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## Can Florida's Springs Coast provide a Potential Refuge for Calcifying Organisms? Evidence from Benthic Foraminifera

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Can Florida's Springs Coast provide a Potential Refuge for Calcifying Organisms? Evidence  
from Benthic Foraminifera

by

Kyle E. Amergian

A thesis submitted in partial fulfillment  
of the requirements for the degree of  
Master of Science  
College of Marine Science  
University of South Florida

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Keywords: Distribution, Miliolida, refugia, bioindicator, *Archaias angulatus*

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## DEDICATION

To my grandfather, Richard Amergian, who always believed in me, and my love for the microscopic world. Without his encouragement and support this would not have been possible.

## ACKNOWLEDGMENTS

I would like to acknowledge my committee, Dr. Pamela Hallock Muller, Dr. Kendra Daly and Dr. Susan Bell, for their expertise, input, and continuous support. It was an honor to work with such inspiring and trailblazing women in marine science. Thank you to the Cushman Foundation for Foraminiferal Research for providing partial funding through the Joseph A. Cushman Award for Student Research. Thanks also to Brian Huber and Jennifer Jett for providing me access to the Cushman Foraminiferal Collection at the U.S. National Museum of Natural History, where I was able to check my identifications and correct them when appropriate. Thank you to the Oceanography Camp for Girls Fellowship for their support of this research. Dr. Paul Carlson and the Seagrass Integrated Mapping and Monitoring program of the Florida Fish and Wildlife Conservation Commission–Fish and Wildlife Research Institute provided sediment samples to the Reef Indicators lab. Thank you Cordey Seldon for providing the environmental data spreadsheet. Sean Beckwith for teaching me how to use ArcGIS, and Christian Gfatter for introducing me to this research project.

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## ABSTRACT

Florida's Springs Coast, located in the northeast Gulf of Mexico, includes an extensive system of salt marshes that discharge millions of liters of fresh water into coastal waters daily. The chemical properties of the spring waters include high alkalinity and high calcium concentrations due to the Paleogene limestone lithology of this region of Florida. Benthic foraminifers, which are recognized as ecologically important bioindicators, occur abundantly on the shallow shelf off the Springs Coast. Based on the prevalence of the benthic foraminifer *Archaias angulatus* in the seagrass beds along this shallow shelf, a previous study proposed that the Springs Coast provides favorable conditions for such "subtropical" calcifying organisms, despite existing literature indicating that salinities and winter temperatures are suboptimal for such species. Thus, a motivation for my study was to provide insight into the hypothesis that, during times of ocean acidification, limestone lithofacies may provide suitable water chemistry and physical habitat to provide refuges for calcifying organisms.

Selected environmental parameters and sediments from 41 sites at depths  $\leq 8$  m were sampled in September 2013, during routine seagrass monitoring by researchers from the Florida Fish and Wildlife Research Institute. The 152 benthic foraminiferal species identified included 71 porcelaneous, 67 hyaline, and 14 agglutinated species. Overall, 74% of the specimens identified were porcelaneous and most of the remainder were hyaline; agglutinates composed <1% of those counted. Species dominance in samples revealed an apparent distribution reversal compared to previous reports from Gulf of Mexico coastal habitats. Smaller miliolids, notably

*Quinqueloculina* spp., dominated in samples from most of the inshore brackish sites. In contrast, at the more offshore sites characterized by normal marine salinities, hyaline taxa such as *Haynesina* spp. were much more abundant. We postulate that these unusual distributions are associated with the calcium and carbonate chemistry of the brackish waters. The salinity threshold for small miliolids appeared to be lowered by the carbonate saturation state ( $\Omega$ ).

Although 152 species were identified, only 13 species accounted for 56% of the specimens counted. The high diversity coupled with low abundances of most species may indicate the influence of foraminiferal propagule dispersal. The seasonal range of environmental conditions and the diversity of habitats available within the seagrass may allow a diverse array of propagules to recruit and grow at suitable times during the year, while not necessarily establishing sustained populations.

## INTRODUCTION

### **Florida's Springs Coast**

In seagrass meadows along Florida's Spring Coast, the common Caribbean foraminiferal species, *Archaias angulatus* (Fichtel and Moll), was observed in abundance by Dr. Paul Carlson of the Seagrass Integrated Mapping and Monitoring Program (SIMM) of Florida Fish and Wildlife Conservation Commission's Research Institute (Jones et al., 2016). The observation of a thriving population of this subtropical/tropical soritid species, which hosts chlorophyte endosymbionts, came as a surprise because both the winter temperatures and reduced salinities were below the environmental limits previously published for this species (e.g., Martin, 1986; Hallock & Peebles, 1993; Weinmann et al., 2013). Observations of *Ar. angulatus* in an unusual area prompted the collection of sediment samples during a FWRI survey of the seagrass habitat along the Springs Coast during the late summer of 2013.

Florida's Springs Coast is a unique coastal system of salt marshes spanning approximately one degree of latitude (28°–29°N) along Florida's west coast. Many springs discharge directly into coastal waters or into rivers that collectively discharge millions of liters of fresh water into coastal waters every day. The lithology in this region of Florida is dominated by Paleogene limestone that extends offshore, with a limited cover of quartz sand and shell debris (e.g., Beckwith, 2016, and references therein). The chemical properties of the spring water include elevated alkalinity and calcium concentrations (Beckwith et al., 2019).

## **Foraminifera as Bioindicators**

Benthic protists of the Phylum Foraminifera occur abundantly worldwide, living in estuaries, marshes, and other shallow shelf systems similar to Florida's Springs Coast, as well as in most other marine environments and even in some freshwater and moist terrestrial habitats. Though foraminifers lacking shells are being increasingly identified using molecular genetics (Pawlowski et al., 2003), most research has focused on shelled forms, because of the preservation potential of the shells, also commonly called "tests" (e.g., Sen Gupta, 1999; Murray, 2006).

Environmental parameters such as food availability, pH, alkalinity, dissolved oxygen, salinity, temperature, and substrate variability influence the abundance and diversity of foraminiferal assemblages. Benthic foraminifers fill specific niches and have relatively short lifespans, which allow them to quickly respond to environmental change, making them useful in differentiating between long-term changes and episodic events (e.g., Hallock et al., 2003; Carnahan et al., 2009). Additionally, foraminifers are widely distributed, diverse, and typically well preserved in the sediment record. Sampling of foraminifers is relatively easy and inexpensive due to their small size and high abundance, and collection has both low environmental impact and cost (e.g., Schafer, 2000; Hallock et al., 2003). As a consequence, benthic foraminifers are becoming more widely utilized as ecologically important bioindicators (e.g., Hallock, 2012, and references therein; Schönfeld et al., 2012, and references therein).

## **Foraminiferal Functional Groups**

Several studies have used the concept of functional or morphological groups in ecological studies of benthic foraminiferal assemblages. Perhaps the most common categorization is

infaunal versus epifaunal (e.g., Bandy, 1954; Jorissen, 1999; Murray, 2006, and references therein). Large changes in pore-water chemistries can take place within the sediment-water interface and within sediments immediately below the interface. This is particularly characteristic of fine-grained sediments, because coarse-grained sediments allow for a deeper penetration of water motion and oxygen. However, in shallow-water environments similar to the Springs Coast, living Foraminifera are found in considerable sediment depths without noticeable compositional changes with depth (Jorissen, 1999).

Murray (e.g., 1973, 2006) refers to foraminifers as morphospecies that are primarily defined by wall structure, chamber and test shape, and the positions of apertures, and therefore used ternary diagrams to distinguish habitats, plotting wall structure (agglutinated, porcelaneous and hyaline) as the three reference points. Agglutinated taxa are commonly prevalent in shallow waters with low carbonate saturations such as most brackish environments, while miliolid taxa tend to be prevalent in highly carbonate-saturated waters that are common in warm, normal-marine to hypersaline conditions.

Langer (1993) categorized four epiphytic morphotypes, including attached, temporarily motile, suspension-feeding motile, and grazing-motile. Other authors, especially those working in the Mediterranean where seagrasses are prolific, have adopted or modified Langer's (1993) epiphytic morphotypes (e.g., Mateu-Vicens et al., 2014). Mateu-Vicens et al. (2014) further separated attached morphotypes into two categories: encrusting and sessile.

Hallock et al. (2003) defined three benthic-foraminiferal functional groups that occur in lower-latitude, warm coastal waters: algal-symbiont-bearing, stress-tolerant, and other smaller taxa, which includes most smaller miliolids, some smaller rotaliids, and some agglutinates. Each functional group has an optimal range of environmental parameters in which the foraminifers can

thrive. Large, symbiont-bearing foraminifers, like *Ar. angulatus*, prefer warm-water environments with normal marine salinity and low nutrients. Stress-tolerant taxa can thrive in marginal environments defined by having high variability in environmental parameters such as temperature, salinity, food supply, dissolved oxygen, pH and alkalinity. *Ammonia* is a well-documented eurytopic genus found in coastal and estuarine environments; Poag (2015) considered this the dominant genus in inshore-coastal waters around the Gulf of Mexico. Agglutinated species also are common among low salinity environments (e.g., Poag, 2015, and references therein). Most smaller miliolids and smaller rotaliids thrive where food supplies are adequate but not in sufficient excess to deplete oxygen concentrations at the sediment-water interface (Hallock et al., 2003). Miliolids typically thrive in normal to hypersaline waters (e.g., Murray, 2006), because their calcification mechanism requires relatively high carbonate-saturation states (Bentov & Erez, 2006; de Nooijer et al., 2009).

### **Previous Work in the Gulf of Mexico**

Research on foraminiferal assemblages of the Gulf of Mexico has a long history, summarized in three major compendia (Culver and Buzas, 1981; Poag, 1981, 2015). Remarkably, in reviewing 77 publications recognizing 295 species, Culver & Buzas (1981) showed only one sample site just north of my study area (Parker, 1954, 28°49' N, 83°40' W), as well as four samples along an east–west transect off Tarpon Springs (Bandy, 1956; 28°08' N, 82°57'–28°09' N, 83°41'W) near the southern boundary of the watershed classified as the Springs Coast by the Southwest Florida Water Management District (see Beckwith, 2016, fig. 16).

Some coastal areas around the Gulf of Mexico, with salinities ranging from brackish to hypersaline, and coastal temperatures reaching 38°C, have been classified by Murray (2006) as

marginal-marine environments. Three genera, *Quinqueloculina*, *Triloculina*, and *Elphidium*, are among the dominant genera in coastal and shelf habitats throughout the Gulf of Mexico. Murray (2006) plotted species diversities with site salinities, based upon numerous studies from the Gulf of Mexico (p. 109, fig. 4.16), which showed sites classified as normal marine to have higher diversities than brackish sites. The ternary plot of foraminiferal shell type for the Gulf of Mexico from Murray (2006, fig. 4.19) shows brackish sites to be dominated by agglutinated foraminifers, while normal marine sites have a more even distribution of species with porcelaneous and hyaline walls. Murray (2006) concluded that, in general, “brackish subtidal environments have assemblages with a mixture of agglutinated and hyaline walls.”

Poag (2015) provides an extensive review and summary of benthic foraminiferal distributions showing predominant genera of facies and biofacies in the Gulf of Mexico. *Ammonia* is mapped as the dominant genus along the coastal area of the west Florida shelf, extending approximately 40 km offshore in the Springs Coast area. Past 40 km offshore in this area, miliolids are mapped as the dominant biofacies. Poag (2015) illustrates this common distribution pattern throughout the Gulf of Mexico, with stress-tolerant foraminifers such as *Ammonia* and *Elphidium* dominating coastal areas.

### **Motivation for this Research**

Earth’s geological record shows numerous natural events and changes related to carbon cycling and global climate change throughout the past 300 million years (e.g., Honisch et al., 2012). Processes such as ocean acidification have been studied using paleoenvironmental indicators, including foraminifers. The assemblages and shell geochemistries of these organisms

have been used to create models to predict the influences of modern-day ocean acidification, global climate change, and the Earth's response to future changes (Whiteside & Grice, 2016).

At several intervals in Earth's history, mass extinction events have been recorded, typically characterized by a hiatus in preservation of calcium carbonate shells and skeletons (e.g., Coccioni & Luciani, 2004; Dameron et al., 2017). An interesting paleontological phenomenon has often been observed following mass extinctions; the "Lazarus phenomenon" refers to observations of fossil species that disappear from the fossil record, but reappear, often millions of years later (e.g., Flessa & Jablonski, 1983; BouDagher-Fadel & Price, 2009). Apparently, when ocean acidification events have occurred, the shells of many species disappeared from the fossil record. However, many species, especially of foraminifers, can live in environments where there is very little preservation potential (Engel et al., 2015). When the ocean waters re-equilibrate so that shells can be preserved, some species reappear in the fossil record. For example, Uthicke et al. (2013) predicted that ongoing ocean acidification will result in the extinction of all foraminifers that produce calcium-carbonate shells by 2100. In contrast, Engel et al. (2015), Knorr et al. (2015) and others have suggested that many carbonate-producing foraminifers will survive in areas where temperatures and chemical properties allow them to live, even though their shells will dissolve after the death of the individual protists.

