing density of decapods and negatively with the densities of polychaetes and amphipods.

Young et al. (1976), Young and Young (1977), and Nelson et al. (1982) have pointed out a gradient of decreasing environmental variability toward the southern end of the Indian River. This decreasing gradient is positively correlated with the increase in foraminiferal density to the south. A similar pattern of higher foraminiferal density in an area of less environmental variability was reported by Buzas et al. (1977) in Jamaica, West Indies.

Hydrographically, the inlets and Haulover differ from other areas because they represent extremes of tidal influence. The inlets experience strong, diurnal tidal changes, whereas Haulover, in the “blind” end of the River, experiences almost no tidal influence at all. Each of these areas is discriminated by changes in the densities of the most abundant foraminiferal species in the Indian River. While species diversity generally increases southward, we observed no increase in species diversity at the three inlets. This contrasts markedly with Gilmore (1977), who found the highest number of fish species at inlets, and Mook (1980), who found an increased diversity of fouling organisms at Fort Pierce Inlet as compared to Vero Beach.

No studies of foraminifera have been made in estuaries near the Indian River. To the north in Pamlico Sound, North Carolina, Grossman (1967) defined several biofacies. Some biofacies are characterized by species such as Elphidium excavatum and E. gunteri, which also occur in the Indian River. In general, however, the Pamlico Sound fauna is very different from the Indian River fauna.

Farther south, foraminifera have been studied in Florida Bay and adjacent waters by Stubbs (1940), Bock et al. (1971), and Rose and Lidz
Bock (1971) and Rose and Lidz (1977) have defined biofacies containing abundant *Ammonia beccarii*, the dominant species in the Indian River. The foraminiferal fauna of these southern waters, however, does not closely resemble the fauna from the Indian River. The sediments to the south are mainly carbonates (Milliman et al., 1972), unlike the quartz sands of the Indian River. This carbonate sedimentary regime marks the northernmost extension of the Bahamian or Caribbean faunal province (Buzas and Culver, 1980), thus explaining why the foraminiferal species are so different between central and southern Florida.

**Systematic Catalog**

The following catalog uses the general systematic structure of the *Treatise of Paleontology* (Loeblich and Tappan, 1964), even though we believe the overall taxonomic philosophy of the *Treatise* is too rigid. For example, we have assigned species with both optically radial and granular walls to the genus *Elphidium*, although strict adherence to the *Treatise* would have placed them in different superfamilies. We believe, however, the systematic arrangement used here is more useful than an alphabetical scheme.

Where possible, our synonymies are based on direct inspection of the types cited. In a few cases the only specimens accessible were from Pacific collections or were type specimens.

Illustration of foraminifera is a continuing source of difficulty for researchers. Although it has become fairly easy to take high quality scanning electron micrographs, they do not convey the transparent qualities of foraminiferal tests, a severe drawback, as most work is done with optical microscopes. Furthermore, the gold coating necessary for scanning electron microscopy makes the specimen opaque and very difficult to use, subsequently, under a binocular microscope. The alternative, a good drawing by a scientific illustrator, does not harm the specimen and produces a view of the specimen as it appears under an optical microscope. For anything more than a small number of views, however, the time and expense are rarely justified.

In this study we have attempted to use scanning electron micrographs of very thinly coated specimens. The gold coating was 50 angstroms, about one-quarter of the thickness normally used. This coating is virtually transparent, and the specimens are still quite useful for optical work. The electron micrographs, however, tend to have charged areas and strange scan lines due to the inadequate conductivity of the thin coating. By using very low accelerating voltages (less than 5 KV), we were able to hold these bad effects to a minimum. In spite of this, a few of the figures have some visibly charged areas. We feel, however, that the preservation of the optical characters of the specimens warrants the defects in the figures.

Specimens deposited in the National Museum of Natural History, Smithsonian Institution, are listed under the abbreviation "USNM" (for the collection numbers of the former United States National Museum). Representatives of most species are deposited in the Indian River Coastal Zone Museum, Fort Pierce, Florida.

**HIERARCHY.—From order through genus:**

Order Foraminifera Eichwald, 1830
Suborder Allogromina Loeblich and Tappan, 1961
Superfamily Lagynacea Schultze, 1854
Family Allogromiidae Rhumbler, 1904
Genus Allogromia Rhumbler, 1904

Suborder Textularina Delage and Herouard, 1896
Superfamily Lituolacea de Blainville, 1825
Family Hormosinidae Haeckel, 1894
Subfamily Hormosininae Haeckel, 1894
Genus Reophax Montfort, 1808
Family Lituolidae de Blainville, 1825
Subfamily Lituolinidae de Blainville, 1825
Genus Ammobaculites Cushman, 1910

Family Trochamminidae Schwager, 1877
Subfamily Trochammininae Schwager, 1877
Genus Trochamina Parker and Jones, 1859
Family Atoxophragmidae Schwager, 1877
Subfamily Verneuilininae Cushman, 1911
Genus Gaudryina d'Orbigny, 1839

Suborder Miliolina Delage and Herouard, 1896
Superfamily Miliolacea Ehrenberg, 1839
Family Fischerinidae Millet, 1898
Subfamily Cyclopyrinæ Loeblich and Tappan, 1961
Genus *Cyclogya* Wood, 1842  
Family *Nubeculariidae* Jones, 1875  
Subfamily *Opthalmidiinae* Weisner, 1920  
Genus *Edentostomina* Collins, 1958  
Genus *Weisnerella* Cushman, 1933  
Subfamily *Spiroloculininae* Weisner, 1920  
Genus *Spiroloculina* d'Orbigny, 1826  
Family *Miliolidae* Ehrenberg, 1839  
Subfamily *Quinqueloculininae* Cushman, 1917  
Genus *Quinqueloculina* d'Orbigny, 1826  
Genus *Massilina*  
Genus *Pateoris* Loeblich and Tappan, 1953  
Genus *Triloculina* d'Orbigny, 1826  
Subfamily *Miliolinellinae* Vella, 1957  
Genus *Miliolinella* Weisner, 1931  
Genus *Biloculinella* Weisner, 1931  
Genus *Scutulons* Loeblich and Tappan, 1953  
Subfamily *Tubinellinae* Rhumbler, 1906  
Genus *Tubinella* Rhumbler, 1906  
Genus *Articulina* d'Orbigny, 1826  
Ishamella, new genus  
Family *Soritidae* Ehrenberg, 1839  
Subfamily *Peneroplinae* Schultze, 1854  
Genus *Peneroplis* Montfort, 1808  
Subfamily *Soritinae* Ehrenberg, 1839  
Genus *Sorites* Ehrenberg, 1839  
Suborder *Rotaliina* Delage and Herouard, 1896  
Superfamily *Nodosariaceae* Ehrenberg, 1838  
Family *Nodosariidae* Ehrenberg, 1838  
Subfamily *Nodosariinae* Ehrenberg, 1838  
Genus *Lagena* Walker and Jacob  
Genus *Ammonia* Briinnich, 1772  
Family *Elphidiidae* Galloway, 1933  
Subfamily *Elphidiinae* Galloway, 1933  
Genus *Elphidium* Montfort, 1808  
Genus *Haynesina* Banner and Culver, 1978  
Superfamily *Orbitoidacea* Schwager, 1876  
Family *Eponidae* Hofker, 1951  
Genus *Eponides* de Montfort, 1808  
Family *Cibicididae* Cushman, 1927  
Subfamily *Cibicidinae* Cushman, 1927  
Genus *Cibicides* de Montfort, 1808  
Family *Planorbulinidae* Schwager, 1877  
Genus *Planorbulina* d'Orbigny, 1826  
Family *Bolivinidae* Cushman, 1927  
Genus *Bolivina* d'Orbigny, 1839  
Family *Buliminidae* Jones, 1875  
Subfamily *Bulimininae* Jones, 1875  
Genus *Bulimina* d'Orbigny, 1826  
Genus *Pavonina* Eimer and Fickert, 1899  
Genus *Pavonia* d'Orbigny, 1826  
Family *Nonionidae* Schultze, 1854  
Subfamily *Nonioninae* Schultze, 1854  
Genus *Nonion* de Montfort, 1808  
Genus *Nonionella* Cushman, 1926  
Family *Anomaliniidae* Cushman, 1927  
Genus *Hanawaua* Asano, 1944  

Genus *Allogromia* Rhumbler, 1904  

?Allogromia species

Since the technique used in preparing the samples included several acetone rinses and drying under heat lamps, there is a good possibility that most of the allogromids present were destroyed. Perhaps these specimens are not *Allogromia* at all and may merely be pieces of debris that were stained by the rose bengal.

Specimens scattered throughout the Indian River are thus referred. (Total: 12; range: 0–3.)
Genus *Reophax* Montfort, 1808

*Reophax nana* Rhumbler

**Plate 1: figure 1**


A few specimens, mostly from the Fort Pierce and St. Lucie inlets, were referred to this category. Figured hypotype: USNM 310285. (Total: 18; range: 0–7.)

Genus *Ammobaculites* Cushman, 1910

*Ammobaculites exiguus* Cushman and Bronniman

**Plate 1: figures 2, 3**

*Ammobaculites exiguus* Cushman and Bronniman, 1948b:38, 39, pl. 7: figs. 7, 8.—Parker, 1952b:457, pl. 1: fig. 16.—Bandy, 1956:192, pl. 30: fig. 2.—Todd and Bronniman, 1957:23, pl. 2: fig. 7.—Lankford, 1959:2097, pl. 1: fig. 9.

The specimens referred to this category are generally more slender than those referred to *Ammobaculites exilis* and have a much rounder cross section in the uniserial portion. For a further discussion see *A. exilis*.

All but one of the specimens are from the Buoy 195 transect.

Figured hypotype: USNM 310280. (Total: 6; range: 0–4.)

*Ammobaculites exilis* Cushman and Bronniman

**Plate 1: figures 4, 5**

*Ammobaculites exilis* Cushman and Bronniman, 1948b:38, pl. 7: fig. 9.—Bandy, 1956:192, pl. 30: fig. 3.—Buzas, Smith, and Beem, 1977:64, pl. 1: figs. 5, 6.

All specimens referred to this category are fine grained and match the holotype and paratypes well. The neck is generally compressed. Only a few of the specimens are uncoiling, and only a few have distinct sutures.

Although some authors have chosen to synonymize *Ammobaculites exilis* with *A. exiguus*, we feel that in the Indian River there are two distinct populations: one, *A. exilis*, is compressed and only slowly uncoiling into a uniserial section; the other, *A. exiguus*, is rather inflated and has a distinct break between the coiled early section of the test and the cylindrical uniserial later portion.

This species occurs throughout the Indian River and is most abundant near Fort Pierce Inlet (Jim’s Flat of this study).

Figured hypotype: USNM 310281. (Total: 83; range: 0–23.)

*Ammobaculites cf. exilis* Cushman and Bronniman

**Plate 1: figures 6, 7**

Specimens thus referred are similar in shape to *Ammobaculites exilis* sensu stricto but have tests composed of much coarser grains. As we do not see a gradational series between the coarse- and fine-grained forms and do find both forms in the same replicate, we do not feel that the forms are conspecific. Unfortunately there are never more than three of each form in a replicate, and so it is possible that we never see a large enough sample to get a complete view of the population.

