Study of microfauna foraminifera as bioindicator for coral reef condition in Tambelan Island, Riau Island Province

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Abstract. Tambelan Islands is one of the coral reef habitats in Indonesia. This area is the southern part of Natuna Sea and South China Sea Throughflow (SCSTF) exit area, which influenced the dynamics of the ocean and climate in Indonesia. Foraminifera is one of the potential bioindicator that can be used to determine the conditions of waters and the environmental health of coral reef. Twenty surface sediment samples were taken and quantitative analysis were made in order to obtain the condition of waters. This analysis including calculation of abundance, community structure, and analysis of biozonation (cluster and SHEBI). Meanwhile, to determine the condition of coral reef was using FORAM Index (FI). The results showed that there were 52 species of benthic foraminifera included in 41 genera. The most abundant genera were Amphistegina (average 28.08%) and Operculina (average 23.85%) which were a type of genera that associated with coral reefs. The FI values range from 3.57–9.12 indicating that environmental conditions are conducive to coral reefs. Biozonation from the cluster and SHEBI showed different results, indicating that the abundance of foraminifera in research area are influenced by complex factors such as substrate conditions and the activities on land.

1. Introduction
Tambelan Islands administratively is part of the Riau Islands Province. It is located off the west coast of the West Kalimantan Province, in the east side of Batam - Bintan, and southern part of of Natuna. The bathymetry of Tambelan Islands waters ranged from 10-55 meter which can be categorized as a shallow seas. Geographically, Tambelan Islands waters are classified as continental shelf. Sedimentation in the Tambelan Islands which is located in the outer part of the Sunda shelf is an interesting phenomenon. The outflow from the South China Sea (South China Sea Through-flow, SCSTF), local currents, and terrigenous input from Borneo Island will influence the depositional process. Various sources of sediment will produce a different types of sediments in the southern part and in the northern part of Tambelan Islands. This differences can be identified from the sediment texture, grain size and composition, or organism within the sediment [1]. In addition, Tambelan Islands is one of the coral reef areas in Indonesia, that need to be conserved [2]. Therefore, this study is conducted in order to understand the environmental condition of Tambelan Waters, including the health of its coral reef habitat, by analyzing foraminiferal assemblage, a microfaunal group that found abundant in marine sediment.

Foraminifera is a potential bioindicator for understanding the ecological conditions of the waters. This is because foraminifera has a relatively simple body structure and a hard shell, short life cycle, a
wide distribution, and a high ability to respond to the environmental changes [3,4]. Foraminifera is widely used as a bioindicator of water quality (including water depth, water temperature, sedimentation, nutrient content, oxygenation, turbidity, and water brightness), and water heavy metal pollution [5]. Furthermore, because of the dependence of both foraminifera and coral on algal symbiont for their growth and test calcification, previous research [6] has developed a method to monitor the health of coral reef environment from foraminiferal assemblages known as Foraminifera in Reef Assessment and Monitoring Index (FORAM Index), which has been widely applied by several researchers.

2. Method

2.1. Study area

For this study, 20 surface sediment samples from Tambelan Islands were analysed (Figure 1 and Table 1). These samples have been collected using grab samplers by the research team from Marine Geological Institute in 2008.

![Figure 1. The position of surface sediment samples (small black square in the index map) (modification from Tambelan Team [7]).](image)