Among the foraminifers, members of the Order Miliolida are assumed to be most vulnerable to ocean acidification because they produce shells of 10–15 mol% Mg-calcite, which are more soluble than shells containing lower concentrations of Mg (Knorr et al., 2015). As a consequence, the Miliolida tend to be most abundant in normal to slightly elevated salinities (Murray, 2006) and many can thrive at salinities >40 (e.g., Amao et al., 2018). Miliolids also decline in abundance with decreasing temperatures (Waters & Hallock, 2017). Temperature and



salinity both influence carbonate saturation of the water and, therefore, the calcification and survival of miliolid foraminifers (Crevison & Hallock, 2007).

Algal symbiont-bearing miliolids, such as *Ar. angulatus*, are typically abundant in carbonate sediments of the Caribbean and western tropical Atlantic (Hallock et al., 1986; Martin, 1986; Langer & Hottinger, 2000). Within the Gulf of Mexico, Poag (2015, p. 86) reported their distribution as being “especially notable in Florida Bay, and on West Florida and Campeche shelves.” *Archaias angulatus* has been characterized as a stenohaline species that prefers normal salinity, well oxygenated waters, are often associated with high-energy reefs (Martin, 1986), and can withstand winter temperatures as low as 14°C (Hallock & Peebles, 1993).

The occurrence of *Ar. angulatus* in higher latitudes and lower salinity environments than considered typical has sparked the question: might the chemical properties of the freshwater from Florida springs provide environmental conditions that allow subtropical/tropical taxa to thrive in this region? If so, can this occurrence provide insight into how and where calcareous taxa have survived during past ocean acidification events and where they may continue to live as ocean acidification increases over the next century or more? To explore this question further, my thesis research will document the distribution of total foraminiferal assemblages as they relate to the unique environmental setting and microhabitats off Florida’s Springs Coast.

## MATERIALS AND METHODS

### **Sample Collection and Laboratory Analyses**

Surface-sediment samples were collected in September 2013 along Florida's Springs Coast by Dr. Paul Carlson and other members of the seagrass-habitat team of the Florida Fish and Wildlife Conservation Commission's Research Institute. Surface-sediment samples from 41 sites throughout the Springs Coast were used for this research (Fig. 1). The northernmost sample was taken approximately 8 km north of Homosassa Springs; the southernmost sample was taken approximately 13 km north of Anclote Key. Samples were sealed in 118-ml widemouth containers and frozen. Location and environmental data, which were collected at the same time as the sediment samples, are provided in Appendix A.

Standard sieving procedures were performed for all 41 samples to determine grain-size fractions (e.g., Carnahan et al., 2009). Frozen samples were removed from the freezer to partially thaw for approximately one hour to subdivide the sample without disturbing grain distributions. Then 1/8<sup>th</sup> of the sample was rinsed briefly in deionized (DI) water to remove salts and placed on a pre-weighed, consumer-grade coffee filter within a fume hood to dry overnight. Once dried, the subsample was weighed, recording the weight of the sample and filter. The dry subsample was placed in DI water in a 50-ml beaker and sonicated for five minutes using a Fisher Scientific® Ultrasonic Cleaner. Once disaggregated, the subsample was washed over a 63 µm-mesh sieve to remove mud. Again, the subsample was placed into a pre-weighed filter and dried overnight.

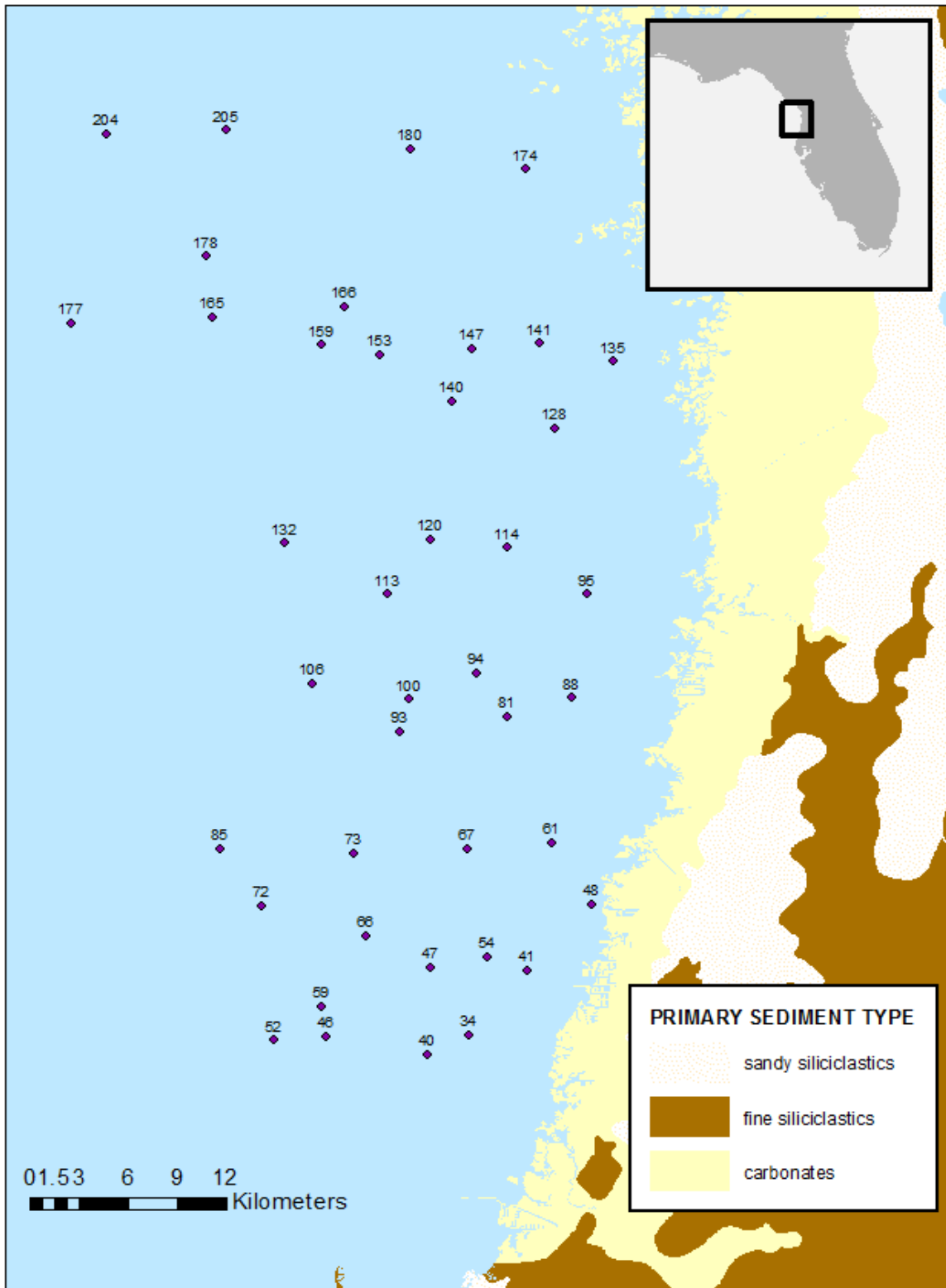
Once dry, the sample was weighed to determine the sand fraction. The difference between the first and second dry weight was recorded as part of the mud fraction.

Grain-size distribution for each sample was determined using a standard set of 10 cm-diameter sieves (2 mm, 1 mm, 0.5 mm, 0.25 mm, 0.125 mm, 0.063 mm) and the pan that collects the finest sediments <0.063 mm (Folk, 1980). Each sieve and pan were weighed. Each subsample was placed into the tower of sieves and set on a shaker for 10 minutes at medium setting. Each sieve was reweighed with the sediment, and the weight percent for each range of grain size was calculated, including the original mud removed prior to dry sieving.

All 41 samples also were assessed for total foraminiferal assemblages. A second 1/8<sup>th</sup> portion of the sediment from each sample site was isolated, washed over a 63  $\mu$ m mesh sieve with DI water, dried, and weighed. From this subsample, increments of sediment of approximately 0.2 g were weighed, examined using a stereo-zoom microscope, and all foraminiferal specimens were removed. This process was repeated until a minimum of 200 foraminiferal specimens were collected for each site. For each sample site, the foraminiferal specimens were identified to species level, then glued onto a micropaleontology slide with approximately 1–6 individuals per grid.

## **Data Analyses**

This study used the Shannon Diversity Index (H), Fisher's alpha ( $a$ ), and inverse Simpson's [ $1/(1-D)$ ] to assess the diversity of the foraminiferal assemblages (e.g., Hayek and Buzas, 1997). Buzas & Gibson's (1969) evenness measure ( $e^H/S$ ) was used to describe how evenly the species were distributed within the assemblage identified for each sample. Evenness



**Figure 1.** Sampling sites along Florida’s Spring Coast. The site numbers are written above each point. Predominant terrestrial sediments are also noted.

values range from zero to one, with a value of zero representing a site containing a single taxon, and a value of one representing an evenly distributed assemblage. Shannon Diversity Index,

Fisher's alpha, Simpson's diversity, and evenness were calculated using PAST3 (Hammer et al., 2001). Qualitative data (species identification) and quantitative (total assemblage, foraminiferal-shell density per gram of sediment, absolute and relative abundance of species) analyses of the assemblages were performed.

I also assessed assemblage distributions using functional groups that included a blend of the Murray (2006) ternary approach and the Hallock et al. (2003) sensitivity/stress-tolerance approach. This resulted in five categories: taxa known to host algal endosymbionts (e.g., *Ar. angulatus*), taxa recognized as "stress tolerant" (e.g., *Ammonia*), and other members of the three groups used by Murray (2006), smaller rotaliids, miliolids and agglutinates that were not specifically known to be stress tolerant.

Test degradation (dissolution and breakage) of *Archaias angulatus* was analyzed using a light microscope for 12 sites containing ten or more *Ar. angulatus* specimens. Specimens that were alive during the time of sample collection [indicated by green coloration (Fig. 4)] were excluded in this analysis. For each site, ten specimens were randomly selected and classified according to the stage criteria of Cottey & Hallock (1988, table 1). For the four sites with abundances of 30 or more *Archaias* specimens (sites 159, 120, 140, and 180), the random selection and classification of ten individuals was repeated three times. After a dissolution and breakage stage was assigned to each specimen, the relative abundance of each stage was determined for the 12 sites.

## **Multivariate Analyses**

Multivariate analyses were performed using MATLAB\_R2017a. A square-root transformation was applied to all relative-abundance data prior to analyses to meet the assumption of normality. Cluster analyses and non-metric multidimensional scaling (nMDS) plots were constructed for foraminiferal assemblages (R-mode) and sites (Q-mode) using the Bray-Curtis similarity index. This index is widely used for multivariate analyses of assemblage data (Clarke et al. 2006). An agglomerative, hierarchal, and unweighted pair-group method with arithmetic mean (UPGMA) was used for all cluster analyses reported in this thesis.

A nMDS plot is a dimension reduction and ordination technique that constructs a configuration of sites or variables. For each plot, a stress value, ranging from 0–1, indicates the “badness of fit.” A stress value from 0–0.05 is considered to be excellent, 0.05–0.1 is good, 0.1–0.2 is considered useful, and a stress value of 0.2–0.3 indicates a poor 2-dimensional representation. Both the cluster analyses and nMDS plots were made using the Fathom Toolbox for Matlab (Jones, 2012).

Distance-based redundancy analyses (db-RDA) were performed to determine the variability of relative foraminiferal abundance that is explained by the environmental factors that included percent grain-size distribution and percent seagrass cover. The  $R^2$  value represents the amount of variability explained by the environment. A p-value  $<0.05$  indicates a significant multivariate relationship between the response and predictor variables. Canonical axes I and II represent the amount of variability being explained by the X and Y axes, respectively. The vector headings represent the direction of underlying gradient increase.

Multivariate analyses were performed on both species and generic level data for comparability of this research to previously published work. Additionally, functional groups

were used for some db-RDA's. Relative abundance data were used for all analyses unless otherwise noted. The primary environmental data used in this study included abiotic measurements from the bottom-water (temperature, pH, salinity, and dissolved oxygen), sediment grain-size data, and percent coverage from seagrass.

## RESULTS

### **Environmental Parameters**

The depths of sampling sites ranged from 1.10–8.05 m, excluding Site 47 for which depth was not recorded. Site 177 was both deepest and furthest from shore. The shallowest location, Site 48, was the closest site to shore. All but four sites had clear visibility throughout the entire water column. Water clarity data were not recorded for Site 47. Site 180 was the most turbid.