*Ammobaculites cf. exilis* is the only form of *Ammobaculites* found at Herman’s Bay. Perhaps further investigation would reveal the sediment there to be composed of coarser-than-average grains.

Figured specimen: USNM 310282. (Total: 69; range: 0–20.)

Genus *Trochamina* Parker and Jones, 1859

*Trochamina cf. advena* Cushman

**Plate 1: figures 8, 9**

The specimens referred to this category have deeper sutures than do the types from the Dry Tortugas, designated by Cushman in 1922. They resemble *Trochamina cf. advena* of Phleger, Parker, and Peirson (1953). They also resemble the specimens designated *T. advena* by Phleger and Parker (1951) and Parker (1952a, 1954). They differ
enough from the primary types, and so we feel that synonymization cannot be made.
Most of the specimens were collected at Buoy 195.
Figured specimen: USNM 310286. (Total: 11; range: 0–4.)

_Trochamina ochracea_ (Williamson)

Plate 1: figures 10, 11

_Rotalina ochracea_ Williamson, 1858:55, pl. 4: fig. 112; pl. 5: fig. 113.
_Trochamina ochracea_ (Williamson).—Cushman 1944:19, pl. 2: figs. 12, 13.—Parker, 1952a:408, 409, pl. 4: figs. 13, 14; 1952b:460, pl. 3: fig. 5.—Todd and Low, 1961:16, pl. 1: fig. 18.

Our specimens have the compressed concave-convex test and umbilical flaps characteristic of this normally deep-water species.
Most were found in the southern part of the Indian River.
Figured hypotype: USNM 310287. (Total: 25; range: 0–8.)

_Trochamina species_

Three small specimens are thus referred. Unfortunately, the single unbroken specimen was lost. This specimen had a high spire and clearly showed three chambers in the final whorl.
All specimens were collected at Buoy 195. (Total: 3; range: 0–3.)

_Genus Gaudryina_ d’Orbigny, 1839

_Gaudryina exilis_ Cushman and Bronniman

Plate 1: figures 12, 13


The specimens compare well with the holotype and paratypes, ranging from long and slender to short and squat. Some of the longer individuals tend toward being triserial, but all fit within the range of the numerous paratypes designated by Cushman.
This species is found only south of Sebastian Inlet and is most abundant south of Fort Pierce Inlet.
Figured hypotypes: USNM 310283, 310284. (Total: 158; range: 0–26.)

_Genus Cyclogyra_ Wood, 1842

_Cyclogyra planorbis_ (Schultze)

Plate 1: figure 14

_Cornuspira planorbis_ Schultze, 1854:40, pl. 2: fig. 21.—Phleger and Parker, 1951:8, pl. 4: figs. 8, 9.—Todd and Bronniman, 1957:30, pl. 4: fig. 8.
_Cornuspira involvens_ (Reuss).—Cushman, 1921:62; 1922a:58; 1941:7.—Cushman and Parker, 1931:5, pl. 2: fig. 1.

Our specimens show very little variation, all having three whorls. The small prolocular chamber matches well that of Buzas et al. (1977, unfigured) and Haake (1975, unfigured).
_Cyclogyra planorbis_ is one of the species characteristically occurring at Haulover and the inlets.
Figured hypotype: USNM 310247. (Total: 162; range: 0–67.)

_Genus Edentostomina_ Collins, 1958

_Edentostomina cultrata_ (Brady)

Plate 1: figures 15, 16

_Miliolina cultrata_ Brady, 1884:161, pl. 5: figs. 1, 2.
_Quinqueloculina cultrata_ (Brady).—Todd and Bronniman, 1957:27, pl. 3: fig. 14.—Parker, Phleger, and Peirson, 1953:12, pl. 2: figs. 7, 8.—Lankford, 1959:2099, pl. 1: fig. 15.
_Edenlosomina cultrata_ (Brady).—Haake, 1975:19, pl. 1: figs. 5, 6.

The specimens deposited in the Cushman collection by Haake are not those illustrated by him but are from the same material.
Our five specimens range from the well-rounded form with no neck (Lankford, 1959) to the keeled form with a long neck (Haake, 1975).
They occur mainly in the southern part of the Indian River.
Edentostomina cf. cultrata (Brady)

The single specimen thus assigned differs from Edentostomina cultrata sensu stricto in having longitudinal striations. Unfortunately the specimen was lost during mounting for SEM.

The specimen was found at Buoy 195. (Total: 1; range: 0–1.)

Genus Weisnerella Cushman, 1933

Weisnerella auriculata (Egger)

Plate 1: figure 17

Planispirina auriculata Egger, 1893:245, 246, pl. 3: figs. 13–15.—Cushman, 1922a:62, pl. 10: fig. 8; 1929a:93, 94, pl. 22: fig. 3.

Weisnerella auriculata (Egger).—Cushman 1933a:33, pl. 3: figs. 7–9.—Parker, 1954:501, 502, pl. 5: fig. 13.

Our specimens match well the specimens in the Cushman collection. This widely distributed species is remarkable in its invariant appearance.

This species was found only at the St. Lucie transect.

Figured hypotype: USNM 310279. (Total: 17; range: 0–5.)

Genus Spiroloculina d’Orbigny, 1826

Spiroloculina depressa d’Orbigny

Plate 2: figures 1, 2

Spiroloculina depressa d’Orbigny, 1826:298; “Modèle” no. 92.—Bandy, 1956:197, pl. 29: fig. 2.

Our single specimen has a bifid tooth and a small opposing simple tooth, just as many of the examined topotypes. Although Bandy’s figured specimen does not have the opposing tooth, many specimens from the same study do.

The specimen was found at Jensen Beach.

Figured hypotype: USNM 310276. (Total: 1; range: 0–1.)

Genus Quinqueloculina d’Orbigny, 1826

Quinqueloculina agglutinans d’Orbigny

Plate 2: figures 3–6

Quinqueloculina agglutinans d’Orbigny, 1839a:195, pl. 12: figs. 11–13.—Cushman, 1929a:22, pl. 1: fig. 1.—Bandy, 1956:196.—Todd and Bronniman, 1957:27, pl. 3: fig. 4.—Bock, 1971:16, pl. 4: figs. 3–5.

Our specimens are smaller than most of the specimens in the Cushman collection and have tests composed of better-sorted sand grains. Only a few of the specimens have the bifid tooth common to the larger specimens deposited in the Cushman collection.

A few scattered specimens were found throughout the Indian River.

Figured hypotypes: USNM 310260, 310261. (Total: 14; range: 0–3.)

Quinqueloculina cf. akneriana d’Orbigny

Plate 2: figures 7, 8

The specimens referred to this category are smaller than the topotypes in the Cushman collection and generally have sharper peripheries. Some approach the almost stellate appearance of Quinqueloculina lamarkiana but as a group are closer to Q. akneriana. Although there is one small topotype in the Cushman collection that seems to be conspecific with our specimens, the general ranges of the two groups do not overlap.

This species was found only south of Fort Pierce Inlet.

Figured specimen: USNM 310262. (Total: 19; range: 0–4.)

Quinqueloculina cf. bidentata d’Orbigny

Plate 2: figures 9, 10

Our specimens are finer grained than most of those in the Cushman collection. The surface has some attached grains and the small bifid tooth shown in d’Orbigny’s drawings and in the micrographs of Le Calvez’s topotypes (1977).
This species was found in three replicates, two from Herman’s Bay and one from Jensen Beach. The figured specimen: USNM 310263. (Total: 9; range: 0–5.)

**Quinqueloculina carinata-striata** (Weisner)

Plate 2: figures 11–13

*Adelosina milletti* Weisner var. *carinata-striata* Weisner, 1923:76, 77, pl. 44: figs. 190, 191.

Although we have not examined any specimens of this species, Weisner’s drawing is very good and leaves little doubt as to the conspecificity of our specimens. The specimens are heavily costate with an angled periphery. The costae are not parallel to the periphery but meet at it to form a small keel. The aperture is round with a small simple tooth.

Five individuals were found throughout the Indian River.

Figured hypotype: USNM 310264. Hypotypes: USNM 310308, 310309. (Total: 5; range: 0–2.)

**Quinqueloculina goesi** (Weisner)

Plate 2: figures 14–17

*Miliolina goesi* Weisner, 1923:52, 53, pl. 7: fig. 79.

*Quinqueloculina goesi* (Weisner).—Haake, 1975:33, 34, pl. 3: figs. 58, 59, pl. 4: figs. 60–66.

The type figure of this species shows a specimen with chambers that have a rectangular cross section. Although some of the specimens illustrated by Haake have a similar rectangular cross section, others are more rounded. The specimens deposited in the Cushman collection by Haake range in form from rounded to sub-rounded. Only a few of our specimens displayed the rounded cross section; most have the rectangular cross section that is more typical of the species.

Most of the specimens were found at Herman’s Bay; a few were found in the northern portion of the Indian River.

Figured hypotypes: USNM 310265, 310266. (Total: 20; range: 0–5.)

**Quinqueloculina gualtieriana** d’Orbigny

Plate 3: figures 1, 2

*Quinqueloculina gualtieriana* d’Orbigny, 1839a:186, pl. 11: figs. 1–3.

There are no figured specimens of this species from the Atlantic in the Cushman collection. Our specimens, however, match the SEM of Le Calvez (1977) and d’Orbigny’s figures, their long, thin simple tooth being characteristic.

Two representatives of this species were found in one replicate from St. Lucie Inlet.

Figured hypotype: USNM 310267. (Total: 2; range: 0–2.)

**Quinqueloculina impressa** Reuss

Figure 23; Plate 3: figures 3, 4

*Quinqueloculina impressa* Reuss, 1851:87, pl. 7: fig. 59.—Haake, 1975:24, pl. 1: figs. 24, 25.

Our specimens have a well-rounded outline, both in side view and in apertural view. Some authors have listed similar forms as *Quinqueloculina akneriana* or *Q. lamarkiana*, but examination of
topotypes shows *Q. impressa* to be much more rounded than either.

Surprisingly, this common Indian River millolid has not been described from elsewhere in Florida or even from the east coast of North America (Culver and Buzas, 1980).

Figured hypotypes: USNM 310268, 310299. Hypotypes: USNM 310298, 310300, 310301, 310302, 310303, 310304, 310305, 310306, 310307. (Total: 961; range: 0–92.)

**Quinqueloculina poeyana** d'Orbigny

**Plate 3: figures 5, 6**

*Quinqueloculina poeyana* d'Orbigny, 1839a:191, pl. 11: figs. 25–27.—Cushman, 1921:67, fig. 9, pl. 16: figs. 7, 8; 1929a:31, pl. 5: fig. 2.—Parker, Phleger, and Peirson, 1953:12, pl. 2: figs. 13, 14.—Bandy, 1956:196, pl. 29: fig. 6.—Todd and Bronnimann 1957:27, pl. 3: fig. 6.—Todd and Low, 1971:c-8, pl. 2: fig. 4.

This widely distributed species tends to be rather small in most of our samples. Most of our specimens have a long simple tooth with a bifid tip like the neotype designated by Le Calvez (1977). D'Orbigny described the species as having a simple tooth. The specimens in the Cushman collection have teeth that range from bifid to almost no tooth at all.

Most of the specimens were found in the southern half of the Indian River.