| No | Sample | Coordinate X | Coordinate Y | Depth (m) | No | Sample | Coordinate X | Coordinate Y | Depth (m) |
|----|--------|--------------|--------------|-----------|----|--------|--------------|--------------|-----------|
| 1  | T-1    | 107.21110    | 0.95892      | 30        | 11 | T-11   | 113.42701    | 1.03868      | 32        |
| 2  | T-2    | 113.51100    | 0.95359      | 15        | 12 | T-12   | 113.39254    | 1.01311      | 10        |
| 3  | T-3    | 113.50191    | 0.96852      | 25        | 13 | T-13   | 113.42217    | 1.05482      | 35        |
| 4  | T-4    | 113.50700    | 1.01418      | 20        | 14 | T-14   | 113.43401    | 1.07380      | 15        |
| 5  | T-5    | 113.47498    | 0.98858      | 33        | 15 | T-15   | 113.40491    | 1.05273      | 35        |
| 6  | T-6    | 113.48594    | 1.02980      | 17        | 16 | T-16   | 113.39302    | 1.08244      | 25        |
| 7  | T-7    | 113.45597    | 0.98756      | 20        | 17 | T-17   | 113.38301    | 1.06767      | 41        |
| 8  | T-8    | 113.46592    | 1.02501      | 35        | 18 | T-18   | 113.36681    | 1.04750      | 50        |
| 9  | T-9    | 113.46196    | 1.04427      | 25        | 19 | T-19   | 107.36917    | 1.08219      | 47        |
| 10 | T-10   | 113.44400    | 1.03946      | 35        | 20 | T-20   | 107.44886    | 0.97409      | 5         |
2.2. Sample preparation and identification
Samples preparation was conducted at Core Laboratory of Marine Geological Institute, Cirebon. The samples were soaked in water for ± 12 hours to separate the shell of foraminifera from sediment grains. After that, samples were washed while filtered using a sieve sized 0.150 mm. Sediment that has been filtered then dried in temperature 40°-60°C. About 300 specimen of foraminifera were separated from other material for quantitative analysis, in case of large sample volume, the sample was splitted to obtain approximately 300 specimens. Foraminifera which have been separated from other materials were then identified under a binocular microscope which refers to several identification books such as Adisaputra [8], Barker [9], Lobelich and Tappan [10], and Nobes and Uthicke [11].

2.3. Data analysis
2.3.1. Relative abundance. Relative abundance is the percentage of each species in each sample. The calculations is using this formula:

\[
\text{Relative Abundance} = \frac{Ni}{N}
\]  

Formula description :
Ni = Total individu of species  
N = Total foram at one sample

2.3.2 Diversity index, evenness index, and dominance index. In addition to knowing the diversity level of foraminifera, these three indices can also be used to identify biozonation that is related to water depth factor. This is known as the SHEBI method [12], will be described more detail afterwards.

A. Diversity index was calculated using the formula below [13]:

\[
H' = -\sum Pi \ln Pi
\]  

Formula description :
H' : Shannon-Weinner Index  
Pi : Proportion of species i  
Index range :
• H' = 0-2 : Low diversity of foraminifera  
• H' = 2-3 : Moderate diversity of foraminifera  
• H' >3 : High diversity of foraminifera

B. Evenness index was calculated using the formula below [14]:

\[
E = \frac{e^H}{S}
\]  

Formula description :
E : Evenness index  
e^H : Shannon-Weinner Index  
S : Total of species  
Index range :
• E' <0.4 : Low evenness of population  
• 0.4< E' <0.6 : Moderate evenness of population  
• E' >0.6 : High evenness of population
C. Dominance index was calculated using the formula below [15]:

\[ D = \left( \frac{n_i}{N} \right)^2 \]  

Formula description:

\( D \): Dominance Index  
\( n_i \): Total individu of species  
\( N \): Total foram at one sample  

Index range:
- \( 0 < D \leq 0.5 \): Low of dominance  
- \( 0.5 < D \leq 0.75 \): Moderate of dominance  
- \( 0.75 < D \leq 1 \): High of dominance

2.3.3 Biozonation identification. Biozonation identification were analysed by using two methods, first method is SHEBI (SHE analysis for biofacies identification), classify group of foraminifera related to water depth. The SHEBI analysis identifies the microfauna biofacies based on the biodiversity data (diversity and evenness) of the samples that have been ordered based on similarity environmental conditions, particularly water depth. Previous research had managed to determine the relationship between biodiversity and biofacies based on water-depth zones by analysing the values of S, H, and E. It is known that diversity will increase as water-depth increase at least up to the outer neritic zone [12][13][16][17][18]. For SHEBI analysis, S, H and E are related by equation:

\[ H = \ln S + \ln E \]  