Bottom-water temperature, salinity, pH, and dissolved-oxygen data were collected at all 41 sites. Bottom-water temperatures ranged from 26.7°C–30.7°C. The highest temperatures were observed at the southernmost stations, and the lowest temperatures were observed at the northernmost stations. Bottom-water salinity ranged from 22.5–34.6. Sites with salinity < 30 were considered brackish. Sites with salinities of 30–36 were considered normal marine. The lowest salinities were observed at sites closest to shore. Bottom-water pH ranged from 8.09–8.46 for all sites. Bottom-water dissolved oxygen saturations ranged from 75–127%. Seagrass was present at all sites, ranging from 5–100% cover.

### *Grain size*

The sediment samples in this study were heavily dominated by sand across a range of grain sizes [very coarse to very fine as described by Folk (1980)]. A grain-size distribution map is provided in Figure 2 as well as a grain-size summary in Table 1. Sand accounted for an average of 83% of all sediment samples (n=41). Fine sand was the most abundant grain size



(average 38%). The average contribution of gravel (> 2 mm) was 5% of all sediment sampled, and the average for mud (< 0.063 mm) was 12%. Samples with the highest percent of fine sand were dominated by quartz sand, while samples with coarser grain sizes were dominated by shell debris.

Of the 41 sites sampled, 32 had median grain  $\Phi$  sizes of three (Table 1), which is classified by Folk (1980) as fine sand. All of these sites had >34% fine sand. Site 85 had the highest percentage of fine sand (85%). Six of the sites (93, 147, 153, 67, 120, and 180) had median  $\Phi$  size of two (medium sand). The most medium sand was observed at sites between near shore and offshore stations. Site 159 had a median  $\Phi$  size of one (coarse sand) and was dominated by granule gravel (31%). Site 135 had a median  $\Phi$  size of four (very fine sand). Site 95 had a median grain  $\Phi$  size of less than four (mud), as made up 50% of the sampled sediment. Very fine sand and silt were more common at sites near shore.

### **Benthic Foraminiferal Distribution**

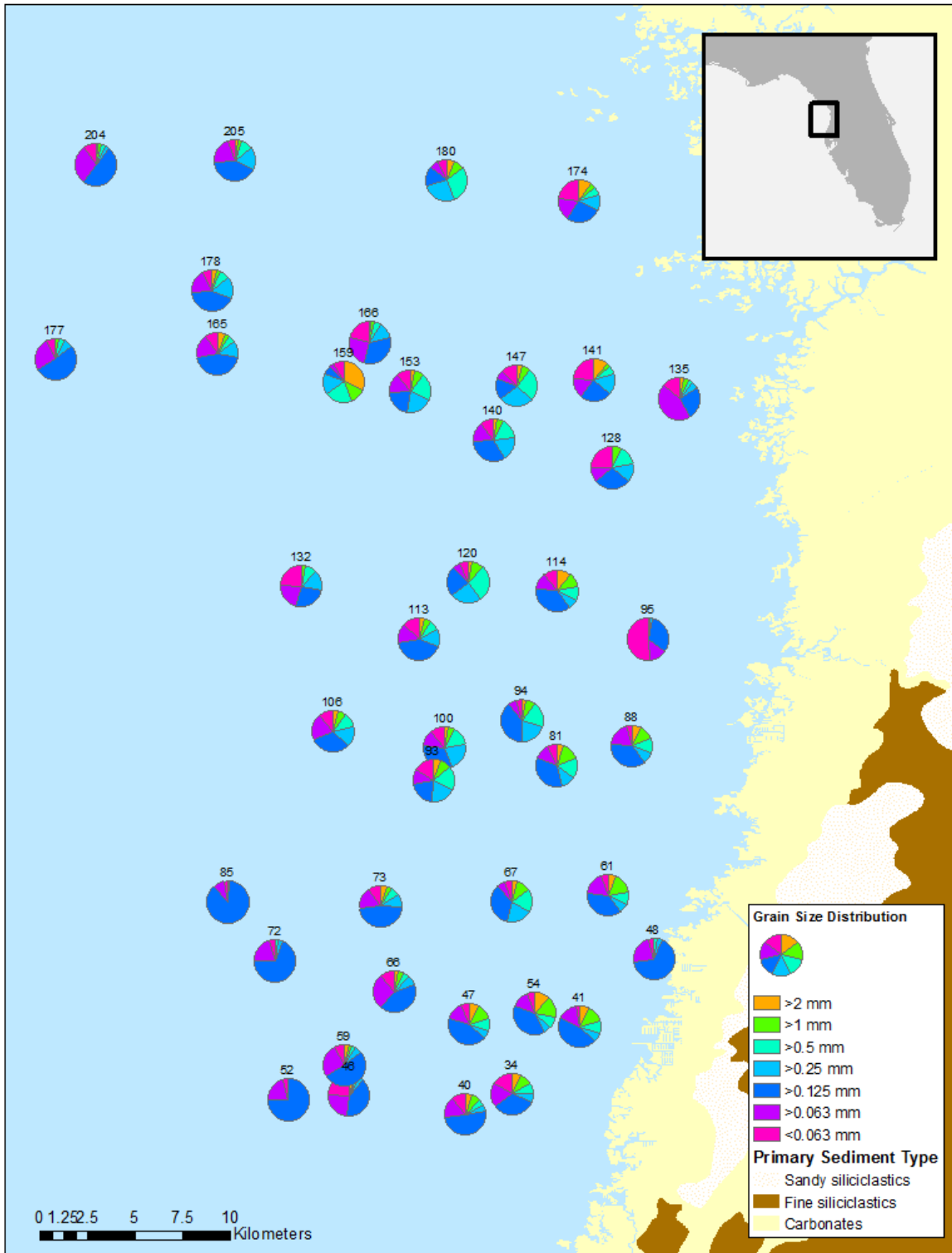
In 41 surface samples analyzed, 152 species of foraminifers were identified. These species belong to 5 orders, 36 families, and 62 genera. Of these species, 71 are calcareous-porcelaneous, including seven species of symbiont-bearing miliolids. Another 67 of the species are calcareous-hyaline, and 14 are agglutinated. The most abundant species across all samples was *Quinqueloculina seminula* (8.5% overall abundance). *Haynesina germanica* dominated at 14 sites, ranging from 9–23%. *Quinqueloculina seminula* dominated six sites (9–24%). *Archaias angulatus* dominated five sites (10–47%); abundance was directly related to grain size (Fig. 3). *Ammonia tepida* dominated four sites (8–30%). *Triloculina bermudezi* dominated three sites, with 11–17% abundance at those sites. *Quinqueloculina impressa* dominated two sites (9% and

13%) as did *Q. laevigata* (6% and 11%). *Ammonia parkinsoniana*, *Cibicides kullenbergi*, *Elphidium discoidale*, *Flintinoides labiosa*, and *Pseudotriloculina linneiana* each dominated one site (18%, 19%, 9%, 15%, and 20% respectively).

The 13 most abundant species (each making up  $\geq 2\%$  total relative abundance) across the entire study area are (in descending order) *Q. seminula*, *H. germanica*, *Ar. angulatus*, *T. bermudezi*, *Q. laevigata*, *Q. poeyana*, *Q. bosciiana*, *E. discoidale*, *Am. tepida*, *F. labiosa*, *Q. impressa*, *Am. parkinsoniana*, and *H. depressula* (Figs. 4, 5). These 13 species made up 56% of the total 9004 specimens counted.

#### *Functional groups*

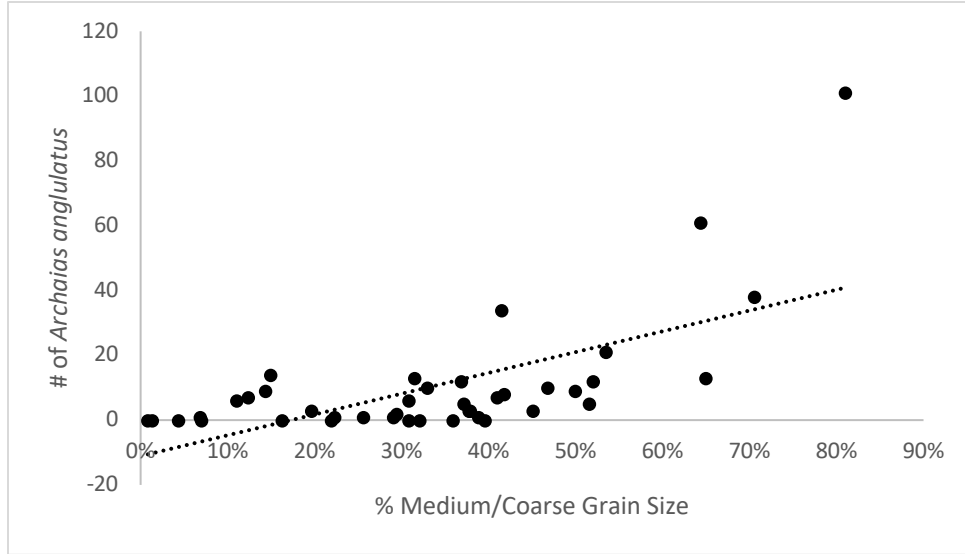
Smaller miliolids were the dominant functional group, making up an average of 58% of total biota. Collectively the samples consisted of an average of 6% algal symbiont-bearing taxa, 28% stress-tolerant taxa, 8% smaller rotaliids, and <1% agglutinated taxa. The most common symbiont-bearing taxon was *Ar. angulatus* (5% overall abundance). *Haynesina germanica* was the most common stress-tolerant taxon (8% overall abundance). *Cibicides kullenbergi* was the most common smaller rotaliid taxon (2% overall abundance). *Quinqueloculina seminula* was the most common species of the smaller miliolids (9% relative abundance). The relative abundance of small miliolids was inversely related to salinity (Fig. 6). The brackish sites (inshore) were heavily dominated by smaller miliolids, while the normal marine sites had a more even distribution of stress-tolerant and smaller-miliolid taxa (Fig. 7).



**Figure 2.** Sediment grain-size distribution for all sites (n=41); the primary terrestrial sediment types along the Springs Coast of Florida are also shown.