Figured hypotype: USNM 310269. (Total: 46; range: 0–11.)

**Quinqueloculina seminula** (Linne)

**Plate 3: figures 7, 8**

*Serpula seminula* Linne, 1758:786.

*Quinqueloculina seminula* (Linne).—Cushman 1917:44, 45, fig. 29, pl. 11: fig. 2; 1929a:24, 25, pl. 2: fig. 2; 1929b:59, 60, pl. 9: fig. 18; 1944:13, pl. 2: fig. 14.—Parker, Phleger, and Peirson, 1953:12, pl. 2: figs. 18, 19.—Parker, 1952a:406, pl. 3: fig. 21, pl. 4: fig. 1; 1952b:456, pl. 2: fig. 7.—Todd and Bronnimann, 1957:27, pl. 3: figs. 9, 10.—Todd and Low, 1961:15, pl. 1: fig. 14.—Buzas, 1965a:56, pl. 1: fig. 6.

Most of the specimens of this species are rather small, with many of them having transluscent rather than porcelanous walls. Some of them approach the form Haake (1975) called *Quinqueloculina pygmaea*. However, having examined a large number of specimens over a wide size range, there can be little doubt that the abundant and widely distributed *Q. seminula* appears in large numbers throughout the Indian River.

Figured hypotype: USNM 310270. (Total: 1297; range: 0–192.)

**Quinqueloculina cf. striata** d'Orbigny

**Plate 3: figures 9, 10**

Two specimens with very fine striations were referred to this category. They are less elongate than *Quinqueloculina striata* sensu stricto.

One specimen is from Buoy 195; the other is from Jensen Beach.

Figured specimen: USNM 310271. (Total: 2; range: 0–1.)

**Quinqueloculina tenagos** Parker

**Plate 3: figures 11, 12**

*Quinqueloculina costata* d'Orbigny, 1826:301.—Cushman, 1922a:66, 67, pl. 11: fig. 5; 1929a:31, pl. 3: fig. 7.

*Quinqueloculina rhodiensis* Parker in Parker, Phleger, and Peirson, 1953:12, pl. 2: figs. 15–17.

*Quinqueloculina tenagos* Parker, 1962:110.

Eight specimens were referred to this category. They are all heavily costate; some have a short neck. The aperture is circular and contains a small short bifid tooth. This species is overall shorter and more rounded in outline than *Quinqueloculina poeyana*.

Figured hypotype: USNM 310272. (Total: 8; range: 0–3.)

**Quinqueloculina species**

**Plate 3: figures 13, 14**

The aperture of this species is about one-fifth of the way from the end of the elongate test and includes a very small bifid tooth. In apertural view the test is slightly stellate.
Both specimens thus referred are from Jensen Beach.

Figured specimen: USNM 310273. (Total: 2; range: 0–2.)

**Genus Massilina Schlumberger, 1893**

?Massilina species

*Plate 3: figures 15, 16*

The single specimen thus referred is not compressed as Loeblich and Tappan (1964) define the genus. It does, however, have a bifid tooth, early quinqueloculine chambers, and later chambers added in a single plane.

The specimen was found at Jim’s Flat.

Figured specimen: USNM 310249. (Total: 1; range: 0–1.)

**Genus Pateoris Loeblich and Tappan, 1953**

*Pateoris dilitata (d’Orbigny)*

*Plate 4: figures 1, 2*

*Quinqueloculina dilitata* d’Orbigny, 1839a:192, pl. 11: figs. 28–30.—Cushman, 1921:67, figs. 7, 8, pl. 16: figs. 5, 6; 1922a:69, pl. 12: fig. 2; 1929a:26, pl. 2: fig. 5.

Three battered representatives of this species were found at the St. Lucie Inlet.

Figured hypotype: USNM 310258. (Total: 3; range: 0–3.)

**Genus Triloculina d’Orbigny, 1826**

*Triloculina cf. trigonula* (Lamarck)

*Plate 4: figures 3, 4*

The specimens referred to this category match very well those of *Triloculina cf. trigonula* collected by Cushman from Cape Canaveral and referred to by Todd (1979). They are much more rounded than *T. trigonula* sensu stricto but have a similar aperture with a large bifid tooth.

The nine specimens referred to this category were all collected south of Fort Pierce Inlet. Seven of the specimens were found in a single replicate from Herman’s Bay.

Figured specimen: USNM 310277. (Total: 9; range: 0–7.)

**Genus Miliolinella Weisner, 1931**

*Miliolinella subrotunda* (Montagu)

*Plate 4: figures 5, 6*


*Miliolinella subrotunda* (Montagu).—Loeblich and Tappan, 1964:c466, 467, pl. 355: fig. 1.—Haake, 1975:39, 40, pl. 5: figs. 94–97.

*Miliolinella labiosa* (d’Orbigny).—Todd and Bronniman, 1957:28, pl. 3: figs. 21, 22.

*Miliolinella subrotunda* is a species that shows much variation. The tests are generally triloculine in structure, but in our specimens they seem to range in form to quinqueloculine. According to Loeblich and Tappan (1964), this would put those specimens into the genus *Scutuloris*. We see a smooth merge from one form to another in our specimens.

Our specimens all have terminal apertures that contain a flap. Some have lips on the aperture. All are smoothly rounded, although some are fairly elongate. As mentioned above, some are trioculine, some are quinqueloculine, and others are in between.

All but one of our specimens were found at the Haulover Canal station.

Figured hypotype: USNM 310250. Hypotypes: USNM 310251, 310252, 310253. (Total: 7; range: 0–3.)

*Miliolinella cf. subrotunda* (Montagu)

*Plate 4: figures 7, 8*

A single specimen was thus referred. It differs from *Miliolinella subrotunda* sensu stricto in that it possesses light longitudinal costae. It may indeed be *M. subrotunda* sensu stricto, but we see no gradation to this form.

The specimen was found at Haulover Canal.

Figured specimen: USNM 310256. (Total: 1; range: 0–1.)
The overall outline of the single specimen thus referred is similar to that of *Miliolinella fictellina*, but the aperture is turned sideways, similar to that of *Weisnerella*. The aperture is nearly filled by a large bifid tooth. The margin is acute, and the surface is smooth.

The specimen was found in the St. Lucie transect.

Figured specimen: USNM 310257. (Total: 1; range: 0–1.)

**Genus Biloculinella Weisner, 1931**

*Biloculinella globula* (Bornemann)

Plate 4: figures 11, 12

*Biloculinella globula* Bornemann, 1855:349, pl. 19: fig. 3.

This bilocular miliolid has a large apertural flap instead of the bifid tooth of *Pyrgo*.

A few specimens were found at Herman’s Bay and Jensen Beach.

Figured hypotype: USNM 310246. (Total: 9; range: 0–4.)

**Genus Scutuloris Loeblich and Tappan, 1953**

*Scutuloris* species

Plate 4: figures 13, 14

The specimens referred to this category are very similar to *Quinqueloculina impressa* but have a slitlike aperture instead of a bifid tooth. There is no well-developed flap in the aperture, but the specimens seem best referred to *Scutuloris*. As mentioned under *Miliolinella subrotunda*, Loeblich and Tappan (1964) define *Miliolinella* and *Scutuloris* as differing only in that the former is triserial and the latter is quinqueloculine. Although we include some quinqueloculine forms in *Miliolinella*, we do not see any triloculine forms, or even any forms tending toward trioculine, in the specimens we are referring to *Scutuloris*.

Most of the specimens were found south of Fort Pierce Inlet.

Figured specimen: USNM 310274. Mentioned specimen: USNM 310275. (Total: 11; range: 0–4.)

**Genus Tubinella Rhumbler, 1906**

*?Tubinella* species

Plate 4: figure 15

The specimens thus referred are broken and do not show the uniserial portion of the test at all well; hence, the tentative assignment.

All four specimens were found at Jim’s Flat.

Figured specimen: USNM 310278. (Total: 4; range: 0–3.)

**Genus Articulina d’Orbigny, 1826**

*Articulina cf. pacifica* Cushman

Plate 4: figure 16

Our single specimen is only very slightly costate, unlike Cushman’s types from Fiji, which have rather heavy costae. It does have the same wide lip and overall shape as Cushman’s smaller, two-chambered paratype. In offshore samples we have found specimens that are costate and are *Articulina pacifica* sensu stricto, and perhaps our specimen is merely a smooth form.

The single specimen was found at Jensen Beach.

Figured specimen: USNM 310245. (Total: 1; range: 0–1.)

**Ishamella, new genus**

Test free; chambers inflated, two in number, closely appressed; septum vestigial; wall calcareous, imperforate; aperture terminal.

This simply constructed genus may be related to *Tubinella*. Like *Tubinella*, the proloculus is large, with the second chamber closely appressed, and it has a vestigial septum. Unlike *Tubinella*, it lacks any final tubular chambers.

The genus is named for Lawrence B. Isham,
FIGURE 24.—Ishamella apertura, USNM 310310, holotype, × 240: a, front view; b, back view; c, side view; d, apertural view; e, transverse section.
who, with his excellent drawings of foraminifera, has contributed more to foraminiferal taxonomy than words can say.

Gender: feminine.

**Type-Species.**—Ishamella apertura, new species.

**Ishamella apertura, new species**

*Figure 24*

Test small; chambers inflated, two in number consisting of proloculus and closely, appressed second chamber, proloculus about twice as large as second chamber, proloculus sometimes with slight folds; septum vestigial; wall calcareous, imperforate, translucent milky color when dry, hyaline when wet; aperture terminal, large, ovate, with a slightly thickened lip.

Figure 24a–d comprises drawings of the holotype of Ishamella apertura. Figure 24e, a transverse section of *I. apertura*, shows the vestigal septum at the junction of the two chambers. The specific name is derived from the large and prominent aperture of the species.

In all, 79 specimens of *I. apertura* were found in the Indian River. The total number of individuals of *I. apertura* is only slightly less than that of Ammobaculites exilis, the least abundant of the 15 most abundant species. Other species with similar densities occur at several areas within the Indian River. With the exception of a single individual found at St. Lucie Inlet, all individuals of *I. apertura* were found at Jim's flat. Perhaps this is a newly arrived or newly evolved species. In any case, the extremely localized distribution of this species is unusual.

The length, width, and thickness in millimeters of the holotype is .27, .19, and .18, respectively. The mean and standard deviation for 12 paratypes are given below.

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<td>Thickness</td>
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Holotype: USNM 310310. Paratypes: USNM 310311, 310312, 310313, 310314. (Total: 79; range: 0–67.)

**Genus Peneroplis Montfort, 1808**

*Peneroplis pertusus* (Forskål)

*Plate 5: figure 1*

*Nautilus pertusus* Forskål, 1775:125.—Brady, 1884:204, pl. 13: figs. 16, 17, 23.

*Peneroplis pertusus* (Forskål).—Cushman, 1921:75, pl. 18: figs. 7, 8; 1930:35, pl. 12: figs. 3–6.—Bock, 1971:34, pl. 13: fig. 10.

None of our specimens were uncoiling; however, they match Cushman's specimens well.

All specimens of this species were found at St. Lucie Inlet.

Figured hypotype: USNM 310259. (Total: 7; range: 0–3.)