For each calculation parameter, the N value (number of individual) for the second sample is the accumulation between the first sample and the second one, then added with the third sample for the third, continued to the last sample. As a result, the trend of log scale will be linear. Afterwards, LnS, H, and LnE are plotted again LnN, then the combination of the three are displayed in a graph of Biodiversity-gram (BDG). Biozone is identified by a linear trend, any breaks of the trend indicate new biozone.

Second method is cluster analysis which classify biozone based on similarity of their constituent species. In contrast to SHEBI which is more influenced by water depth, the biozonation of cluster can be influenced by various parameters of environmental conditions besides depth. SHEBI and Cluster analysis were processed using PAST3 (Paleontological Statistics Ver.3.23) software Hammer et al [19], freely downloaded from http://folk.uio.no/ohammer/past.

2.3.4 FORAM Index. FORAM Index was calculated using the formula based on Hallock et al [6]:

\[ FI = (10 \times Ps) + (Po) + (2 \times Ph) \]  

Formula description:

\( FI \) = FORAM Index  
\( Ps \) = \( N_s / T \) ("s" represents symbiont bearing foraminifers).  
\( Po \) = \( N_o / T \) ("o" represents opportunistic foraminifers).  
\( Ph \) = \( N_h / T \) ("h" represents other small, heterotrophic foraminifers).  
\( T \) = The total number of individuals from the sample  

Interpretation:
- \( F1 > 4 \): Indicates environment conducive to reef growth  
- \( 3 < F1 < 5 \): Transitional environment (environmental decline)  
- \( 2 < F1 < 4 \): Indicates environment marginal for reef growth and unsuitable for recovery  
- \( F1 < 2 \): Indicates stressed conditions unsuitable for reef growth
3. Result and discussion
The result indicates that foraminifera is composed of 52 benthic foraminiferal species, belong to 41 genera. Based on the calculation of relative abundance, there were several predominant genera such as Amphistegina, Operculina, Textularia, Quinqueloculina, Elphidium, and Heterolepa (Figure 2 and 3). The other genera has a percentage range below 1%.

![Figure 2](image1.png)

**Figure 2.** The relative abundance of foraminifera in Tambelan Islands.

![Figure 3](image2.png)

**Figure 3.** Predominant genera of foraminifera: (1) *Heterolepa*, (2-4) *Textularia*, (5) *Rotalidium*, (6-7) *Amphistegina*, (8) *Operculina*, (9) *Elphidium*, (10-11) *Quinqueloculina*, and (12) *Spiroloculina*.

3.1. Diversity, Evenness and Dominance Index
Diversity index ranged from 1.65 to 2.96 with average 2.22, while Evenness index ranged from 0.27-0.8 (0.49 in average), both are categorized as a moderate category, this means the presence of foraminifera in these location are evenly distributed. Furthermore, Dominance Index ranged from 0.06-0.31 with average 0.19, is categorized as low. This means no particular type of foraminiferal is dominates. The three indices (Figure 4 and Table A1) suggest that the condition of the Tambelan Islands waters is still favorable for foraminiferal habitat. The low value of dominance index in contrast high value of evenness indicate that all types of shallow benthic foraminifera able to live and develop with relatively equal abundances, no typical species is extremely dominant. Normally, the value of dominance index is inversely proportional to the evenness index. When the value of dominance index is high, the value of evenness index is low, suggests that the abundance of foraminifera is unevenly distributed. In
this condition an opportunist taxa will exclusively dominant due to unfavorable environmental conditions for other genera, and vice versa.

Figure 4. Diversity, Evenness and Dominance Index.