**Table 1.** Grain-size summary and median  $\Phi$  for all sites (n=41).

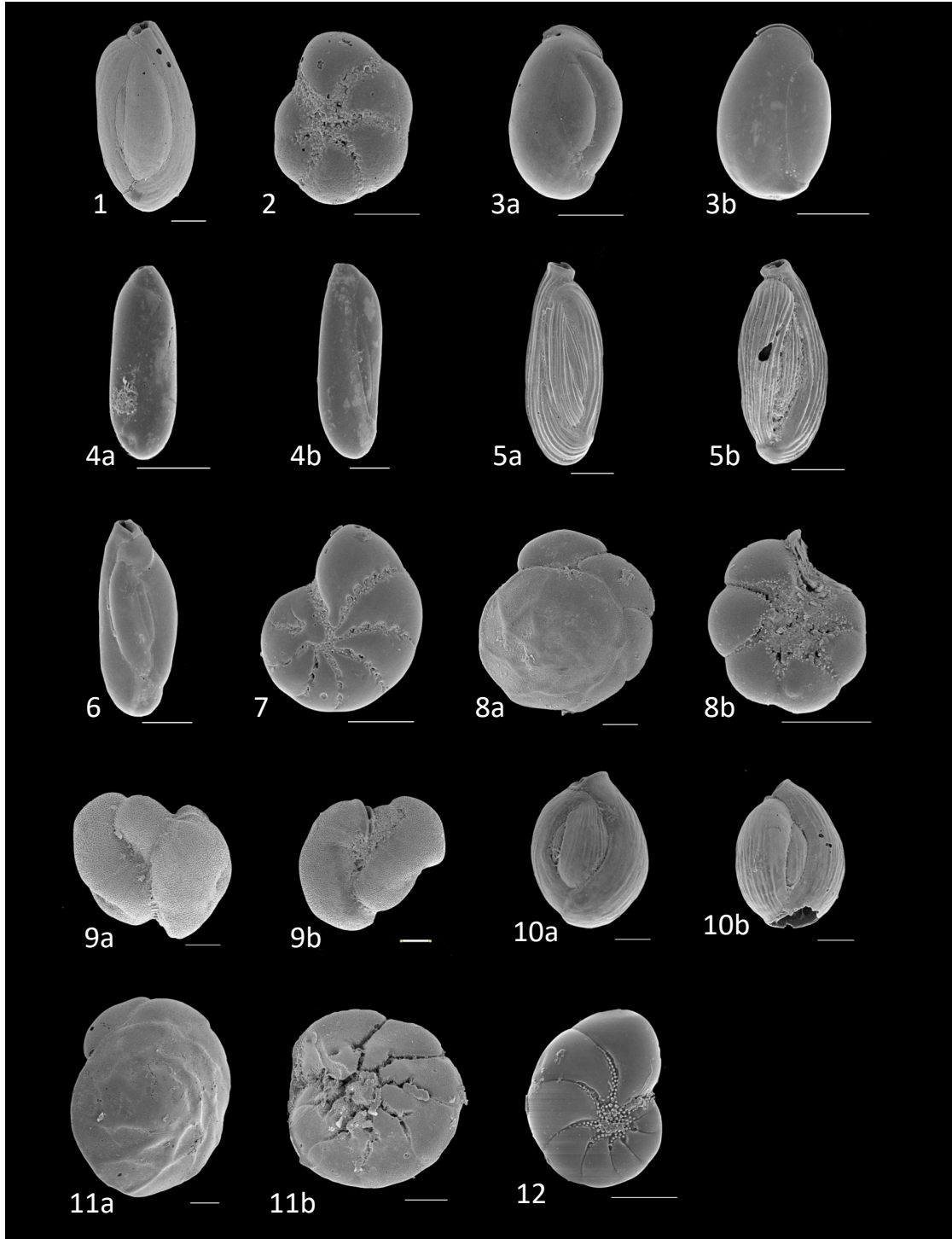
Site	Sample wt (g)	Median $\Phi$						>0.063	<0.063
			>2 mm	>1 mm	>0.5 mm	>0.25 mm	>0.125 mm	mm	mm
			-1	0	1	2	3	4	>4
34	7.41	3	7%	9%	9%	6%	34%	18%	17%
40	9.11	3	5%	7%	5%	5%	50%	16%	11%
46	7.35	3	4%	2%	2%	4%	40%	24%	24%
52	10.59	3	0%	0%	0%	1%	74%	21%	4%
59	8.06	3	4%	2%	3%	5%	52%	25%	8%
88	13.72	3	7%	12%	12%	9%	37%	20%	4%
94	4.47	3	3%	7%	20%	20%	39%	6%	5%
100	6.45	3	3%	5%	14%	22%	32%	11%	12%
106	7.28	3	4%	6%	12%	16%	31%	20%	12%
81	6.88	3	5%	14%	16%	11%	35%	11%	8%
93	4.12	2	5%	8%	19%	19%	21%	12%	16%
135	9.75	4	3%	4%	4%	5%	25%	45%	13%
141	4.38	3	11%	3%	6%	16%	24%	16%	24%
147	3.26	2	4%	7%	26%	28%	16%	7%	13%
159	3.76	1	31%	12%	22%	15%	7%	3%	9%
165	7.40	3	6%	3%	6%	13%	43%	18%	10%
177	19.44	3	1%	2%	5%	7%	52%	27%	7%
140	4.42	3	2%	5%	16%	18%	32%	15%	11%
153	5.72	2	3%	8%	20%	21%	21%	15%	11%
166	6.77	3	1%	2%	5%	13%	33%	24%	21%
178	11.23	3	3%	3%	8%	17%	42%	19%	7%
61	6.19	3	6%	16%	10%	7%	38%	17%	6%
67	9.80	2	4%	11%	19%	19%	35%	7%	5%
73	13.34	3	5%	4%	7%	10%	48%	17%	10%
85	14.82	3	0%	0%	0%	1%	86%	9%	3%
114	5.45	3	11%	11%	11%	7%	36%	13%	11%
120	7.68	2	3%	9%	28%	24%	23%	6%	7%
128	3.87	3	1%	7%	15%	14%	27%	11%	25%
132	6.91	3	1%	3%	9%	16%	26%	21%	24%
95	11.79	>4	0%	0%	1%	2%	32%	13%	50%
113	7.47	3	4%	5%	8%	14%	41%	15%	13%
41	16.03	3	7%	13%	10%	7%	44%	15%	3%
47	16.50	3	7%	13%	10%	7%	43%	14%	6%
48	19.46	3	0%	1%	2%	4%	66%	23%	4%
54	7.45	3	12%	16%	9%	5%	39%	13%	6%
66	6.37	3	3%	4%	5%	7%	42%	27%	11%
72	12.25	3	0%	1%	2%	4%	68%	21%	4%
174	3.38	3	10%	4%	6%	12%	27%	17%	23%
180	8.78	2	6%	9%	29%	26%	16%	7%	7%
204	4.38	3	1%	3%	3%	4%	49%	30%	10%
205	10.76	3	2%	3%	9%	18%	40%	21%	5%



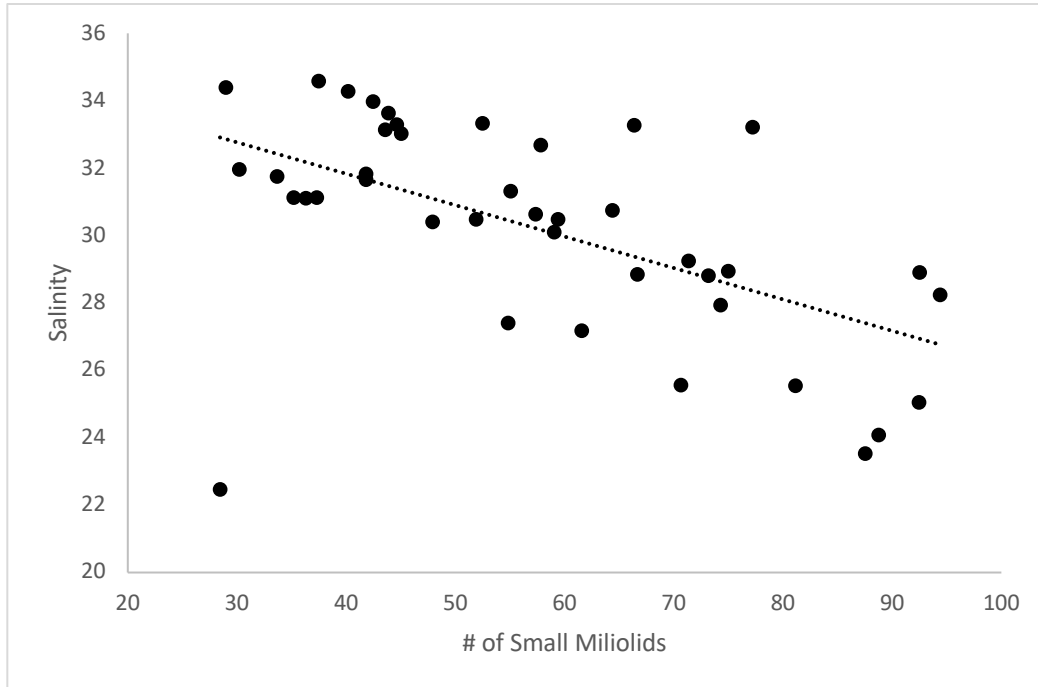
**Figure 3.** Raw abundance of *Archaia angulatus* plotted against the percent of medium/coarse grain-size sediments at each site (n=41). Sediment with a  $\Phi$  of -1–2 are considered medium/coarse.  $R^2 = 0.42$ ;  $p < 0.0001$



**Figure 4.** Images of *Archaia angulatus*, the third most abundant foraminifer in the Springs Coast. The green coloration of the specimen on the left is due to preserved color of the chlorophyll symbionts within the test, indicating that the specimen was alive when collected. Scale bar = 500  $\mu\text{m}$ .



**Figure 5.** Electron micrographs of the species from Florida's Springs Coast with a total relative abundance of  $\geq 2\%$  in descending order, excluding *Archaias angluatus*. **1** *Quinqueloculina seminula*, lateral view; **2** *Haynesina germanica*, lateral view; **3** *Triloculina bermudezi*, lateral view, 3b view opposite of 3a; **4** *Quinqueloculina laevigata*, lateral view, 4b view opposite of 4a; **5** *Quinqueloculina poeyana*, lateral view, 5b view opposite 5a; **6** *Quinqueloculina bosciana*, lateral view; **7** *Elphidium discoidale*, lateral view; **8** *Ammonia tepida*, spiral view, 8b umbilical view; **9** *Flintinoides labiosa*, lateral view, 9b view opposite 9a with aperture visible; **10** *Quinqueloculina impressa*, lateral view, 10b view opposite 10a; **11** *Ammonia parkinsoniana*, spiral view, 11b umbilical view; **12** *Haynesina depressula*, lateral view. Scale bars = 100  $\mu\text{m}$ .



**Figure 6.** Raw abundance of small miliolids plotted against salinity for all sites (n=41). Note that each axis starts at 20, and ~200 specimens were counted in each sample.  $R^2 = 0.32$ ;  $p = 0.0001$

### *Species richness and diversity*

A minimum of 200 individuals were picked for all samples (n=41). In two cases (sites 40 and 205), only 199 individuals were identified because some specimens were too degraded to identify to species.

Species richness (S) varied from 30–58 species per site (Table 2). Site 54 had the lowest species richness. Site 205 had the highest at 58, followed by Site 204 with 57; these two sites are the northernmost sites and furthest offshore. The average species richness across all sites was 41 [standard deviation (sd) = 7.5].

The density of foraminiferal tests per gram of sediment across all sites varied over more than an order of magnitude, from 110–1455 specimens/g (Table 2). Sites 174 and 88 had the highest density of tests (1455 and 1315specimens/g respectively). Site 85 had the lowest density

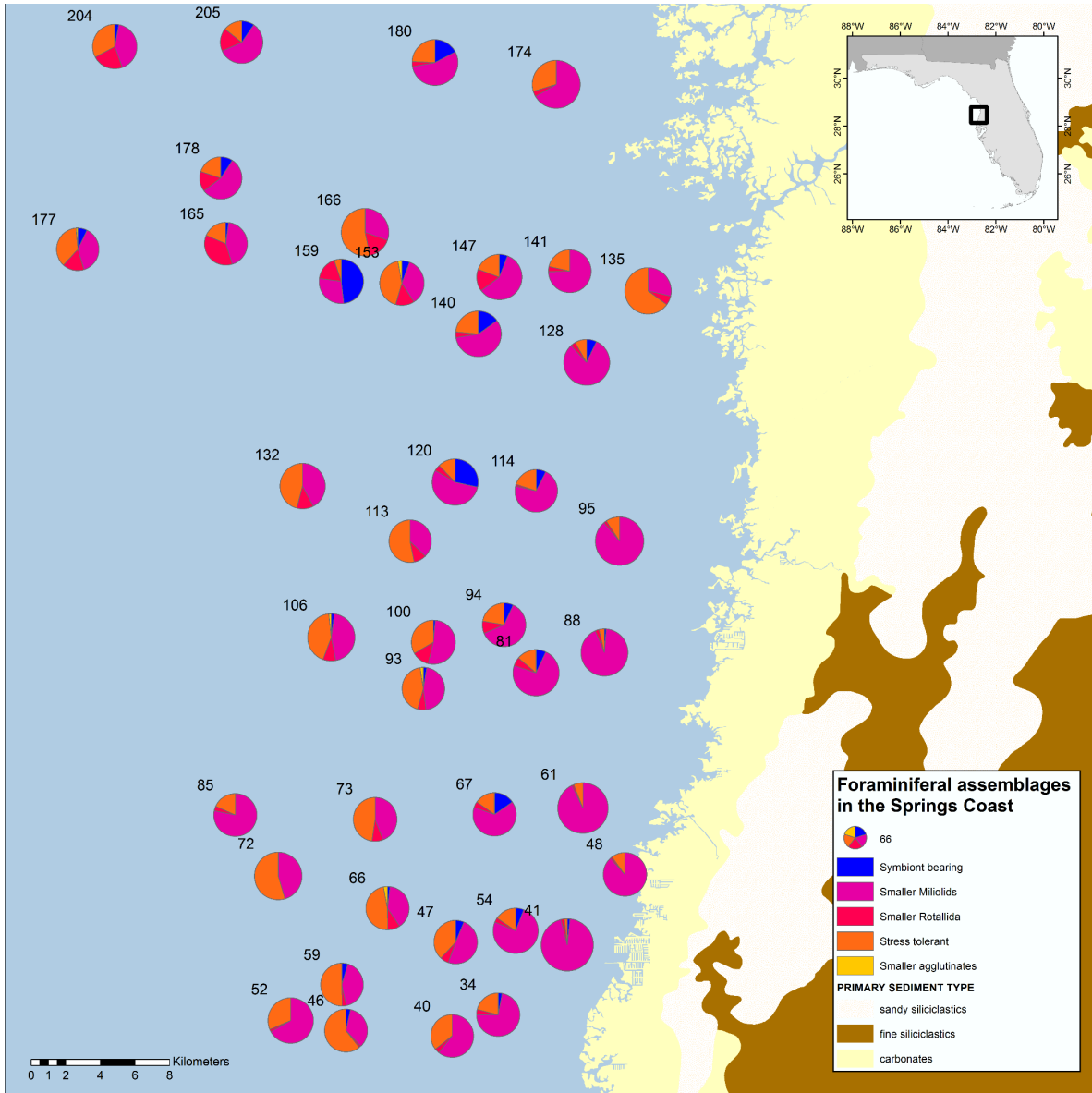
(110 specimens/g) and Site 52 had the second lowest with 125 specimens/g; sediment at both sites was primarily fine quartz sand.