**Genus Sorites Ehrenberg, 1839**

*Sorites marginalis* (Lamarck)

*Orbulites marginalis* Lamarck, 1816:196.

*Sorites marginalis* (Lamarck).—Cushman, 1930:49, 50, pl. 18: figs. 1–4.—Bock, 1971:36, 37, pl. 14: figs. 5, 6.

All representatives of this species were found at St. Lucie Inlet or St. Lucie transect, the southernmost areas in the river. This species is common near Miami (Bock, 1971); thus the Indian River may be near the northern range boundary of the species.

(Total: 5; range: 0–3.)

**Genus Lagena Walker and Jacob**

*Lagena cf. doveyensis* Haynes

*Plate 5: figure 2*

Our specimens are similar to those described by Haynes (1973:82, 83, pl. 12: figs. 7, 8). The specimens have long slender tests that taper gradually to a neck. The end of the neck may have a phialine lip; however, the neck on our specimens is so delicate that the lip is frequently broken. Our specimens differ from Haynes' in that his specimens are much larger and have about 20 striations around the base of the test, whereas ours have only about 15, and in that our speci-
mens have a flattened, not rounded, base on the test.

All our specimens were found in the southern part of the Indian River.

Figured specimen: USNM 310182. (Total: 10; range: 0–3.)

Optically: radial.

**Genus Fissurina Reuss, 1850**

**Fissurina lucida** (Williamson)

**Plate 5: figure 3**

*Entosolenia marginata* (Montagu) var. *lucida* Williamson, 1848:17, 18, pl. 2: fig. 17.

_Fissurina lucida* (Williamson).—Loeblich and Tappan, 1953:76, 77, pl. 14: fig. 4.—Todd and Low, 1967:28, pl. 3: fig. 31.

This small species has a very distinctive clear area in the center of the test, surrounded by a frosted horseshoe-shaped margin. The test is slightly compressed with a rounded margin. A few specimens have a very small spine opposite the aperture, as does the specimen of Todd and Low.

Although none of the figured specimens in the Cushman collection are from the Florida area, the species was reported on the Southeastern Continental Shelf by Wilcoxon (1964).

Scattered specimens were found throughout the Indian River.

Figured hypotype: USNM 310183. (Total: 29; range: 0–5.)

Optically: radial.

**Fissurina species**

**Plate 5: figure 4**

A single specimen with an elongate and well-rounded test is referred to this category. The surface of the test is frosted and opaque.

The specimen was found in the St. Lucie transect.

Figured specimen: USNM 310184. (Total: 1; range: 0–1.)

Optically: radial.

**Genus Buliminella Cushman, 1911**

**Buliminella elegantissima** (d'Orbigny)

**Plate 5: figure 5**

_Buliminella elegantissima* d'Orbigny, 1839b:51, pl. 7: figs. 13, 14.

_Buliminella elegantissima* (d'Orbigny).—Cushman and Parker, 1931:13, pl. 3: figs. 12, 13.—Phleger and Parker, 1951:17, pl. 8: figs. 3, 4.—Parker, Phleger, and Pierson, 1953:6, 7, pl. 4: figs. 8, 9.—Bandy, 1956:193.—Todd and Bronniman, 1957:32, pl. 8: figs. 1, 2.—Lankford, 1959:209, pl. 2: fig. 16.—Buzas, Smith, and Beem, 1977:71, 72, pl. 1: figs. 19, 20.

In addition to the above specimens, many unfigured specimens in the Cushman collection have been examined and found to be conspecific.

This widespread species is found in greatest abundance near the inlets, suggesting it is an open-water species.

Figured hypotype: USNM 310214. (Total: 1257; range: 0–118.)

Optically: radial.

**Genus Bolivina d'Orbigny, 1839**

**Bolivina cf. compacta** Sidebottom

**Plate 5: figure 6**

Only one specimen was referred to this category. It has no striations, is coarsely perforate, and is rather inflated. Although it might be considered an extreme form of _Bolivina striatula_, it is probably better referred to _B. cf. compacta_, as we see no gradation to this form.

The specimen was collected at Link Port.

Figured specimen: USNM 310192. (Total: 1; range: 0–1.)

Optically: radial.

**Bolivina paula** Cushman and Cahill

**Plate 5: figure 7**

_Bolivina paula* Cushman and Cahill in Cushman and Ponton, 1932:84, pl. 12: fig. 6.—Cushman, 1937:91, pl. 11: fig. 9.—Cushman and McGlamery, 1938:107, 108, pl. 25: figs. 14, 18, 19.—Parker, 1954:516, pl. 7: fig. 26.—Buzas, Smith, and Beem, 1977:74, pl. 2: figs. 1, 2.
A few of our specimens are opaque like the holotype, but most are translucent to transparent. Perhaps the opacity of these specimens is due to weathering, particularly for the holotype, named from the Miocene. All specimens have flush arculate sutures that do not cross the median. The periphery is smoothly rounded. Most specimens flair rapidly. Although most of our specimens have few pores, those pores that exist are concentrated along the sutures, as they are on the holotype.

Most of the specimens referred to this species were found south of Fort Pierce Inlet.

Figures hypotype: USNM 310193. (Total: 34; range: 0–11.)
Optically: radial.

**Bolivina striatula Cushman**

Plate 5: figure 8

Bolivina striatula Cushman, 1922a:27, 28, pl. 3: fig. 10; 1941:10.—Parker, Phleger, and Peirson, 1953:6, pl. 4: figs. 4, 5.—Bandy, 1954:135, 136, pl. 31: fig. 9; 1956:193.—Todd and Bronniman, 1957:34, pl. 8: figs. 12–16.—Lankford, 1959:2097, pl. 3: fig. 6.—Buzas, Smith, and Beem, 1977:75, 76, pl. 2: figs. 5–10.

Although this species shows much variation, it forms a distinct species. Most specimens have parallel sides and slightly depressed sutures, giving a slightly lobe periphery. The margin is well rounded; the test is compressed.

Smaller specimens tend to flair slightly; it seems that only the later chambers are added in parallel fashion. The test is usually transparent, although extremely dense striations, particularly near the base, may make the test opaque. The striations are most prominent on the initial third of the test. Only a few of the specimens were totally lacking in striations; Buzas, Smith, and Beem (1977) reported as many as a third to be nonstriate.

Although this species is common throughout the Indian River, it is most abundant in the southern portion.

Figured hypotype: USNM 310194. (Total: 2462; range: 0–271.)
Optically: radial.

**Bolivina subexcavata Cushman and Wickenden**

Plate 5: figure 9

Bolivina subexcavata Cushman and Wickenden, 1929:9, pl. 4: fig. 4.—Todd and Bronniman, 1957:34, pl. 8: fig. 29.—Buzas, Smith, and Beem, 1977:76–78, pl. 2: figs. 11–22.

Bolivina plicatella Cushman.—Cushman and Parker, 1931:15, 16, pl. 3: fig. 19.—Cushman, 1937:89, pl. 11: figs. 3.4.

Bolivina plicatella var. merula Cushman and Ponton.—Todd and Bronniman, 1957:33, pl. 8: fig. 30.

A good discussion of this variable species is given by Buzas, Smith, and Beem (1977). Our specimens generally have slowly tapering biserial tests composed of about 10–12 chambers. The surface of the chambers is rough, giving the specimens a frosted appearance. The sutures are depressed and only slightly, if at all, curved. Some of the specimens have fine longitudinal striations, particularly on the early portion of the test.

Most of the specimens thus referred were found at Buoy 195 and the St. Lucie Inlet.

Figured hypotype: USNM 310195. (Total: 49; range: 0–6.)
Optically: radial.

**Bolivina sp. A**

Plate 5: figure 10

The test is long and narrow. The chambers are inflated, and the sutures are slightly depressed. The pores are fine and concentrated on the lower half of the chambers, making them almost opaque. The earliest chambers are almost completely covered with pores.

The specimens are similar to the middle Oligocene topotypes of Bolivina beyrichi Reuss, but the later are more compressed and flair more.

This species was found at only one station of the Buoy 195 transect.

Figured specimen: USNM 310196. (Total: 3; range: 0–3.)
Optically: radial.

**Bolivina sp. B**

Plate 5: figure 11

Our specimens are translucent with moderately depressed sutures and inflated chambers. Most of
the specimens are parallel sided. The chambers have few pores; those present are concentrated along the base of the chambers.

Of the 35 specimens found, 18 occurred at Herman’s Bay and Jensen Beach, where they were part of the group that composed 95% of the total living population.

Figured specimen: USNM 310197. (Total: 35; range: 0–6.)
Optically: radial.

Genus Bulimina d’Orbigny, 1826

Bulimina acculeata d’Orbigny

PLATE 5: FIGURE 12
Bulimina acculeata d’Orbigny, 1826:269.—Cushman and Parker, 1938:92, pl. 6: figs. 9, 10.—Phleger, 1939:1403, pl. 3: fig. 24.—Cushman, 1944:28, pl. 3: fig. 47.—Phleger and Parker, 1951:15, pl. 7: fig. 23.

The topotypes in the Cushman collection (Cushman and Parker, 1938) are larger and more opaque than any of our specimens. However, our specimens have the radiating spines that are common to this species and which serve to differentiate it from Bulimina marginata d’Orbigny, which has serrated margins on its chambers.

Most of our specimens were found at Herman’s Bay.

Figured hypotype: USNM 310209. (Total: 13; range: 0–5.)
Optically: radial.

Genus Pavonina d’Orbigny, 1826

?Pavonina species

PLATE 5: FIGURE 13

A single small specimen is tentatively referred to Pavonia. It has the low arched chambers and radial wall structure common to the genus but is very finely perforate. Owing to its small size, it is difficult to tell whether or not the specimen has the initial triserial stage of the genus.

The specimen was found at St. Lucie Inlet.

Figured specimen: USNM 310233. (Total: 1; range: 0–1.)
Optically: radial.

Genus Hopkinsina Howe and Wallace, 1932

Hopkinsina pacifica Cushman

PLATE 5: FIGURE 14
Hopkinsina pacifica Cushman, 1933b:86, pl. 8: fig. 16.—Todd and Bronniman, 1957:35, 36, pl. 9: figs. 3, 4.
Hopkinsina pacifica var. atlantica Cushman, 1944:30, pl. 4: fig. 1.
Hopkinsina pacifica var. atlantica Cushman.—Parker, 1952b:451, pl. 4: figs. 14–16.

Although some authors have called the Atlantic version of Hopkinsina pacifica a subspecies, we prefer to follow the approach of Todd and Bronniman (1957): “...the difference between populations is not of subspecific rank.” The holotype of H. pacifica and the holotype and paratypes of H. pacifica var. atlantica all appear conspecific with our specimens, although some of our specimens are not so twisted as most of the primary types.

This species occurs only in the southern portion of the Indian River.

Figured hypotype: USNM 310190. (Total: 70; range: 0–17.)
Optically: radial.

Hopkinsina cf. pacifica Cushman

PLATE 5: FIGURE 15

Two specimens are referred to this category. Although they match Hopkinsina pacifica sensu stricto in overall shape and surface texture, they are extremely compressed laterally, perhaps to the point of being strictly biserial.

Both specimens were found at Jensen Beach.

Figured specimen: USNM 310191. (Total: 2; range: 0–1.)
Optically: radial.