3.2. Biozonation Analysis

The SHEBI analysis divided foraminifera in Tambelan Islands into 3 biozones (Figure 5 and Table 2). Biozone I (5-15m depth) is indicated by decrease of diversity (H) and log evenness (LnE) while log of species number (LnS) increased. Biozone II (15-25m depth) is indicated by relatively constant H value, decrease of LnE, in contrast increase of the log species number (LnS). Biozone III (25-50m depth) is characterized by the value of diversity H and log of species number LnS that are relatively constant with slight decreased of the LnE.

Meanwhile, the result from Cluster Analysis exhibits 2 biozones, where the second group is divided into 2 sub-groups (Figure 6). Group I is consisted of only 1 sample (T-20), located off Benua Island in the southern part of Tambelan Islands, and the other 19 locations belong to Group II. The separation of these two groups was clearly due to the differences in environmental conditions. Group I (T-20) is dominated by genera *Rotalidium*, while group II is dominated by genera *Amphistegina* and *Operculina*.

Figure 5. (a – c) Ln S, H, and LnE plot to the LnN value, (d) Biodiversity-gram (BDG) of SHEBI analysis in Tambelan Islands.
Table 2. The results of the SHEBI analysis showed 3 biozonation.

| Biofacies | N | Sample | Depth (m) | N | ln N | S | ln S | H | E | ln E |
|-----------|---|--------|-----------|---|-----|---|------|---|---|-----|
| I         | 3 | T-20   | 5         | 309| 5.733| 24| 3.178| 2.955| 0.800| -0.223 |
|           |   | T-12   | 10        | 600| 6.397| 28| 3.332| 2.794| 0.584| -0.539 |
|           |   | T-2    | 15        | 908| 6.811| 34| 3.526| 2.621| 0.404| -0.905 |
| II        | 6 | T-14   | 15        | 1209| 7.098| 38| 3.638| 2.802| 0.434| -0.836 |
|           |   | T-6    | 17        | 1501| 7.314| 41| 3.714| 2.769| 0.389| -0.945 |
|           |   | T-4    | 20        | 1793| 7.492| 45| 3.807| 2.800| 0.365| -1.007 |
|           |   | T-7    | 20        | 2101| 7.650| 46| 3.829| 2.786| 0.353| -1.043 |
|           |   | T-3    | 25        | 2429| 7.795| 50| 3.912| 2.751| 0.313| -1.161 |
|           |   | T-9    | 25        | 2765| 7.925| 50| 3.912| 2.717| 0.303| -1.195 |
| III       | 11| T-16   | 25        | 3038| 8.019| 50| 3.912| 2.795| 0.327| -1.118 |
|           |   | T-1    | 30        | 3339| 8.113| 50| 3.912| 2.759| 0.316| -1.153 |
|           |   | T-11   | 32        | 3634| 8.198| 51| 3.932| 2.769| 0.312| -1.163 |
|           |   | T-5    | 33        | 3936| 8.278| 51| 3.932| 2.771| 0.313| -1.161 |
|           |   | T-8    | 35        | 4271| 8.360| 51| 3.932| 2.763| 0.311| -1.169 |
|           |   | T-10   | 35        | 4564| 8.426| 51| 3.932| 2.752| 0.307| -1.180 |
|           |   | T-13   | 35        | 4873| 8.492| 51| 3.932| 2.754| 0.308| -1.178 |
|           |   | T-15   | 35        | 5210| 8.558| 51| 3.932| 2.751| 0.307| -1.181 |
|           |   | T-17   | 41        | 5537| 8.619| 52| 3.951| 2.726| 0.294| -1.225 |
|           |   | T-19   | 47        | 5832| 8.671| 52| 3.951| 2.737| 0.297| -1.214 |
|           |   | T-18   | 50        | 6151| 8.724| 52| 3.951| 2.751| 0.301| -1.200 |

Figure 6. Dendogram of cluster analysis in Tambelan Islands.