At Site 205, the northernmost offshore station, the highest Shannon's diversity index ( $H = 3.78$ ) and the highest Fisher's alpha ( $a = 27.5$ ) were recorded. Site 159 had the lowest  $H$  value (2.52) and site 48 had the lowest  $a$  value (8.3). Across all sites, the average  $H = 3.15$ , and  $a = 15.5$ . Evenness values varied from 0.29–0.76. The site with the highest  $H$  also had the highest evenness (Site 205) and the site with the lowest  $H$  had the lowest evenness (Site 159). The dominance of *Ar. angulatus*, which made up 47% of the specimen counted at Site 159, resulted in the low evenness value. Site 72 had the second lowest evenness value (0.42) as *Am. tepida* made up 30% of the specimens at this station. Overall, normal marine salinity sites had higher diversities than brackish sites (Fig. 8).

#### *Foraminiferal shell type*

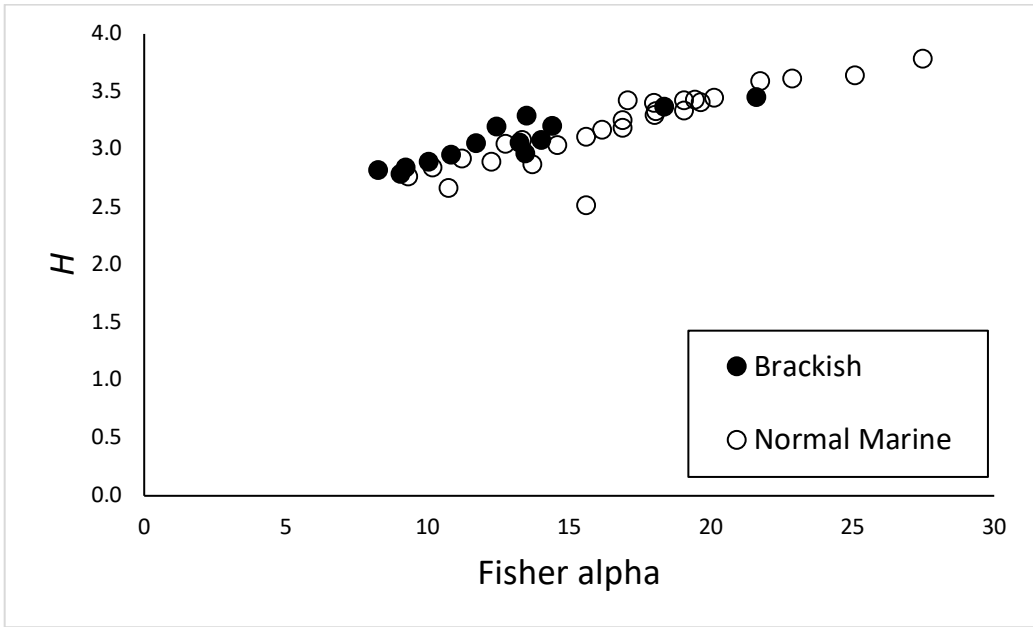
The total foraminiferal specimens counted at all sites combined was 9004. Of that total count, porcelaneous specimens made up 74% and hyaline specimens made up 26%; with agglutinated specimens making up <1%. Both porcelaneous and hyaline taxa were present at all sites. Agglutinated taxa were present at 21 of the 41 sites. Site 66 had the most agglutinated specimens (10), which made up 5% of the sample, followed by Site 106, which had 9 agglutinated specimens making up 4% of the sample. Site 41 had the greatest number of porcelaneous foraminifers (273), which made up 96% of the sample. All of the nearshore sites except Site 135 were dominated by porcelaneous taxa. Sites 135 and 166 had the most hyaline specimens present, at 71% and 68% respectively.



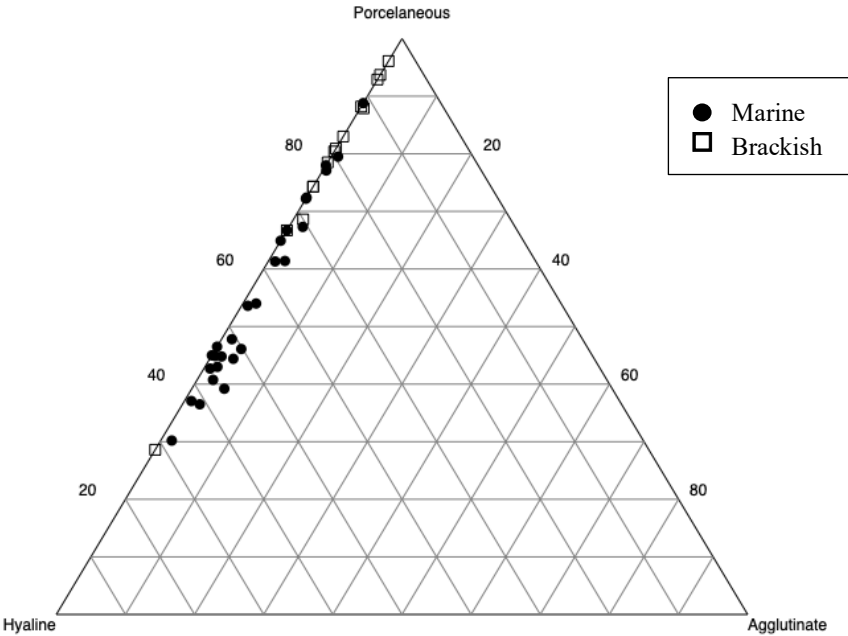


**Figure 7.** Functional group distribution for all sites (n=41) and the primary terrestrial sediment types along the Springs Coast of Florida.

A clear delineation can be seen between normal marine salinity sites and brackish sites (Fig. 9). Brackish sites were dominated by porcelaneous taxa while normal marine sites had a more even distributions of porcelaneous and hyaline taxa. Site 135 is an outlier, as it was dominated by hyaline species *Haynesina germanica* (19% relative abundance), *Elphidium* spp. and *Criboelphidium* spp.



**Figure 8.** Shannon diversity index (H) and Fisher's alpha (*a*) plotted for all sites (n=41,  $p < 0.0001$ )



**Figure 9.** Ternary plot of foraminiferal shell type for all sites (n=41).

**Table 2.** Number of individuals, number of taxa, density per 1 g of sediment, and diversity indices for total foraminiferal assemblages at all sites (n=41) along Florida's Springs Coast.

Site	Individuals	Density per 1 g	S	Shannon's	Fisher alpha	Inverse Simpson's	Evenness
34*	206	1005	46	3.36	18.4	1.05	0.63
40	199	311	52	3.61	22.9	1.04	0.71
46	205	625	38	2.87	13.7	1.10	0.46
52	222	125	30	2.76	9.4	1.10	0.53
59	200	499	35	2.89	12.3	1.10	0.51
88*	238	1315	34	2.95	10.9	1.08	0.56
94*	207	441	51	3.45	21.6	1.05	0.62
100	211	329	44	3.18	16.9	1.07	0.55
106	243	659	51	3.41	19.7	1.05	0.59
135*	231	967	32	2.89	10.1	1.09	0.56
141*	202	1247	37	3.06	13.3	1.07	0.57
147	222	1014	49	3.43	19.5	1.05	0.63
159	214	312	42	2.52	15.6	1.31	0.29
165	205	234	47	3.33	19.1	1.06	0.60
177	201	459	45	3.40	18.0	1.05	0.67
61*	267	1103	31	2.79	9.1	1.09	0.52
67	205	404	47	3.42	19.1	1.04	0.65
73	207	362	44	3.42	17.1	1.04	0.70
85	200	110	33	2.92	11.3	1.10	0.56
114*	201	340	39	3.20	14.4	1.06	0.63
120*	230	562	39	2.96	13.5	1.11	0.50
128*	228	1295	39	3.29	13.5	1.05	0.69
132	221	966	50	3.45	20.1	1.05	0.63
81*	230	565	37	3.20	12.5	1.06	0.66
93	201	364	36	3.04	12.8	1.09	0.58
95	249	1102	33	2.84	10.2	1.10	0.52
113	200	366	41	3.11	15.6	1.09	0.54
140	225	507	45	3.25	16.9	1.06	0.57
153	216	451	38	3.08	13.4	1.08	0.57
166	245	1061	45	3.17	16.2	1.08	0.53
178	205	313	51	3.59	21.8	1.04	0.71
41*	284	1235	32	2.84	9.3	1.09	0.54
47	213	550	46	3.29	18.0	1.06	0.59
48*	207	444	27	2.82	8.3	1.09	0.62
54*	220	451	35	3.05	11.7	1.07	0.60
66	212	555	46	3.33	18.1	1.06	0.61
72	242	222	34	2.67	10.8	1.15	0.42
174*	246	1456	41	3.08	14.1	1.07	0.53
180	227	604	41	3.03	14.6	1.08	0.51
204	218	276	57	3.64	25.1	1.04	0.67
205	199	143	58	3.78	27.5	1.03	0.76

*Note:* Asterisks represent sites with brackish salinity.

## Test Surface Degradation of *Archaias angulatus*

*Archaias angulatus* tests are white with a smooth appearance. The surface of the test is covered with shallow pseudopores. Internally, the tests are divided into rectangular chamberlets and, as the lateral chamber wall is removed, the chamberlets become visible (Cotter & Hallock, 1988). This is a common feature seen with both test dissolution and breakage (Fig. 10).

A total of 200 *Archaias* tests were analyzed for test dissolution and breakage (Fig. 11). Four sites (159, 120, 140, and 180) had relatively abundant *Archaias* (>30 individuals), for which 30 specimens per site were analyzed. For each of the remaining eight sites, 10 individuals were analyzed. Across all sites (Fig. 12), 70 individuals (35%) exhibited minimal dissolution (Stage 1), 50 (25%) were in Stage 2, 16 (8%) in Stage 3, 14 (7%) in Stage 4, and 50 (25%) in Stage 5. The highest percentage of tests in Stage 1 dissolution (70%) was found at Site 81, while sites 153 and 177 had the lowest (10%). Sites 177 and 67 had the highest percentages of tests with Stage 5 dissolution (both 50%). Across all sites, tests in dissolution stages 3 and 4 accounted for 7% each of the total.

Test breakage of *Archaias* was determined by the extent of the outer test edge that was broken (Cotter & Hallock, 1988). Across all sites (Fig.13), 64 tests (32%) were near pristine (Stage 1), and 60 tests (30%) were in Stage 2. The fewest broken tests were found at Site 81, with 60% Stage 1 tests. Stage 5 breakage was found in 15% of the specimens assessed. Similar to the dissolution stages analyzed, tests at breakage stages 3 and 4 were the least common, making up 12% and 11%, respectively.

No relationship was found between *Archaias* test dissolution or breakage and grain sizes. A negative relationship between *Archaias* tests at Stage 5 of dissolution and pH was noted (Appendix C). Sites with a lower pH had higher percentages of Stage 5 dissolved tests.

## Multivariate Analyses

### *Species level analyses*

The 13 foraminiferal species each with total abundances  $\geq 2\%$  for all sites were separated into three natural groups and three individual species using a SIMPROF cluster analysis (Fig. 14). In the dissimilarity profile analysis, a pi value of 5.93 was calculated. The pi value was analyzed for significance using a p-value of 0.001, implying that there is multivariate structure within this data set. *Ammonia tepida* and *Am. Parkinsoniana* formed one group, as they are similar stress-tolerant taxa. *Archaias angulatus*, *H. depressula*, a stress-tolerant species, and *Q. impressa* each exhibited distributions distinct from other species. *Triloculina bermudezi* and *Flintinoides labiosa* formed a group. Both species are small miliolids and *F. labiosa* was previously named *Triloculina labiosa* (d'Orbigny, 1839). The remaining species grouped together, with the other *Quinqueloculina* spp. Clustering strongly at  $<25\%$  dissimilarities in their distributions. The stress-tolerant species, *H. germanica* and *E. discoidale*, more loosely clustered with the *Quinqueloculina* spp.

Based on the cluster analysis (Fig. 14), a nMDS was performed (Fig. 15). The stress value of this nMDS was 0.078, indicating a good 2-dimensional representation of the data. *Archaias angulatus*, which was the only large, symbiont-bearing species that occurred in sufficient abundance to include in the analyses, plotted well away from the other taxa. The two *Ammonia* species formed their own cluster. Interestingly, *Elphidium discoidale* grouped with the smaller miliolids.



**Figure 10.** *Archaias angulatus* tests from Site 159 illustrating the five stages of test dissolution and breakage described by Cottey & Hallock (1988). Images taken with Dino-Lite Digital Microscope. Scale bar = 500  $\mu\text{m}$ .