Genus Trifarina Cushman, 1923

Trifarina occidentalis (Cushman)

PLATE 5: FIGURE 16
Uvigerina angulosa Cushman, 1922a:34, pl. 5: figs. 3–4.
Uvigerina occidentalis (Cushman).—Cushman, 1923:169, 170.
Angulogerina occidentalis (Cushman).—Todd and Bronniman, 1957:36, pl. 9: figs. 5, 6.
Trifarina occidentalis (Cushman).—Buzas, Smith, and Beem, 1977:82, pl. 3: figs. 7-10.

Most of the specimens are rather battered and broken. They are all short and triangular in appearance. None have the long, almost uniserial form identified by Todd and Bronniman (1957, pl. 9: fig. 5).

Figured hypotype: USNM 310210. (Total: 10; range: 0-2.)
Optically: radial.

Genus Rosalina d'Orbigny, 1826

Rosalina bulbosa (Parker)

Plate 5: figures 17-19

"Discorbis" bulbosa Parker, 1954:523, pl. 8: figs. 10–12.
Rosalina bulbosa (Parker).—Buzas, Smith, and Beem, 1977:85.

Our specimens match Parker's types well, as well as matching the unfigured specimens of Buzas, Smith, and Beem (1977) from Jamaica. Three of our specimens were found attached, two to miliolids, and one to an Elphidium mexicanum.

Scattered specimens were found throughout the Indian River.

Figured hypotypes: USNM 310234, 310235. Hypotype: USNM 310236. (Total: 14; range: 0–1.)
Optically: radial.

Rosalina concinna (Brady)

Plate 6: figures 1, 2

Discorbina concinna Brady, 1884:646, pl. 90: figs. 7, 8.
Discorbis concinnus (Brady).—Bandy, 1956:193, pl. 31: fig. 4.
Rosalina concinna (Brady).—Buzas, Smith, and Beem, 1977:85, 86, pl. 4: figs. 4-6.

This species has a round outline and is fairly compressed. The spiral side has flush sutures. The umbilical side has slightly depressed sutures. There are usually only four chambers visible on the umbilical side, surrounding a small umbilical pit. The final chamber usually covers one-third to one-half of the umbilical side.

Parker's specimens of Rosalina cf. concinna (Parker, 1954, pl. 8: figs. 17, 18) seem to fit into our suite of specimens without any difficulty.

Scattered specimens were found throughout the Indian River.

Figured hypotype: USNM 310237. (Total: 44; range: 0–7.)
Optically: radial.

Rosalina floridana (Cushman)

Plate 6: figures 5, 6

Discorbis floridana Cushman, 1922a:39, 40, pl. 5: figs. 11, 12; 1931:21, pl. 4: figs. 7, 8.—Cushman and Parker, 1931:18, 19, pl. 4: fig. 5.—Phleger and Parker, 1951:20, pl. 10: fig. 4.
Discorbis floridanus (Cushman).—Bandy, 1954:136, pl. 31: fig. 1.
Rosalina floridana (Cushman).—Parker, 1954:524-525, pl. 8: figs. 19, 20.—Todd and Bronniman, 1957:36, pl. 9: figs. 16–21.—Buzas, Smith and Beem, 1977:86, pl. 4: figs. 7-9.

The most distinctive characteristic of this rosalinid is the overlapping nature of the chambers on the umbilical side. Frequently, the overlapping portions of the chambers form flaps that extend over a deep umbilical pit. The aperture is long, from the umbilical area (generally in the pit) to the periphery. The aperture is low and frequently has a small lip. Our specimens are generally neither as coarsely perforate nor as compressed as those in the Cushman collection but fall well within their range of variation.

This species was most abundant at Vero Beach and Link Port.

Figured hypotype: USNM 310238. (Total: 159; range: 0–39.)
Optically: granular.

Rosalina aff. floridensis (Cushman)

Plate 6: figures 3, 4

Our few specimens are distinctive and perhaps are a new species. The test is compressed. The spiral side is coarsely perforate. The chambers fill the umbilical side, making it flat. The sutures are very hard to see on the umbilical side unless the specimen is wet. The umbilical side is covered with a coarse granular layer.
All specimens were found at Vero Beach.  
Figured specimen: USNM 310239. (Total: 3;  
range: 0–2.)  
Optically: granular.

**Rosalina globularis** d’Orbigny

PLATE 6: FIGURES 7, 8

*Discorbis columbiensis* Cushman, 1925:43, pl. 6: fig. 13.  
*Tretomphalus bulloides* (d’Orbigny).—Cushman, 1934:86, pl. 11: fig. 2.  
*Tretomphalus myersi* Cushman, 1943:26, pl. 6: figs. 4–6.  

This much-confused species was well described by Douglas and Sliter in 1965. Its considerable variation has led to its taxonomic confusion over the years.

Our specimens tend to have a slightly higher spire than most of those in the Cushman collection but fit well into the range established by Douglas and Sliter (1965). Only one of our specimens had a float chamber.

This species is widely distributed in the Indian River but is most abundant in the southern part.  
Figured hypotype: USNM 310240; (Total: 175; range: 0–27.)  
Optically: radial.

**Rosalina subaraucana** (Cushman)

PLATE 6: FIGURES 9–12

*Discorbis subaraucana* Cushman, 1922a:41, pl. 7: figs. 1, 2; 1931:32, pl. 7: fig. 2.  
*Discorbis floridana* Cushman.—Parker, Phleger, and Peirson, 1953:7, pl. 4: figs. 18, 19.  

Only one representative of this species is large; it matches the specimen of Buzas, Smith, and Beem (1977) very well. The small specimens are more transparent and have very few pores, but the overall shape is identical to that of the single large specimen and those specimens in the Cushman collection.

This species was found mainly at Vero Beach and St. Lucie Inlet.  
Figured hypotypes: USNM 310242, 310243. (Total: 32; range: 0–14.)  
Optically: radial.

**Rosalina juveniles**

Some very small trochospiral specimens were put in this category. When a specimen has only three or four chambers, specific, or even generic, placement is almost impossible.

Total: 16; range: 0–5.

**Genus Stetsonia** Parker, 1954

**Stetsonia minuta** Parker

PLATE 7: FIGURES 1, 2


Only two specimens of this species were found. Unfortunately one was lost, and the other was heavily gold coated for SEM use.

Both specimens were found at St. Lucie Inlet.  
Figured hypotype: USNM 310244. (Total: 2; range: 0–1.)  
Optically: radial.

**Genus Glabratella** Dorreen, 1948

**Glabratella species**

PLATE 7: FIGURES 3, 4

Three compressed specimens from Buoy 195 were referred to this category.  
Figured specimen: USNM 310220. (Total: 3; range: 0–3.)  
Optically: radial.

**Genus Glabratellina** Seiglie and Bermudez, 1965

**Glabratellina sagrai** (Todd and Bronnimann)

PLATE 7: FIGURES 5, 6

*Rosalina sagrai* Todd and Bronnimann, 1957:37, pl. 9: fig. 22.  
Glabratellina sagrai (Todd and Bronnimann).—Buzas, Smith, and Beem, 1977:91, pl. 5: figs. 25–27.
Although our specimens generally do not have as high a spire as those mentioned above, they do have the pustules on the umbilical side that are distinctive to this species. They generally have 7–8 chambers visible in the final whorl.

Scattered specimens occur throughout the Indian River.

Figured hypotype: USNM 310221. (Total: 28; range: 0–3.)

Optically: radial.

**Genus Mychostomina Berthelin, 1881**

*Mychostomina revertens* (Rhumbler)

**PLATE 7: FIGURES 7, 8**


*Spirillina vivipara* Ehrenberg var. *densepunctata* Cushman.—Cushman and Parker, 1931:18, pl. 4: fig. 1.

*2Coniospirillina atlantica* Cushman, 1947:91, pl. 20: fig. 8.

*Mychostomina revertens* (Rhumbler).—Smith and Isham, 1974:66, pl. 1: figs. 1–3, 7–9.—Buzas, Smith, and Beem, 1977:93, pl. 6: figs. 7–12.

Although our specimens do not match any of Smith and Isham’s (1974) drawings extremely well, they do match USNM 211312 exactly. This unfigured specimen from Jamaica was selected by Smith for Buzas, Smith, and Beem, 1977. Apparently it represents an extreme form of this species, a form that has many whorls on the spiral side and has only very few very fine pores.

Most of the specimens occur at Vero Beach.

Figured hypotype: USNM 310223. (Total: 11; range: 0–4.)

Optically: radial.

**Genus Ammonia Brünich, 1772**

*Ammonia beccarii* (Linne)

**PLATE 7: FIGURES 9, 10**

*Nautilus beccarii* Linne, 1758:710.

*Rotalia beccarii* (Linne).—Cushman, 1922a:52, pl. 8: figs. 7–9; 1928:104, pl. 15: figs. 1–7; 1931:58, pl. 13: figs. 1, 2; 1944:35, pl. 4: fig. 22.—Post, 1951:176.—Parker, 1952b:457, 458, pl. 5: fig. 8.

*Rosalina parkinsonia* d’Orbigny, 1839a:99, pl. 4: figs. 25–27.

*Rotalia beccarii* (Linne) var. *parkinsonia* (d’Orbigny).—Parker, 1952b:457, 458, pl. 20: figs. 5, 6.

*Rotalia beccarii* (Linne) var. *tepsida* Cushman, 1926:79, pl. 1; 1931:61, pl. 13: fig. 3.—Parker and Beem, 1951:23, pl. 12: fig. 7.—Post, 1951:176.—Parker, 1952b:457, 458, pl. 5: fig. 8.

*Rotalia beccarii* (Linne) var. *sobrina* Shupack, 1934:6, 7, fig. 4.—Post, 1951:176.—Parker, 1952b:457, 458, pl. 5: fig. 8.

Although some researchers divide this species into several varieties, we feel that all are found in similar areas or even in the same replicate, and thus we believe that subspecific nomenclature is not warranted.

This is the most abundant species in the Indian River, and it is found throughout the river. Only one station, in the Jensen Beach transect, did not have any members of this species.

Figured hypotype: USNM 310213. (Total: 7468; range: 0–499.)

Optically: radial.

**Genus Elphidium Montfort, 1808**

*Elphidium advenum* (Cushman)

**PLATE 8: FIGURE 1**

*Polystomella advena* Cushman, 1922a:56, 57, pl. 9: figs. 11, 12.

*Elphidium advenum* (Cushman).—Parker, Phleger, and Peirson, 1953:7, pl. 3: fig. 11.—Parker, 1954:508, pl. 6: fig. 14.—Bandy, 1956:193, pl. 30: fig. 18.—Todd and Bronnimann, 1957:39, pl. 6: figs. 5–7.—Bock 1971:56, pl. 20: figs. 7, 8.

Some of our specimens do not have a keel and, at first, could be mistaken for an *Elphidium excavatum* with a glassy umbilicus. However, the two species differ in the shape of their peripheries (that of *E. advenum* is acute, not rounded) and in wall structure. *Elphidium advenum* is granular, not radial. All our specimens have many sutural bridges and fit well within the limits of this species’ variation.