*Rotalidium* genera are known have high tolerant to the change of salinity, and mostly found in estuarine and lagoon areas [20]. In contrast to the other locations, T-20 was collected from very shallow water depth (5 m), moreover its position is very close to the mainland Benua Island. As a consequence,
the impact from the land might be relatively higher in this location compared to the others, hence influence the foraminiferal assemblages and distribution.

In Group II, significant changes of *Amphistegina* and *Operculina* percentages are considered as a distinguishing factor in the two sub-group. Sub-group II-A is consisted of sample T-1, 2, 3, 4, 8, 9, 11, 12, 18 and T-19, it is characterized by high dominance of *Amphistegina* (40.4% in average) and *Operculina* with lower percentage (average percentage is 17.3%). Sub-group II-B composed of sample T-5, 6, 7, 10, 13, 14, 15, 16, and T-17, it is reflected by decrease of *Amphistegina* percentage (16.6%), in contrast percentage of *Operculina* is higher compared to Group II-A (33% in average).

The foraminiferal biozonation derived from the two methods (SHEBI and Cluster Analysis) shows different result, suggests that the abundance of foraminifera in Tambelan Islands is influenced by many complex factors. The depth of water strongly influence the diversity of foramifera. The other factors including type of substrate, current intensity, penetration level, coral reefs environment, and terrigenous input also influence foraminiferal assemblages in shallow water Tambelan Islands.

### 3.3. FORAM Index

The foraminifera were grouped into 3 groups, group that associated with coral reefs, opportunistic group, and heterotrophic group (Table B1). The results of FORAM Index calculations range from 3.57 to 9.12 (Figure 7). Based on this FI value (FI > 4), the waters of the Tambelan Islands is considered as a conducive environment for the growth of coral reefs. However, 2 locations (T-16 and T-20) indicate lower FI values, although these values are still in conducive zone to coral reef growth. In these two locations *Textularia* and *Rotalidium* are dominant, and the abundance of *Amphistegina* and *Operculina* genera are lower compared to other locations. Sample T-16 was collected from the northern part of the study area, 25 m water depth, composed of gravelly-muddy-sand type of sediment. Sample T-16 is more dominated by *Textularia*. While, sample T-20 collected from the southern part of the study area, very close to Benua Island, with the shallowest water depth (5m) compared to other samples, more dominated by genera of *Rotalidium*.

![Figure 7. FORAM Index value](image.png)

The abundance of *Amphistegina* and *Operculina* genera can be influenced by the type of sediment, water depth, and the nutrients content in the water. Very fine sediment may increase the level of turbidity thus reduce the level of sunlight penetration into the waters. This condition is not favourable for the development of symbiont bearing foraminifera group including *Amphistegina* and *Operculina*. These
two genera need sunlight for conducting photosynthesis process. Conversely, the abundance of *Textularia* is increased in this high turbidity condition because it does not require bicarbonate from the photosynthesis [6,21,22]. Furthermore, terrigenous input from nearby mainland is another factor influence the abundance of *Amphistegina* and *Operculina*, particularly related to changes in pH conditions and nutrient supply.

4. Conclusion
Foraminifera that were found in the Tambelan Islands very abundant, dominated by algal symbiont bearing larger benthic foraminifera such as *Amphistegina* and *Operculina* genera. It was observed that the abundance of foraminfera in Tambelan Islands is not only influenced by water depth factors, but also influenced by more complex factors such as sediment type and the influence from the mainland around the Tambelan Islands. FORAM Index analysis indicated that Tambelan Islands waters are naturally conducive to coral reef growth. However, the possibility in water quality degradation might be occurred confirmed by the low FORAM Index values in 2 locations associated with decrease in *Amphistegina* and *Operculina* abundance, that need to be concerned.