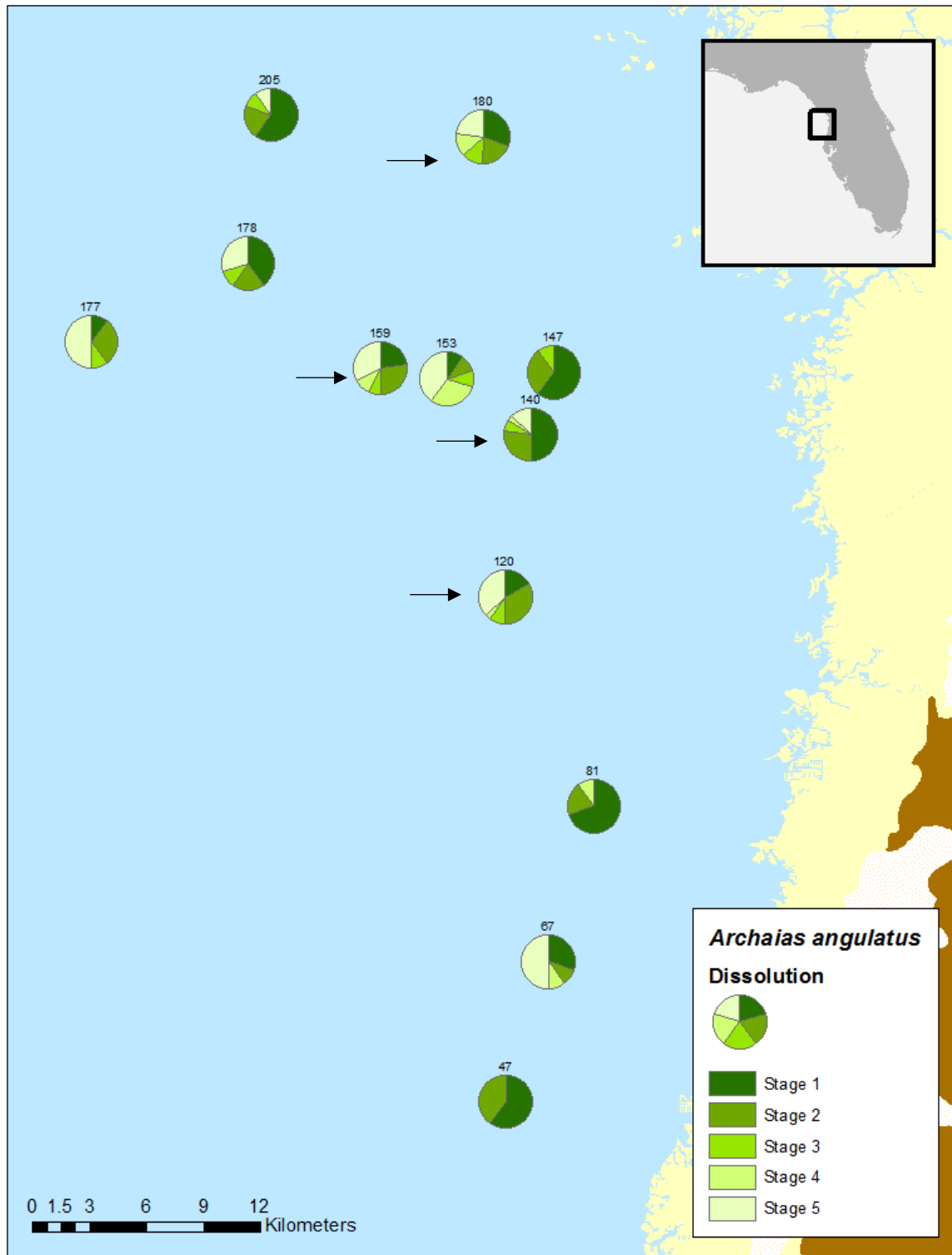


**Figure 11.** Results of taphonomic analysis of *Archaia angulatus* test from 12 sites. The colored legend depicts the five stages of dissolution and breakage. Stage criteria are illustrated in Figure 13.

The db-RDA plot (Fig. 16) has a p-value of 0.001, indicating a significant effect of the environmental parameters on the abundance and composition of the foraminiferal assemblages. An  $R^2$  value of 0.32 indicated that 32% of the variability is explained by these environmental parameters. *Ammonia tepida* and *Am. Parkinsoniana* show a positive relationship with temperature. *Archaia angulatus* negatively correlates with temperature and seagrass coverage.

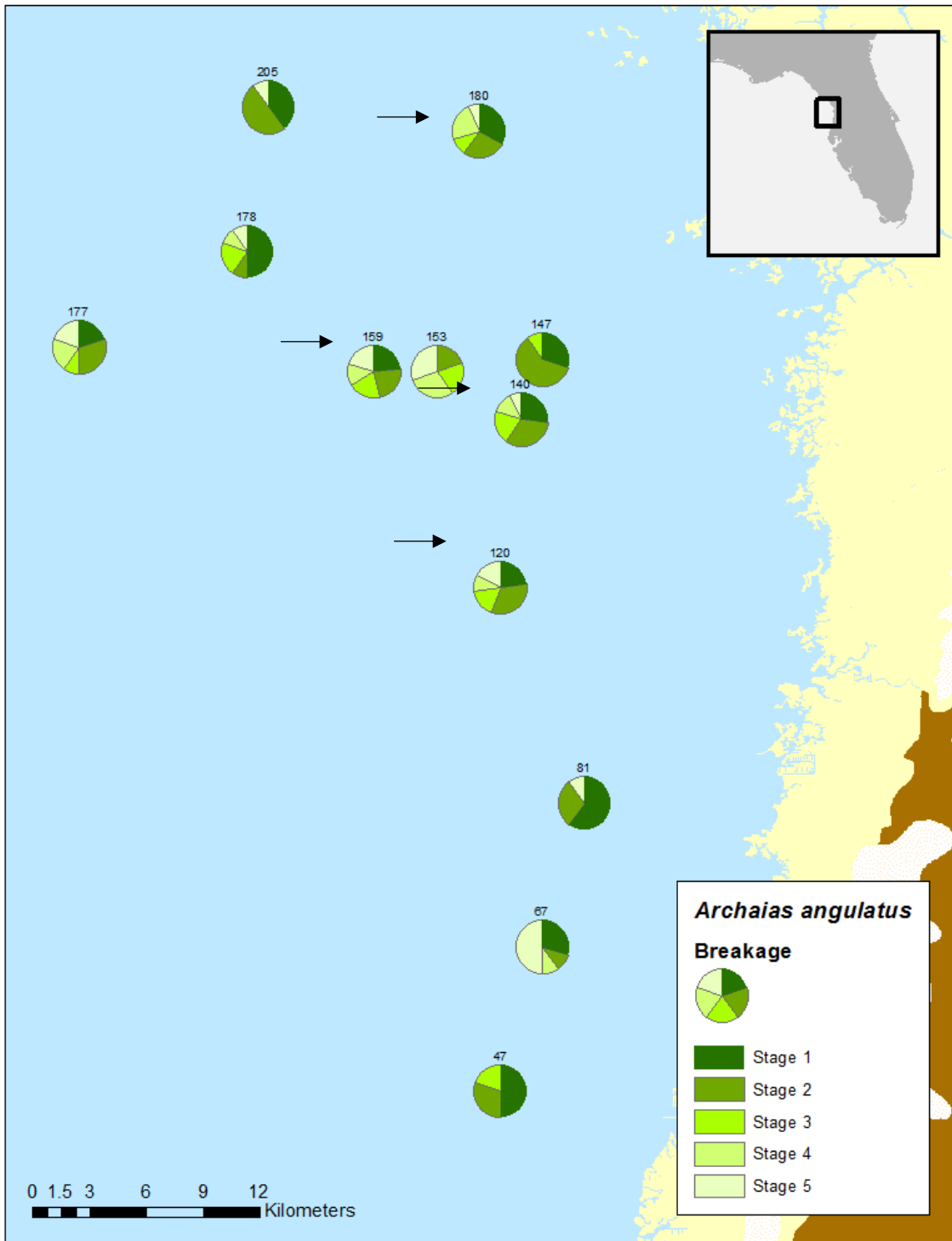
### *Genus-level analyses*

As previously stated, all foraminiferal multivariate analyses were also performed at genus level. A SIMPROF analysis of the relative abundance data indicated three natural groups, with most of the genera plotting independently of others (Fig. 17). A pi value of 4.92 was calculated, indicating significant multivariate structure ( $p= 0.001$ ). *Quinqueloculina* taxa were most



**Figure 12.** Distribution map of *Archaia angulatus* tests in dissolution stages 1–5 described by Cottey & Hallock (1988). The site numbers are above each pie chart. Arrows denote the four sites from which 30 tests were analyzed.





**Figure 13.** Distribution map of *Archaia angulatus* tests in breakage stages 1–5 described by Cottey & Hallock (1988). The site numbers are above each pie chart. Arrows denote the four sites from which 30 tests were analyzed.

Dissimilar to other taxa, as the most abundant genus within the Springs Coast, making up 39% of the total identified. Five other genera, including *Cibicides*, *Pseudotriloculina*, *Ammonia*, *Archaias*, and *Criboelphidium*, also did not group with other genera. Similar to the species level SIMPROF (Fig. 14), *Haynesina* and *Elphidium* clustered closely, with *Triloculina* associated with <25% dissimilarity.

A nMDS analysis was performed based on the genus level SIMPROF (Appendix B). With a stress level of 0.153, plot is considered a useful 2-dimensional representation of the data. However, the only distinct grouping from this analysis was *Elphidium* and *Haynesina*.

The output of the distance-based redundancy analysis (db-RDA) provided an F-statistic of 4.69 with a p-value of 0.001 (Fig. 18), therefore there is a significant effect of environmental characteristics on the abundance and composition of foraminiferal genera present. An  $R^2$  value of 0.40 indicates that 40% of the variability is explained by the environmental data. Canonical axes I and II account for about 35% of the total variation. The sites with *Archaias*, *Cibicides*, *Bolivina*, *Rosalina*, and *Haynesina* taxa showed an inverse relationship with temperature and seagrass coverage. *Ammonia* and *Elphidium* taxa were associated with sites having higher seagrass coverage. The pH levels appeared to influence distributions of *Flinitinoides*, *Quinqueloculina*, and *Triloculina* taxa. *Flinitinoides* and *Triloculina* have an inverse relationship with salinity and a positive relationship with dissolved oxygen. Variation among the sites is primarily driven by salinity, temperature, and pH. A notable inverse relationship is seen between salinity and pH.

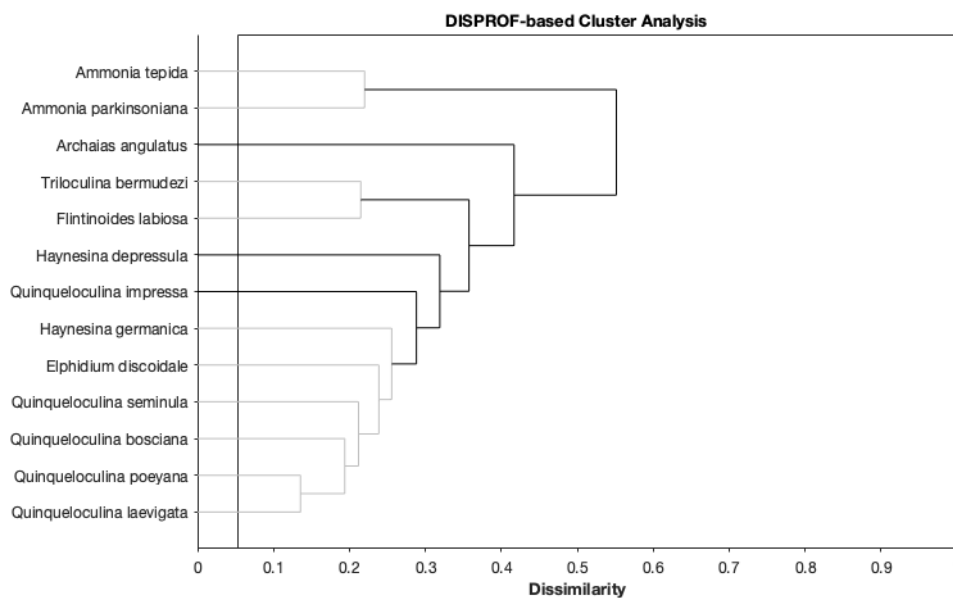
The db-RDA of genus-level abundance data and sediment grain-size distribution produced an F-statistic of 4.03, with a p-value of 0.001, revealing a significant effect of sediment texture on the abundance and composition of foraminiferal assemblages (Fig. 19). An  $R^2$  value of

0.46 indicated that nearly half of the variability is explained by the grain-size distribution.

*Ammonia* spp. Are characterized by sites with a high percentage of very fine sands ( $0.063 \text{ mm} < X \leq 0.125 \text{ mm}$ ). Sites dominated by *Archaias* are characterized by medium to coarse sand-sized grains  $> 0.25 \text{ mm}$ .