Only a few of the specimens referred to this species occur north of Fort Pierce Inlet.
Elphidium excavatum (Terquem)

Plate 8: figure 2

Polystomella excavata Terquem, 1875:25, pl. 2: fig. 2.
Elphidium incertum var. clavatum Cushman, 1930:20, pl. 7: fig. 10.
Elphidium clavatum Cushman.—Loeblich and Tappan, 1953:98, 99, pl. 19: figs. 8-10.—Todd and Bronnimann, 1957:39, pl. 6: fig. 10.—Buzas, 1965a:58, 59, pl. 2: figs. 6, 7, pl. 3: figs. 1, 2; 1966:591, pl. 71: figs. 1-8.

Only a few specimens have the “characteristic brown color” of this species, and most of them tend to be smaller than specimens from further north. Our specimens do have the umbilical bosses, sutural bridges, and deep coarse pores characteristic of the species.

This species occurs in low abundance throughout the Indian River but is most abundant at John’s Island and St. Lucie Inlet.

Figured hypotype: USNM 310202. Hypotype: USNM 310201. (Total: 493; range: 0-49.)
Optically: radial.

Elphidium galvestonense (Kornfeld)

Plate 8: figure 3

Elphidium gunteri Cole var. galvestonensis Kornfeld, 1931:87, pl. 15: fig. 1.—Phleger and Parker, 1951:10, pl. 5: figs. 13, 14.—Bandy, 1954:136, pl. 30: fig. 2.
Elphidium galvestonense (Kornfeld).—Parker, Phleger, and Peirson, 1953:7, 8, pl. 3: figs. 15, 16.

We have examined the specimen designated by Kornfeld as Elphidium gunteri var. galvestonensis Kornfeld, microspheric form (691), later designated by Parker, Phleger, and Peirson (1953) as a lectotype. It matches our specimens extremely well. Our specimens are large and have an almost porcelaneous sheen.

This species occurs mainly in the northern part of the Indian River.

Figured hypotype: USNM 310200. (Total: 26; range: 0-4.)
Optically: radial.

Elphidium gunteri Cole

Plate 8: figure 4

Elphidium gunteri Cole, 1931:34, pl. 4: figs. 9, 10.—Parker, 1954:508, pl. 6: fig. 16.—Bandy, 1956:194, pl. 30: fig. 19.—Lankford, 1959:2098, pl. 2: fig. 7.

This species has deep coarse pores and is frequently brown. The umbilical area is usually filled with many glassy pustules.

This species occurs mostly in the narrow, island-filled portion of the river at the John’s Island and Vero Beach stations.

Figured hypotype: USNM 310203. Hypotype: USNM 310204. (Total: 446; range: 0-53.)
Optically: radial.

Elphidium kugleri (Cushman and Bronnimann)

Plate 8: figure 5

Cribroelphidium kugleri Cushman and Bronnimann, 1948a:18, 19, pl. 4: fig. 4.

Specimens flare rapidly and have regular septal bridges, as do the primary types. Not all of our specimens are so transparent as the types; instead, some are a milky white, possibly due to etching.
Scattered specimens of this species occur throughout the river.

Figured hypotype: USNM 310205. (Total: 110; range: 0-18.)
Optically: radial.

Elphidium mexicanum Kornfeld

Figure 25; Plate 8: figure 6

Elphidium incertum var. mexicanum Kornfeld, 1931:89, pl. 16: fig. 1.

We had the opportunity to examine Kornfeld’s types. Our material looks most like Kornfeld’s specimen no. 694. Kornfeld’s specimen has 12 chambers in the final whorl, but ours usually have from 9 to 11. In his description, he indicated a variation from 10 to 12. The umbilical area on our specimens is usually larger than on Kornfeld’s specimen and is often depressed, whereas it is flush on his specimen. Furthermore, our specimens often contain one or more umbilical bosses,
Elphidium mexicanum, side view, USNM 310289, hypotype, X 200.

but Kornfeld’s type does not. In his description, however, Kornfeld did use the phrase “umbilical region multiple or central,” indicating, perhaps, that some of the individuals he examined also had multiple bosses. Despite the differences noted above, we believe our specimens are best referred to E. mexicanum.

This species occurs throughout the Indian River but is most abundant at the inlets.

Figured hypotypes: USNM 310288, 310289. Hypotypes: USNM 310290, 310291, 310292, 310293, 310294, 310295, 310296, 310297. (Total: 613; range: 0-74.)

Optically: granular.

Elphidium cf. mexicanum Kornfeld

Plate 8: figure 7

The two specimens that were referred to this category are more compressed and flair more than Elphidium mexicanum sensu stricto. Their sutures are curved to a slightly greater degree, and the sutural bridges are much more regular than those of the majority of the E. mexicanum sensu stricto specimens. They may represent an extreme form of E. mexicanum, but we do not see sufficient gradation between the two forms.

Both specimens were found in a single Buoy 195 replicate.

Figured specimen: USNM 310207. (Total: 2; range: 0–2.)

Optically: granular.

Elphidium norvangi Buzas, Smith, and Beem

Plate 8: figure 8


A few specimens of this distinctive small Elphidium were found. All had the spike-shaped papillae on the apertural face, the unique feature of the species.

Most of the specimens were found at Buoy 195. Figured hypotype: USNM 310206. (Total: 13; range: 0–2.)

Optically: radial.

Elphidium species

Plate 8: figure 9

The walls of these specimens are opaque and milky white. The sutures are slightly depressed and crossed by regularly spaced sutural bridges. There are about 16 chambers in the final whorl; they are inflated, making the periphery smoothly rounded.

Two specimens of this granular species were found south of the Fort Pierce Inlet.

Figured specimen: USNM 310208. (Total: 2; range: 0–1.)

Optically: granular.

Genus Haynesina Banner and Culver, 1978

Haynesina germanica (Ehrenberg)

Plate 8: figure 10

Nonionina germanica Ehrenberg, 1840:23; 1841, pl. 2: figs. 1a–g.

Nonion germanicum (Ehrenberg).—Cushman, 1930:8, 9, pl. 3: fig. 5.

Nonion lisburyensis Butcher, 1948:21, 22, figs. 1–3.
Protelphidium lisburyense (Butcher).—Parker and Ahearn, 1959:342, pl. 50: figs. 26, 32.
Haynesina germanica (Ehrenberg).—Banner and Culver, 1978, pl. 4: figs. 1-6, pl. 5: figs. 1-8, pl. 6: figs. 1-7, pl. 8: figs. 1-10, pl. 9, figs. 1-11, 15, 18.

The specimens have granular material in the umbilical area and curved, depressed sutures with no sutural bridges. As a group our specimens do not match those of Banner and Culver (1978) exactly, but the two populations show considerable overlap. Our specimens tend to have slightly straighter sutures and slightly less granular material in the umbilical area than do those of Banner and Culver (1978), but we do not consider the difference to be of specific importance. This widely distributed species was found in low abundance, mostly in the northern half of the Indian River.

Figured hypotype: USNM 310211. (Total: 53; range: 0-11.)
Optically: radial.

Genus Eponides de Montfort, 1808

Eponides repandus (Fichtel and Moll)

Plate 9: figures 1, 2

Nautilus repandus Fichtel and Moll, 1798:35, pl. 3: figs. a–d.
Eponides repanda (Fichtel and Moll).—Cushman 1931:49-51, pl. 10: fig. 7.
Eponides repandus (Fichtel and Moll).—Parker, 1954:529, pl. 9: figs. 27, 28.—Bock, 1971:58, pl. 21: figs. 6, 7.

A few specimens of this well-known open-water species were found near the St. Lucie Inlet.

Figured hypotype: USNM 310219. (Total: 6; range: 0–2.)
Optically: radial.

Genus Cibicides de Montfort, 1808

Cibicides aff. floridana (Cushman)

Plate 9: figures 3, 4

Our four specimens differ from Cibicides floridana sensu stricto in having very indistinct sutures and in having a flatter umbilical side.

Three specimens were found at St. Lucie Inlet; the fourth was found at Jensen Beach.

Figured specimen: USNM 310215. (Total: 4; range: 0–3.)
Optically: granular.

Cibicides species

Plate 9: figures 5, 6

Our two specimens are small with a flattened, but still convex, spiral side. The sutures on the umbilical side are radial and extend to the center of the specimen. The spiral side is coarsely perforate with a depressed spiral sutural line.

Both specimens are from Buoy 195.

Figured specimen: USNM 310216. (Total: 2; range: 0–2.)
Optically: radial.

Genus Planorbulina d’Orbigny, 1826

Planorbulina mediterranensis d’Orbigny

Plate 9: figure 7

Planorbulina mediterranensis d’Orbigny, 1826:280, pl. 14: figs. 4–6 [6 bis].—Cushman, 1922a:45, 46, pl. 6: figs. 1, 2; 1931:129, 130, pl. 24: figs. 5–8.—Bandy, 1954:137, pl. 31: fig. 3.—Parker, 1954:545, pl. 13: fig. 9.

A single broken representative of this species was found at St. Lucie Inlet.

Figured hypotype: USNM 310189. (Total: 1; range: 0–1.)
Optically: radial.

Genus Cymbaloporetta Cushman, 1928

Cymbaloporetta atlantica (Cushman)

Plate 9: figures 8, 9

Tretomphalus atlanticus Cushman, 1934:86, 87, pl. 11: fig. 3, pl. 12: fig. 7.—Phleger and Parker, 1951:26, pl. 14: fig. 3.
Cymbaloporetta atlantica (Cushman).—Buzas, Smith, and Beem, 1977:101, pl. 7: figs. 22–24.

Two specimens were referred to this species. They are large and have the cymbaloporetoid chambers on the final whorl. Neither has a float chamber as do many of Cushman’s specimens.
Our specimens are slightly more inflated than most of those in the Cushman collection.

One specimen was found at Buoy 195, the other at Herman’s Bay.

Figured hypotype: USNM 310217. (Total: 2; range: 0–1.)

Optically: radial.

**Cymbaloporetta species**

**PLATE 9: FIGURES 10, 11**

A single broken specimen from Herman’s Bay is thus referred.

Figured specimen: USNM 310218. (Range: 0–1; total: 1.)

Optically: granular.

**Genus Fursenkoina Loeblich and Tappan, 1961**

**Fursenkoina fusiformis** (Williamson)

**PLATE 10: FIGURE 1**

*Bulimina pupoides* (?) var. *fusiformis* Williamson, 1858:63, figs. 129, 130.

*Virgulina fusiformis* (Williamson).—Parker, 1952a:417, pl. 19: figs. 5, 6; 1952b:461, pl. 4: fig. 10.

The last three chambers of our specimens make up just less than half the length of the test; Williamson’s drawing shows them making up a little more. Our specimens are not so inflated as in the drawing by Williamson but do have the finely perforate walls and triserial to twisted biserial chamber arrangement he describes for the species.

Almost all the specimens occur at Herman’s Bay.

Figured hypotype: USNM 310185. (Total: 11; range: 0–5.)

Optically: radial.

**Fursenkoina mexicana** (Cushman)

**PLATE 10: FIGURE 2**

*Virgulina mexicana* Cushman, 1932:19, pl. 2: figs. 26–28.—Phleger and Parker, 1951:9, pl. 9: figs. 9, 10.—Parker, Phleger, and Peirson, 1953:15, pl. 4: figs. 14, 15.—Parker, 1954:513, pl. 7: fig. 9.—Lankford, 1959:2099, pl. 2: fig. 17.