Appendices
Appendix A. Diversity, Evenness and Dominance Index Value

| Sample | Diversity (H) | Dominance (D) | Evenness (E) |
|--------|---------------|---------------|--------------|
| T-1    | 2.03          | 0.26          | 0.42         |
| T-2    | 1.65          | 0.31          | 0.27         |
| T-3    | 2.13          | 0.21          | 0.35         |
| T-4    | 2.44          | 0.17          | 0.46         |
| T-5    | 2.40          | 0.17          | 0.41         |
| T-6    | 2.23          | 0.18          | 0.41         |
| T-7    | 1.94          | 0.30          | 0.32         |
| T-8    | 2.22          | 0.18          | 0.54         |
| T-9    | 2.13          | 0.20          | 0.49         |
| T-10   | 2.10          | 0.22          | 0.45         |
| T-11   | 2.28          | 0.15          | 0.44         |
| T-12   | 1.66          | 0.25          | 0.41         |
| T-13   | 2.26          | 0.19          | 0.56         |
| T-14   | 2.75          | 0.09          | 0.65         |
| T-15   | 2.10          | 0.16          | 0.75         |
| T-16   | 2.87          | 0.10          | 0.52         |
| T-17   | 1.83          | 0.26          | 0.42         |
| T-18   | 2.30          | 0.13          | 0.66         |
| T-19   | 2.13          | 0.15          | 0.47         |
| T-20   | 2.96          | 0.06          | 0.80         |
Appendix B. Taxonomic Group for FORAM Index Calculation

Table B1. Foraminifera group for FORAM Index calculation.