### *Analyses of sites*

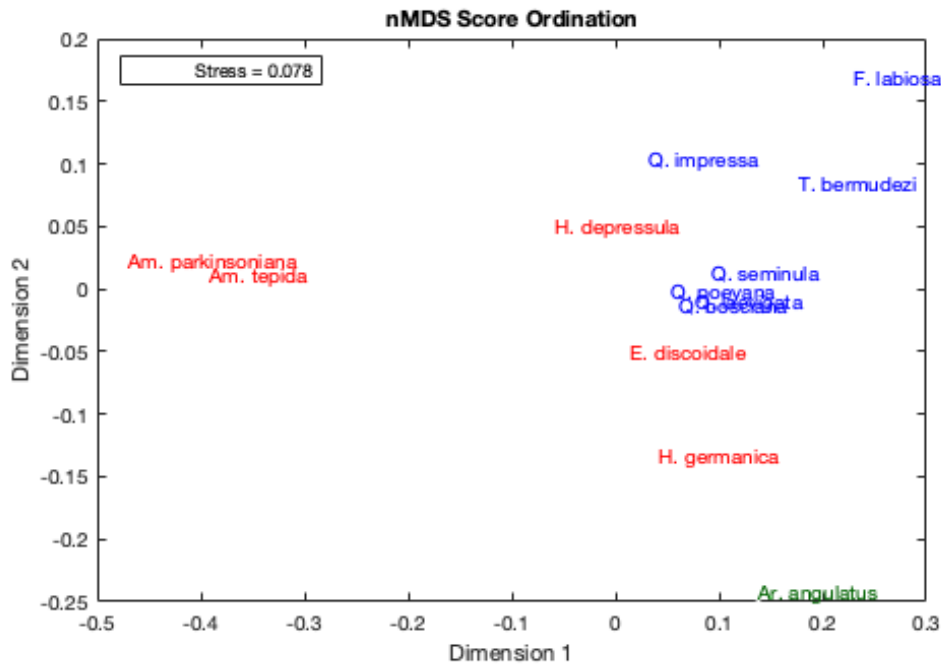
To determine which sites exhibited the most similar foraminiferal assemblages, a SIMPROF cluster analysis was performed using the species-level relative abundance data (Fig. 20). In this analysis, 12 natural groups were identified. The pi value was 21.7, giving a p-value of 0.001. For this cluster analysis, a dissimilarity cutoff was set at 0.475 illustrated by the red dashed line, indicating five major groups (A, B, C, D, and E). The results for all 41 sites are graphically represented in an nMDS plot (Fig. 21) with a stress value of 0.19. The groups are represented by different colored text. All but one of the brackish sites (Site 135) clustered into group D.



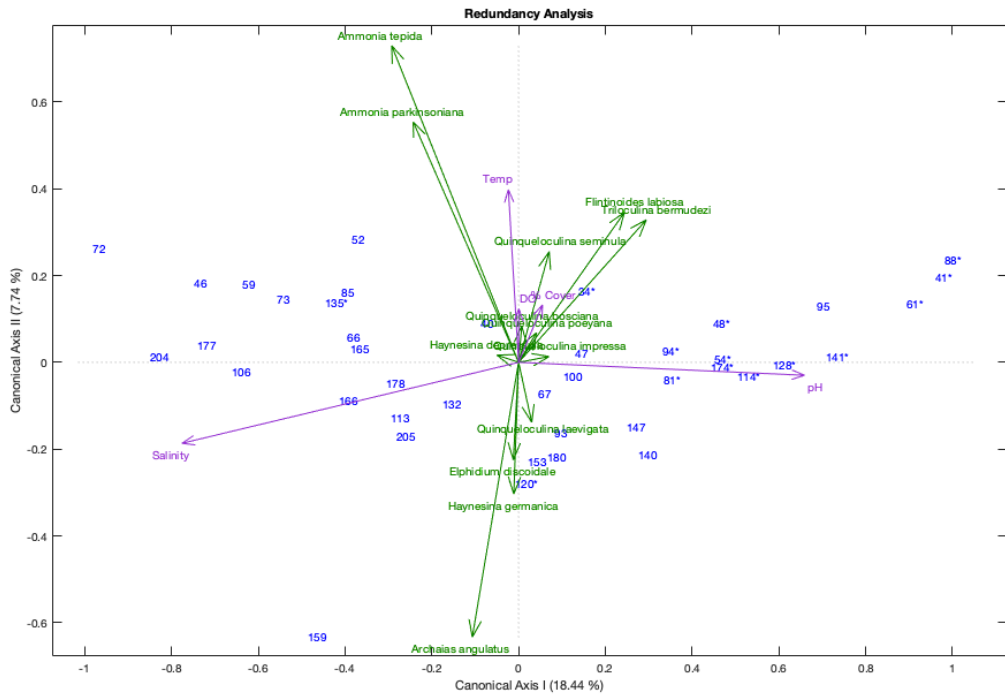
**Figure 14.** Cluster analysis (R mode) of the species making up  $\geq 2\%$  of total specimens identified.

Group A consisted of one sample, Site 159, which had the highest relative abundance of *Ar. angulatus* (47%). Group B also consisted of one sample, Site 205, which had the highest diversity. Group C consisted of five samples predominately from the southwestern region of the Springs Coast. This group was characterized by having a relatively even distribution of small miliolids and stress-tolerant taxa. Group D consisted of 19 sites, including all but one of the brackish sites (Site 135). This group was characterized by low salinity and a high relative abundance of small miliolids (73%). Group E consisted of 15 sites with normal marine salinity. This group had relatively even distributions of small miliolids and stress-tolerant taxa, and the greatest abundance of agglutinated taxa.

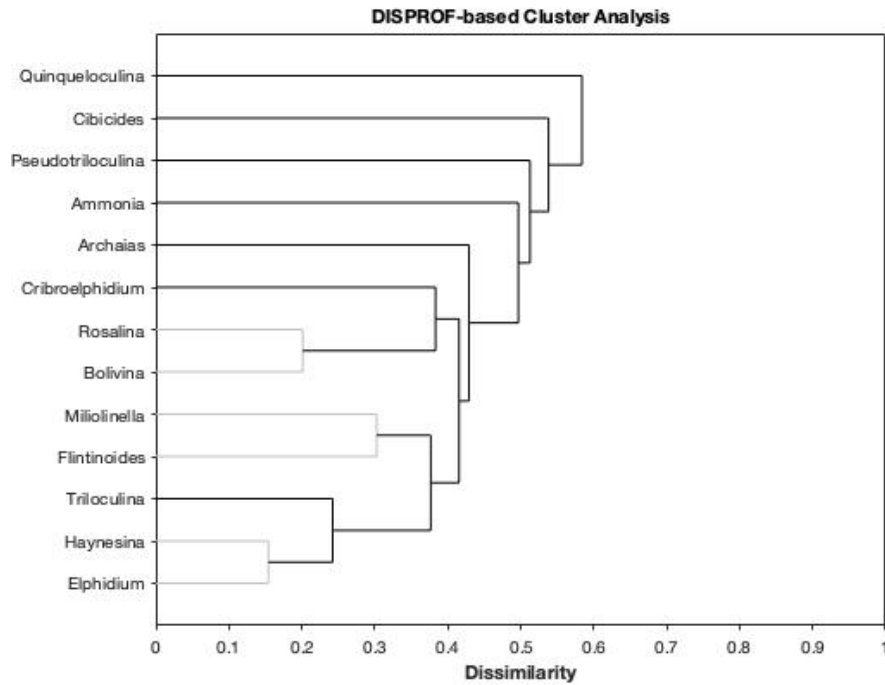
The db-RDA in Figure 20 has a p-value of 0.001, indicating a significant effect of the environmental parameters on the foraminiferal functional group abundance and composition. The environmental data explains 33% of the variability.



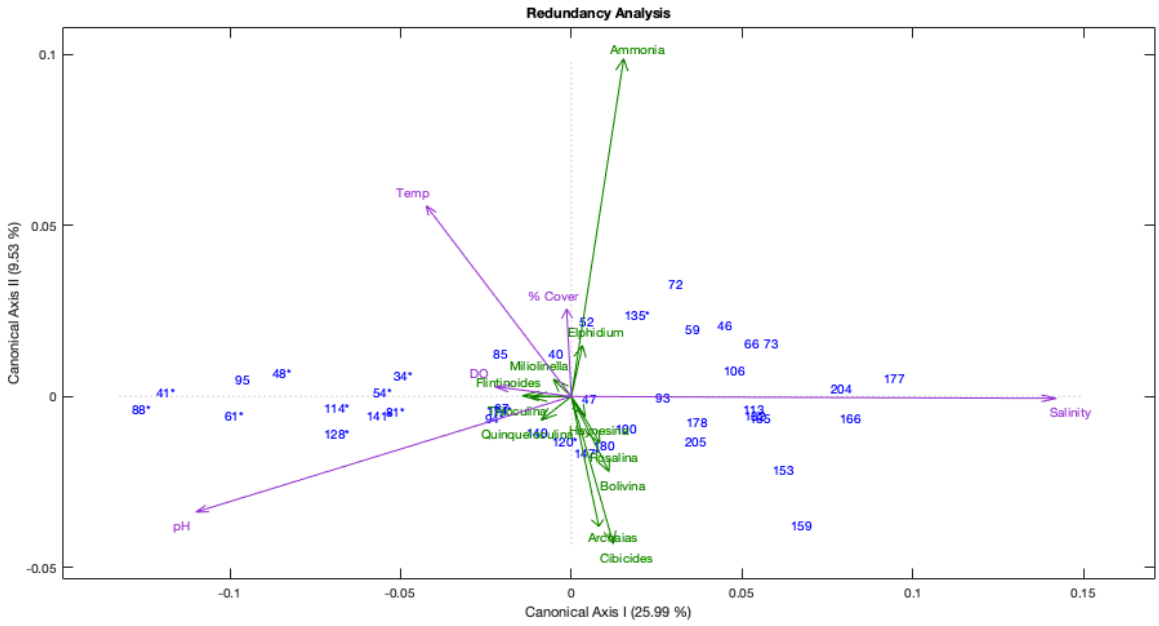
**Figure 15.** nMDS plot (R mode) of species making up  $\geq 2\%$  of all specimens identified. The colors represent the functional group of each species: green = Symbiont bearing; red = Stress tolerant; blue = Smaller miliolids.



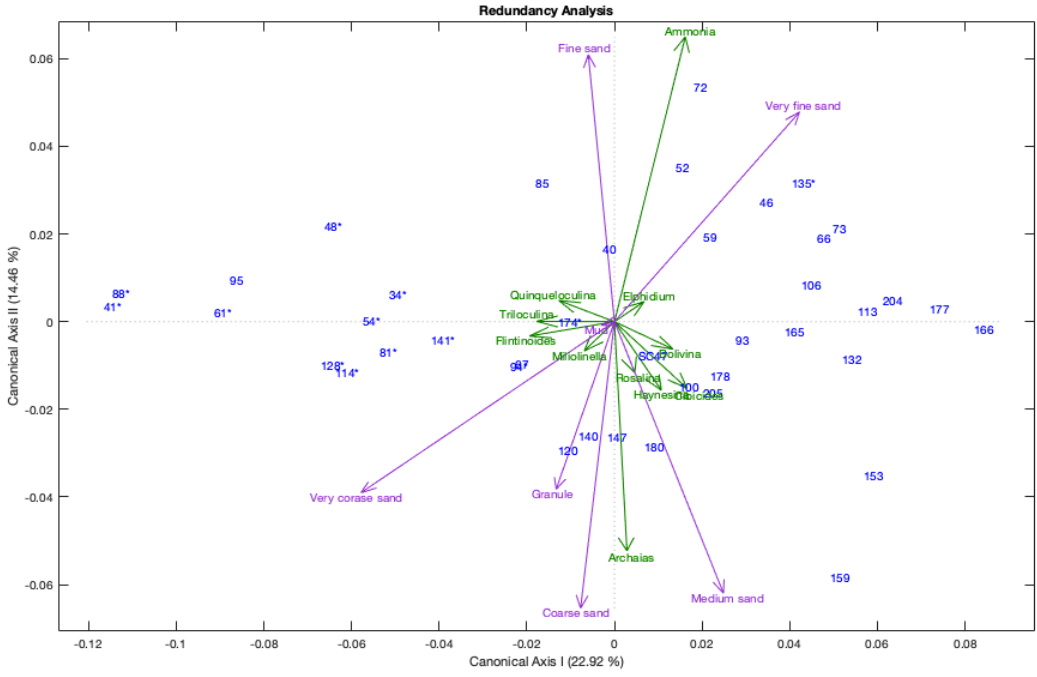
**Figure 16.** db-RDA of the species making up  $\geq 2\%$  total relative abundance and environmental parameters (temperature, pH, salinity, dissolved oxygen, and percent seagrass coverage).