**Fursenkoina pontoni** (Cushman).—Buzas, Smith, and Beem, 1977:102, pl. 8: figs. 9, 10.

This species is compressed laterally and has slightly depressed sutures. It is twisted slightly about its central axis.

The specimens were found near St. Lucie Inlet and at Buoy 195.

Figured hypotype: USNM 310187. (Total: 4; range: 0–2.)

Optically: granular.

**Genus Sigmavirgulina Loeblich and Tappan, 1957**

**Sigmavirgulina tortuosa** (Brady)

**PLATE 10: FIGURE 4**

*Bolivina tortuosa* Brady.—Cushman and Parker, 1931:16, pl. 3: fig. 22.—Cushman, 1937:133, 134, pl. 17: figs. 11–19; 1941:10.—Todd and Bronnimann, 1957:34, pl. 8: fig. 24.

**Sigmavirgulina tortuosa** (Brady).—Buzas, Smith, and Beem, 1977:103, 104, pl. 4: figs. 9–12.
Our single specimen has the twisted test and coarse pores present in the specimens in the Cushman collection.

It was found in the St. Lucie transect.

Figured hypotype: USNM 310188. (Total: 1; range: 0–1.)

Optically: radial.

Genus Cassidulina d'Orbigny, 1826

Cassidulina barbara Buzas

Plate 10: figure 5


Two specimens of this species were found, one at St. Lucie Inlet and the other at Buoy 195.

Figured hypotype: USNM 310212. (Total: 2; range: 0–1.)

Optically: granular.

Genus Nonion de Montfort, 1808

Nonion boueanum (d'Orbigny)

Plate 10: figures 6, 7

*Nonionina boueauna* d'Orbigny, 1846:108, pl. 5: figs. 11, 12. *Nonion boueanum* (d'Orbigny).—Cushman, 1939:12, 13, pl. 3: figs. 7, 8.—Todd and Bronniman, 1957:32, pl. 5: figs. 25, 26.

This rather large *Nonion* has about 14 chambers in the final whorl and has the curved depressed sutures shown in d'Orbigny's drawing and in toptotypes in the Cushman collection.

The three specimens were found at Herman's Bay.

Figured hypotype: USNM 310224. (Total: 3; range: 0–2.)

Optically: granular.

Nonion species

Plate 10: figures 8, 9

The specimens in this category are similar to *Nonion boueanum* in that both species have a round outline, are slightly compressed with an angular, but not sharp, periphery, and have curved sutures. *Nonion sp.* A differs from *N. boueanum*, however, in having flush, not depressed, sutures and in lacking the final greatly inflated chamber common to *N. boueanaum*. The SEM's show some primitive sutural bridges, leading us to suspect the *Nonion* designation.

A few specimens from the stations just north and south of the Fort Pierce Inlet are referred to this category.

Figured specimen: USNM 310225. Mentioned specimen: USNM 310226. (Total: 7; range: 0–3.)

Optically: granular.

Genus Nonionella Cushman, 1926

Nonionella atlantica Cushman

Plate 10: figures 10–12

*Nonionella atlantica* Cushman, 1947:90, 91, pl. 20: figs. 4, 5.—Todd and Bronniman, 1957:32, pl. 5: figs. 30, 31.

This species has very inflated chambers and a moderate amount of granular material in the umbilical region.

A few specimens of this species were found scattered throughout the Indian River.

Figured hypotype: USNM 310227. (Total: 8; range: 0–3.)

Optically: granular.

Nonionella auricula Heron-Allen and Earland

Plate 11: figures 1–3

*Nonionella auricula* Heron-Allen and Earland, 1930:192, pl. 5: figs. 68–70.—Todd and Bronniman, 1957:32, pl. 5: fig. 32.—Buzas, Smith, and Beem, 1977:107.

This species shows a considerable amount of variation. Taxonomic placement of this species is complicated by the poor figure of Heron-Allen and Earland and the misidentification of many of the specimens in the Cushman collection. Many of the specimens in the Cushman collection are either *Nonionella atlantica* or *Nonion grateloupi*.

The larger specimens of this species seem al-
most planispiral. The periphery may be fairly acute but is rounded on most specimens. The chambers are compressed, and the sutures are only slightly depressed. The proloculus is generally visible on the “spiral” side as a large knob, the “umbilical” side usually has little or no granular material in it. In smaller specimens the large prolocular chamber makes the specimen very trochoid; only the larger later chambers tend toward being planispiral.

This species occurs throughout the Indian River but is most abundant in the southern part.

Figured hypotype: USNM 310228. Hypotype: USNM 210229. (Total: 458; range: 0-59.)
Optically: granular.

Nonionella cf. auricula Heron-Allen and Earland
Plate 11: figures 4–6

Three specimens were thus referred. They flair more rapidly than Nonionella auricula sensu stricto. The final chambers tend to be very high and long, with very straight sutures. This group seems to be more compressed and less trochospiral than specimens of similar size that were placed in N. auricula.

The specimens were found at Buoy 195 and Herman’s Bay.

Figured specimen: USNM 310230. Mentioned specimen: USNM 310231. (Total: 3; range: 0–2.)
Optically: granular.

Nonionella opima Cushman
Plate 11: figures 7–9


Our specimens have the circular outline and inflated final chamber of this distinctive species. Very few of our specimens have the curved sutures of Cushman’s types.

This species appears in low numbers throughout the Indian River.

Figured hypotype: USNM 310232. (Total: 11; range: 0–3.)
Optically: granular.

Genus Hanzawaia Asano, 1944

Hanzawaia concentrica (Cushman)
Plate 11: figures 10, 11

Truncatulina concentrica Cushman, 1918:64, pl. 21: fig. 3.
Cibicides concentrica (Cushman).—Cushman, 1931:120, 121, pl. 21: figs. 4, 5, pl. 22: figs. 1, 2.
Cibicides concentrica (Cushman).—Phleger and Parker, 1951:29, pl. 15: figs. 14, 15.—Parker, 1952b:445, 446, pl. 5: fig. 10.

The holotype of this species is missing; however, the four paratypes designated by Cushman were examined. Our specimens do not have sutures that are as depressed as those of the paratypes but otherwise match extremely well.

All but one of our specimens were collected at St. Lucie Inlet.

Figured hypotype: USNM 310222. (Total: 6; range: 0–2.)
Optically: radial.
Appendix

Number of Living Individuals Observed in 20 ml Replicate Samples

(Localities are shown in Figure 1)
SPECIES

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<th>HAULOVER</th>
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7 ALLOGRUMIA

AMMOCULETIS EXIGUA

AMMOCULETIS EXILIS

AMMOCULETIS CV. A. EXILIS

ANTICULINA CF. A. PACIFICA

BULICULINELLA GLABRULA

BULINELLA CF. U. COMPACTA

BULINELLA PAULA

BULINELLA STRIATULA

BULINELLA SUBREXAVA

BULINELLA SP. A

BULINELLA SP. B

BULINELLA ACCURRATA

BULINELLA ELEGANITISSIMA

CASSIDULINA BARBARA

CIBICIDES AFF. C. FLORIDANA

CIBICIDES SP

CYCLOGYRA PLANORBIS

CYMBALOPHETTA AILANTICA

CYMBALOPORETTA

EDENTOSTOMINA CULTRATA

EDENTOSTOMINA CF. E. CULTRATA

ELPHIDIUM ADVENTUM

ELPHIDIUM GALWESTONENSE

ELPHIDIUM QUINTERI

ELPHIDIUM BULCI

ELPHIDIUM MEXICANUM

ELPHIDIUM CF. E. MEXICANUM

ELPHIDIUM NORVANGI

ELPHIDIUM SP. A

EPRODUS HEPAANUS

FISSURINA LUCIDA

FISSURINA SP. A

FURSENKOINA FUSIFORMIS

FURSENKOINA MEXICANA

FURSENKOINA PONTONI

GAUDYMINA EXILIS

GLABRATETHYS SP

GLABRATETHYS SAGRAI

HANZAWAIA CONCENTRICA

HAYNESINA GERMANICA

HOPKINSINA PACIFICA

HOPKINSINA CF. H. PACIFICA

JSAHIELLA APERTURA

LAGENA CF. L. UOYEYENSIS

MILLULINELLA SUPERTUNDA

MILLULINELLA CF. H. SUPERTUNDA

MICHIOMININA REVERTENS

MUNION DUBERANUM

MUNION SP

MUNIONELLA ATLANTICA

MUNIONELLA HAPICULA

MUNIONELLA CF. N. HAPICULA

MUNIONELLA SPIRA

PAETEORIS DILITATA

PAVUMNA SP

PENEROPLIS PERTUSUS

PLANORBULINA MEDITERRANENSIS

QUINUUELOCULINA AGGLUTINANS

QUINUUELOCULINA CF. O. AKNERIANA

QUINUUELOCULINA CF. O. BIDENTATA

QUINUUELOCULINA CF. O. CARINATA-STRIATA

QUINUUELOCULINA GOESI

QUINUUELOCULINA GUELTIELIANA

QUINUUELOCULINA IMPRESA

QUINUUELOCULINA POYTERA

QUINUUELOCULINA SEMIPUERA

QUINUUELOCULINA CF. O. STRIATA

QUINUUELOCULINA TENAGUS

QUINUUELOCULINA SP. A

REUNIAPHA NANA

ROSALINA FULIGOSA

ROSALINA CONCINNA

ROSALINA FLUMINIANA

ROSALINA AFF. A. FLORIDENSI

ROSALINA GLORIUSANES

ROSALINA SIBIRICA

SCULPULINELLA SPLATICOSA

SIEMACULINELLA IFKOSOSA

SIEMACULINELLA MARGINALIS

SPIROLOCULINA UMPRESSA

Ssiculina MINUTA

TYPHANIA OCCIDENTALIS

TRICHOCULINA CF. T. TRIGONULA

TRICHOCULINA CF. T. ADVENTA

TRICHOCULINA UCHMACEA

TRICHOCULINA SP. A

TUNIPELLEA AURICULATA

TULIA

173 114 133 133 57 31 5 97 109 166 170 135 300 411 312 35 70 110 32 202
HERMAN'S BAY JENSEN BEACH

SPECIES

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Boltovskoy, E., and R. Wright

Bornemann, J.G.

Brady, H.B.

Butcher, W.S.

Buzas, M.A.

Buzas, M.A., and K. Carle

Buzas, M.A., and S.J. Culver

Buzas, M.A., and T.G. Gibson

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Cole, W.S.

Culver, S.J., and M.A. Buzas

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Cushman, J.A., and F.L. Parker


Cushman, J.A., and G.M. Ponton

Cushman, J.A., and R.T. Wickenden

d'Orbigny. See Orbigny.

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Egger, J.G.

Ehrenberg, C.G.


Fichtel, L. von, and J.P.C. von Moll
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Loeblich, A.L., Jr., and H. Tappan


Milliman, J.D., O.H. Pilkey, and D.A. Ross

Montagu, G.

Mook, D.

Nelson, W.C., K.D. Cairns, and R.W. Virnstein

Orbigny, A. d’


Parker, F.L.


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Parker, F.L., F.B. Phleger, and J.F. Peirson

Phleger, F.B.

Phleger, F.B., and F.L. Parker

Post, R.J.