| No | Species                        | Suborder  | Order     | Family     | Taxonomic Group   |
|----|--------------------------------|-----------|-----------|------------|-------------------|
| 1  | Ammonomassilina alveoliniformis| Miliolina | Miliolida | Hauerinida | Heterotrophic     |
| 2  | Amphistegina lessoni           | Rotaliina | Rotaliida | Amphisteginida | Symbiont bearing |
| 3  | Amphistegina radiata           | Rotaliina | Rotaliida | Amphisteginida | Symbiont bearing |
| 4  | Articulina pacifica            | Miliolina | Miliolida | Hauerinida | Heterotrophic     |
| 5  | Asterorotalia trispinosa       | Rotaliina | Rotaliida | Ammoniidae | Opportunistic     |
| 6  | Baculogysinoides spinosus      | Rotaliina | Rotaliida | Calcarinida | Symbiont bearing |
| 7  | Calcarina mayori               | Rotaliina | Rotaliida | Calcarinida | Symbiont bearing |
| 8  | Cancris auriculus              | Rotaliina | Rotaliida | Cancellidae | Heterotrophic     |
| 9  | Cibicidoides globulosus        | Rotaliina | Rotaliida | Cibicidae  | Heterotrophic     |
| 10 | Clavulina pacifica             | Textulariina | Textulariida | Valvulinida | Heterotrophic     |
| 11 | Discorbinella sp               | Rotaliina | Rotaliida | Discorbinellida | Heterotrophic     |
| 12 | Elphidium craticulum           | Rotaliina | Rotaliida | Elphididae | Opportunistic     |
| 13 | Elphidium crispum              | Rotaliina | Rotaliida | Elphididae | Opportunistic     |
| 14 | Eponides repandas              | Rotaliina | Rotaliida | Eponidae   | Heterotrophic     |
| 15 | Gypsina vesicularis            | Rotaliina | Rotaliida | Acervulinida | Heterotrophic     |
| 16 | Hanzawaia concentrica          | Rotaliina | Rotaliida | Anomalinidae | Heterotrophic     |
| 17 | Heterostegina depressa         | Rotaliina | Rotaliida | Nannuntidae | Symbiont bearing  |
| 18 | Heterolepa subhaidingeri       | Rotaliina | Rotaliida | Cibicidae  | Symbiont bearing  |
| 19 | Lenticulina papillosoechinata   | Rotaliina | Lagenida  | Vaginulinae | Heterotrophic     |
| 20 | Martinotiella milletti         | Textulariina | Textulariida | Eggerellidae | Heterotrophic     |
| 21 | Miliolinella suborbicularis    | Miliolina | Miliolida | Hauerinida | Heterotrophic     |
| 22 | Neoponides bradyi              | Rotaliina | Rotaliida | Discorbiidae | Heterotrophic     |
| 23 | Operculina ammonoides          | Rotaliina | Rotaliida | Nannuntidae | Symbiont bearing  |
| 24 | Pararotalia domantayi          | Rotaliina | Rotaliida | Calcarinida | Opportunistic     |
| 25 | Peneroplis antilarum           | Miliolina | Miliolida | Peneropidae | Symbiont bearing  |
| 26 | Planispirillina spinigeri      | Rotaliina | Planispirillina | Planispirillina | Heterotrophic     |
| 27 | Planorbulinella acarvalis      | Rotaliina | Rotaliida | Planorbulinida | Heterotrophic     |
| No | Species                        | Suborder     | Order   | Family            | Taxonomic Group |
|----|--------------------------------|--------------|---------|-------------------|-----------------|
| 28 | Planorbullinella larvata       | Rotaliina    | Rotaliida| Planorbullinidae  | Heterotrophic   |
| 29 | Pseudogaudryina triangulata    | Textulariina | Textulariida | Pseudogaudryinida | Heterotrophic   |
| 30 | Pseudohauerina involata        | Miliolina    | Miliolida| Hauerinidae       | Heterotrophic   |
| 31 | Pseudomassilina macilenta      | Miliolina    | Miliolida| Hauerinidae       | Heterotrophic   |
| 32 | Pseudorotalia Schroeteriana    | Rotaliina    | Rotaliida| Ammoniidae        | Opportunistic   |
| 33 | Pyrgo anomala                  | Miliolina    | Miliolida| Hauerinidae       | Heterotrophic   |
| 34 | Quinqueloculina cuvieriana     | Miliolina    | Miliolida| Hauerinidae       | Heterotrophic   |
| 35 | Quinqueloculina intricata      | Miliolina    | Miliolida| Hauerinidae       | Heterotrophic   |
| 36 | Quinqueloculina organica       | Miliolina    | Miliolida| Hauerinidae       | Heterotrophic   |
| 37 | Quinqueloculina parvaggluta    | Miliolina    | Miliolida| Hauerinidae       | Heterotrophic   |
| 38 | Quinqueloculina pseudoreticulata| Miliolina | Miliolida| Hauerinidae       | Heterotrophic   |
| 39 | Rosalina bradyi                | Rotaliina    | Rotaliida| Rosalinidae      | Heterotrophic   |
| 40 | Rotalidium annectens           | Rotaliina    | Rotaliida| Ammoniidae       | Heterotrophic   |
| 41 | Sahulia kerimbaensis           | Textulariina | Textulariida | Textularida   | Heterotrophic   |
| 42 | Schlumbergerella floressiana   | Rotaliina    | Rotaliida| Calcarinidae      | Symbiont bearing|
| 43 | Schlumbergerina alveoliniformis| Miliolina    | Miliolida| Hauerinidae       | Heterotrophic   |
| 44 | Spiroloculina communis         | Miliolina    | Miliolida| Spiroloculinidae | Heterotrophic   |
| 45 | Stilostomella lepidula         | Rotaliina    | Lagenida | Stilostomellida   | Heterotrophic   |
| 46 | Streblos gaimardii             | Rotaliina    | Rotaliida| Ammoniidae       | Opportunistic   |
| 47 | Textularia foliacea            | Textulariina | Textulariida | Textularida   | Heterotrophic   |
| 48 | Textularia paragglutinans      | Textulariina | Textulariida | Textularida   | Heterotrophic   |
| 49 | Textularia stricta             | Textulariina | Textulariida | Textularida   | Heterotrophic   |
| 50 | Tinoporus spengleri            | Rotaliina    | Rotaliida| Calcarinidae      | Symbiont bearing|
| 51 | Triloculina tricarinata        | Miliolina    | Miliolida| Hauerinidae       | Heterotrophic   |
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