Reuss, K.K.

Rhumbler, L.


Rose, P.R., and B. Lidz

Schultze, M.S.

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Stubbs, S.A.

Terquem, M.O.

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Todd, R., and P. Bronnimann

Todd, R., and D. Low


Weisner, H.

Wilcox, J.R., and R.G. Gilmore

Wilcoxon, J.A.

Williamson, W.C.


Young, D.K., M.A. Buzas, and M.W. Young

Young, D.K., and M.W. Young
PLATE 1

(Micrographs reduced to 52.5%)

*Reophax nana* Rhumbler
1. Side view, hypotype, USNM 310285, $\times$ 205.

*Ammobaculites exigius* Cushman and Bronniman
2. Side view, hypotype, USNM 310280, $\times$ 195.
3. Apertural view, hypotype, USNM 310280, $\times$ 350.

*Ammobaculites exilis* Cushman and Bronniman
4. Side view, hypotype, USNM 310281, $\times$ 90.
5. Apertural view, hypotype, USNM 310281, $\times$ 190.

*Ammobaculites cf. exilis* Cushman and Bronniman
6. Side view, figured specimen, USNM 310282, $\times$ 60.
7. Apertural view, figured specimen, USNM 310282, $\times$ 95.

*Trochamina cf. advena* Cushman
8. Spiral side, figured specimen, USNM 310286, $\times$ 475.
9. Umbilical side, figured specimen, USNM 310286, $\times$ 500.

*Trochamina ochracea* (Williamson)
10. Spiral side, hypotype, USNM 310287, $\times$ 540.
11. Umbilical side, hypotype, USNM 310287, $\times$ 540.

*Gaudryina exilis* Cushman and Bronniman
12. Side view, hypotype, USNM 310283, $\times$ 155.
13. Side view, hypotype, USNM 310284, $\times$ 395.

*Cyclogyra planorbis* (Schultze)
14. Side view, hypotype, USNM 310247, $\times$ 220.

*Edentostomina cultrata* (Brady)
15. Side view, hypotype, USNM 310248, $\times$ 80.
16. Apertural view, hypotype, USNM 310248, $\times$ 105.

*Weiwerella auriculata* (Egger)
17. Side view, hypotype, USNM 310279, $\times$ 300.
Plate 2

(Micrographs reduced to 52.5%)

**Spiroloculina depressa** d'Orbigny
1. Side view, hypotype, USNM 310276, × 60.
2. Apertural view, hypotype, USNM 310276, × 95.

**Quinqueloculina agglutinans** d'Orbigny

**Quinqueloculina cf. akneriana** d'Orbigny
7. Side view, figured specimen, USNM 310262, × 105.

**Quinqueloculina cf. bidentata** d'Orbigny
10. Apertural view, figured specimen, USNM 310263, × 275.

**Quinqueloculina carinata-striata** (Weisner)
11. Edge view, hypotype, USNM 310264, × 235.
12. Apertural view, hypotype, USNM 310264, × 400.

**Quinqueloculina goesi** (Weisner)
14. Side view, hypotype, USNM 310265, × 100.
15. Apertural view, hypotype, USNM 310265, × 185.
16. Side view, hypotype, USNM 310266, × 90.
17. Apertural view, hypotype, USNM 310266, × 160.
PLATE 3

(Micrographs reduced to 52.5%)

*Quinqueloculina gaultieri*ana d'Orbigny
2. Apertural view, hypotype, USNM 310267, × 300.

*Quinqueloculina impressa* Reuss

*Quinqueloculina poeyana* d'Orbigny
5. Side view, hypotype, USNM 310269, × 325.

*Quinqueloculina seminula* (Linne)
7. Side view, hypotype, USNM 310270, × 170.
8. Apertural view, hypotype, USNM 310270, × 300.

*Quinqueloculina cf. striata* d'Orbigny
10. Apertural view, figured specimen, USNM 310271, × 270.

*Quinqueloculina tenagos* Parker
11. Side view, hypotype, USNM 310272, × 165.

*Quinqueloculina* species
13. Side view, figured specimen, USNM 310273, × 120.

*Massilina* species
15. Side view, figured specimen, USNM 310249, × 80.
16. Apertural view, figured specimen, USNM 310249, × 100.
PLATE 4

(Micrographs reduce to 52.5%)

*Paeteoris dilitata* (d’Orbigny)
1. Side view, hypotype, USNM 310258, × 310.
2. Apertural view, hypotype, USNM 310258, × 320.

*Trioculina cf. trigonula* (Lamarck)
4. Apertural view, figured specimen, USNM 310277, × 220.

*Miliolinella subrotunda* (Montagu)
5. Side view, hypotype, USNM 310250, × 200.

*Miliolinella cf. subrotunda* (Montagu)
7. Side view, figured specimen, USNM 310256, × 250.

*Miliolinella* species
10. Apertural view, figured specimen, USNM 310257, × 185.

*Biloculinella globula* (Bornemann)
11. Side view, hypotype, USNM 310246, × 175.

*Scutuloris* species
13. Side view, figured specimen, USNM 310274, × 205.

*?Tubinella* species
15. Side view, figured specimen, USNM 310278, × 280.

*Articulina cf. pacifica* Cushman
16. Side view, figured specimen, USNM 310245, × 120.
PLATE 5
(Micrographs reduced to 52.5%)

_Peneroplis pertusus_ (Forskal)
1. Side view, hypotype, USNM 310259, × 220.

*Lagena* cf. _doveyensis_ Haynes
2. Side view, figured specimen, USNM 310182, × 230.

_Fissurina lucida_ (Williamson)

_Fissurina_ species
4. Side view, figured specimen, USNM 310184, × 390.

_Buliminella elegantissima_ (d'Orbigny)
5. Side view, hypotype, USNM 310214, × 260.

_Bolivina_ cf. _compacal_ Sidebottom

_Bolivina paula_ Cushman and Cahill
7. Side view, hypotype, USNM 310193, × 250.

_Bolivina striatula_ Cushman
8. Side view, hypotype, USNM 310194, × 110.

_Bolivina subexcavata_ Cushman and Wickenden

_Bolivina_ sp. A
10. Side view, figured specimen, USNM 310196, × 180.

_Bolivina_ sp. B

_Bulimina aculeata_ d'Orbigny

_Flavonina_ species

_Hopkinsina pacifica_ Cushman

_Hopkinsina_ cf. _pacific与 Cushman
15. Side view, figured specimen, USNM 310191, × 245.

_Tristirina occidentalis_ (Cushman)

_Rosalina bulbosa_ (Parker)
17. Spiral side, hypotype, USNM 301234, × 520.
18. Umbilical side, hypotype, USNM 301234, × 490.
PLATE 6

(Micrographs reduced to 52.5%)

*Rosalina concinna* (Brady)
1. Spiral side, hypotype, USNM 310237, × 290.
2. Umbilical side, hypotype, USNM 310237, × 290.

*Rosalina aff. floridensis* (Cushman)

*Rosalina floridana* (Cushman)
5. Spiral side, hypotype, USNM 310238, × 230.
6. Umbilical side, hypotype, USNM 310238, × 250.

*Rosalina globularis* d'Orbigny
7. Spiral side, hypotype, USNM 310240, × 285.
8. Umbilical side, hypotype, USNM 310240, × 255.

*Rosalina subarauana* (Cushman)
10. Spiral side, hypotype, USNM 310243, × 375.
11. Umbilical side, hypotype, USNM 310242, × 195.
12. Spiral side, hypotype, USNM 310242, × 175.
PLATE 7

(Micrographs reduced to 52.5%)

Stetsonia minuta Parker
1. Spiral side, hypotype, USNM 310244, × 450.
2. Umbilical side, hypotype, USNM 310244, × 450.

Glabratella species
4. Umbilical side, figured specimen, USNM 310220, × 455.

Glabratellina sagrai (Todd and Bronniman)
5. Spiral side, hypotype, USNM 310221, × 360.
6. Umbilical side, hypotype, USNM 310221, × 375.

Mychostomina revertens (Rhumbler)
7. Spiral side, hypotype, USNM 310223, × 165.
8. Umbilical side, hypotype, USNM 310223, × 165.

Ammonia beccarii (Linne)
10. Spiral side, hypotype, USNM 310213, × 205.


Elphidium advenum (Cushman)

1. Side view, hypotype, USNM 310198, × 255.

Elphidium excavatum (Terquem)


Elphidium galvestonense (Kornfeld)


Elphidium gunteri Cole

4. Side view, hypotype, USNM 310203, × 205.

Elphidium kugleri (Cushman and Bronniman)

5. Side view, hypotype, USNM 310205, × 130.

Elphidium mexicanum Kornfeld


Elphidium cf. mexicanum Kornfeld

7. Side view, figured specimen, USNM 310207, × 180.

Elphidium norvangi Buzas, Smith, and Beem

8. Side view, hypotype, USNM 310206, × 485.

Elphidium species


Haynesina germanica (Ehrenberg)

10. Side view, hypotype, USNM 310211, × 225.
PLATE 9

(Micrographs reduced to 52.5%)

*Eponides repandus* (Fichtel and Moll)
1. Umbilical side, hypotype, USNM 310219, × 140.
2. Spiral side, hypotype, USNM 310219, × 130.

*Cibicides* aff. *floridana* (Cushman)

*Cibicides* species
5. Spiral side, figured specimen, USNM 310216, × 420.

*Planorbulina mediterranensis* d’Orbigny
7. Spiral side, hypotype, USNM 310189, × 195.

*Cymbaloporetta atlantica* (Cushman)
8. Spiral side, hypotype, USNM 310217, × 240.

*Cymbaloporetta* species
10. Spiral side, figured specimen, USNM 310218, × 395.
PLATE 10

(Micrographs reduced to 53%)

*Fursenkoina fusiformis* (Williamson)
1. Side view, hypotype, USNM 310185, × 240.

*Fursenkoina mexicana* (Cushman)

*Fursenkoina pontoni* (Cushman)
3. Side view, hypotype, USNM 310187, × 150.

*Sigmavirgulina tortuosa* (Brady)

*Cassidulina barbara* Buzas
5. Side view, hypotype, USNM 310212, × 390.

*Nonion boueanum* (d'Orbigny)
7. Peripheral view, hypotype, USNM 310244, × 90.

*Nonion* species
8. Peripheral view, figured specimen, USNM 310225, × 100.
9. Side view, figured specimen, USNM 310225, × 100.

*Nonionella atlantica* Cushman
10. Spiral side, hypotype, USNM 310227, × 130.
11. Peripheral view, hypotype, USNM 310227, × 130.
12. Involute side, hypotype, USNM 310227, × 130.
PLATE 11
(Micrographs reduced to 53%)

*Nonionella auricula* Heron-Allen and Earland
1. Involute side, hypotype, USNM 310228, × 250.
2. Peripheral view, hypotype, USNM 310228, × 250.
3. Spiral side, hypotype, USNM 310228, × 250.

*Nonionella cf. auricula* Heron-Allen and Earland

*Nonionella opima* Cushman
7. Spiral side, hypotype, USNM 310232, × 190.

*Hanzawaia concentrica* (Cushman)
10. Spiral side, hypotype, USNM 310222, × 165.
11. Umbilical side, hypotype, USNM 310222, × 165.
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