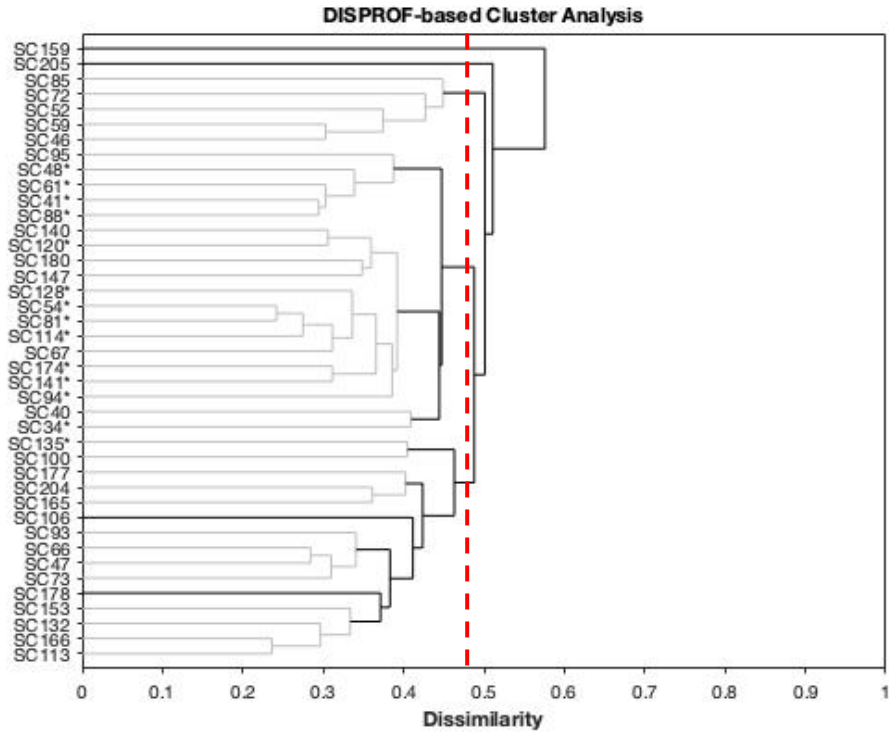
**Figure 17.** Cluster analysis (R mode) of the genera making up  $\geq 2\%$  of total relative abundance.



**Figure 18.** db-RDA analysis of all Springs Coast sites using the abundance data of genera with a total abundance  $\geq 2\%$ . The environmental parameters used are temperature, pH, salinity, dissolved oxygen, and percent seagrass cover.



**Figure 19.** The db-RDA analysis of all Springs Coast sites comparing the abundance of genera with a total abundance  $\geq 2\%$  with grain-size data.

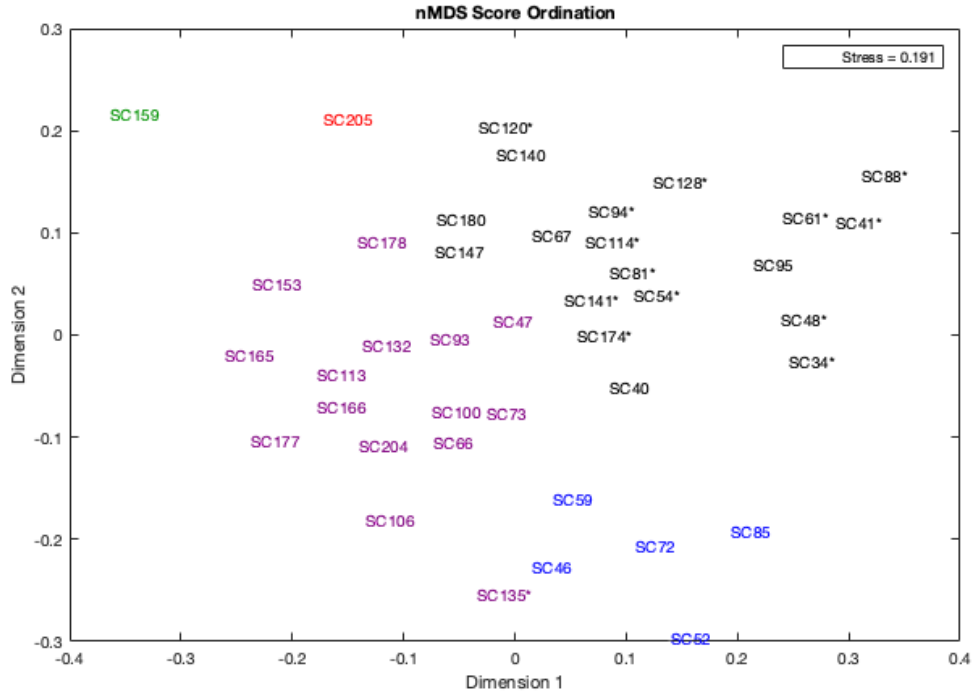


**Figure 20.** SIMPROF Cluster analysis (Q mode) of all sites. An asterisk next to the site name represents a brackish site. Those without asterisks have normal marine salinity. The red dashed line represents the dissimilarity cutoff.

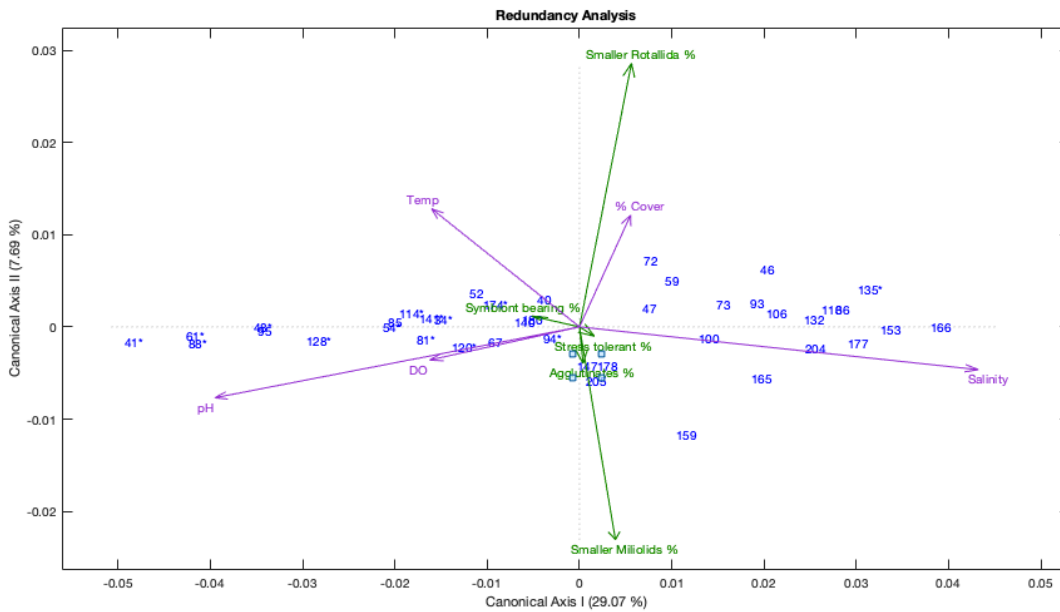
**Table 3.** Statistics (median and range) for each group of sites (defined in Fig. 21): abundance (specimens per g), measures of diversity (Species richness, Fisher index, Shannon Index, and Evenness), grain-size data, and seagrass coverage data.

Group	n	Specimens per g	Species richness	Fisher Index	Shannon Index	Evenness	Median $\Phi$	% Mud	% Seagrass cover
		Median (min.–max.)	Median (min.–max.)	Median (min.–max.)	Median (min.–max.)	Median (min.–max.)	Median (min.–max.)	Median (min.–max.)	Median (min.–max.)
A	1	312	42	15.6	2.52	0.29	1	9.2	25
B	1	143	58	27.5	3.78	0.76	3	5.4	5
C	5	222 (110-625)	34 (30-38)	11.3 (9.4-13.7)	2.87 (2.67-2.92)	0.51 (0.42-0.56)	3 (3-3)	4.4 (3.0-24.0)	10 (5-100)
D	19	604 (311-1456)	39 (27-52)	13.5 (8.3-22.9)	3.08 (2.79-3.61)	0.60 (0.50-0.71)	3 (2-5)	7.6 (3.1-50.1)	75 (5-100)
E	15	451 (234-1061)	45 (32-57)	18.0 (10.1-25.1)	3.33 (2.89-3.64)	0.59 (0.53-0.71)	3 (2-4)	11.2 (5.8-23.8)	100 (15-100)

*Note:* For median  $\Phi$  calculations 5 was substituted for > 4 to calculate overall median.



**Figure 21.** An nMDS plot of sites (Q-mode) created using all relative abundance data. The colors represent groups created by a SIMPROF cluster analysis (Fig. 20). The groups are represented by different colored text. Group A is illustrated by green text, Group B is in red text, Group C is in blue text, Group D is in black text, and Group E is in purple text. All sites with an asterisk are brackish (salinity <30) and sites without an asterisk are normal marine (salinity 30–36).



**Figure 22.** The db-RDA of the Springs Coast foraminiferal functional group data and environmental data (temperature, salinity, pH, dissolved oxygen, percent seagrass coverage).



## DISCUSSION

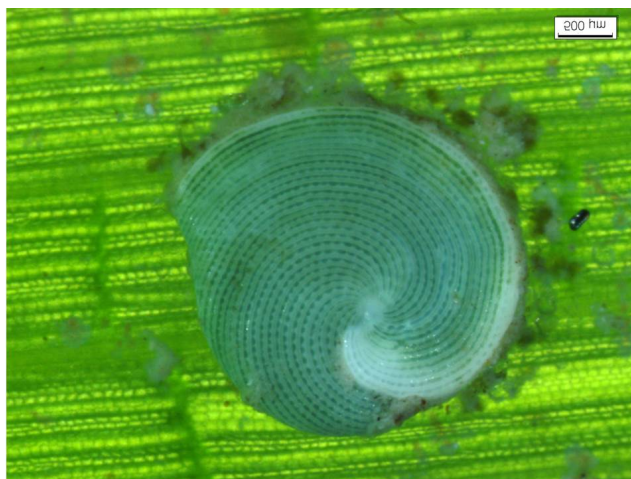
The Seagrass Integrated Mapping and Monitoring Program (SIMM) of Florida Fish and Wildlife Conservation Commission's Research Institute was developed to protect and manage seagrasses in Florida. The Big Bend and Springs Coast region monitored by SIMM makes up 25% of the seagrass acreage in Florida state waters (Yarbro & Carlson, 2016). Seagrass beds are an extremely valuable natural resource and marine habitat. Seagrasses provide numerous important ecological services, such as nutrient cycling, carbon sequestration, stabilizing sediments, and maintaining coastal diversity (Orth et al., 2006; Yarbro & Carlson, 2016). In recent years seagrass coverage has been in decline. Yarbro & Carlson stated that light limitation was the primary cause of seagrass decline in many locations in Florida during the 20<sup>th</sup> century.

During a seagrass mapping and monitoring survey (Jones et al., 2016), Dr. Paul Carlson observed an abundance of live *Archaias angulatus* on seagrass blades, which prompted collection of the sediment samples used in this study. The Springs Coast has a stable trend in seagrass coverage, making up 379,100 acres (153,416 hectares) as of 2007 (Yarbro & Carlson, 2016). Seagrass coverage is an important variable in consideration of shell-producing organisms as it may buffer changes in ocean chemistry and ecological impacts of ocean acidification (Garrard et al., 2014). In a study by Garrard et al. (2014) seagrass density increased in response to a lower pH, as did the number of shell-forming organisms. This finding provides evidence to suggest that highly productive, nearshore habitats, similar to that of the Springs Coast, may provide refuge to its associated calcifying organisms from ocean acidification.

## Benthic Foraminiferal Distribution

The original motivation for this study, focused on the distributions of benthic foraminiferal tests in sediments of the Spring Coast area of the inner West Florida Shelf, was observations by seagrass researchers of live, large *Archaias angulatus* attached to seagrass blades (Fig. 23). This species hosts chlorophyte endosymbionts and is a dominant foraminiferal taxon in carbonate-rich environments in subtropical and tropical waters of the western Atlantic and Caribbean. The thesis research by Beckwith (2016, published in part in Beckwith et al., 2019) explored some of the physical and chemical characteristics of the coastal waters and the freshwaters that are discharged into the coastal waters, including seasonal temperatures and salinities, as well as  $\text{Ca}^{2+}$  concentrations ( $[\text{Ca}^{2+}]$ ) and alkalinities. Beckwith hypothesized that the elevated  $[\text{Ca}^{2+}]$  and alkalinities in the freshwaters might allow this species, which produces a porcelaneous, hi-Mg-calcite test (Toler & Hallock, 2001), to thrive in cooler, lower salinity environments than what was previously reported for this species (e.g., Hallock et al., 1986; Martin et al., 1986; Murray, 2006 and references therein). Beckwith (2016) further hypothesized that waters with elevated  $[\text{Ca}^{2+}]$  and alkalinities might provide refuges for calcareous organisms during times of ocean acidification. My study was motivated by the Beckwith findings, and while *Ar. angulatus* distributions were important, my work focused on the total assemblage of foraminiferal taxa in this area, to determine if other taxa might also reflect the unusual water chemistry.

Indeed, the distributions of the tests of benthic foraminiferal taxa in the Springs Coast samples are surprising in the context of previously published work on coastal foraminiferal assemblages around the Gulf of Mexico, which has been summarized in detail by Murray (2006)



**Figure 23.** *Archaias angulatus* attached to a seagrass blade. Photo provided by Dr. Paul Carlson.

and Poag (2015). In my samples, the nearshore, brackish sites are dominated by smaller miliolids rather than stress-tolerant foraminifers, specifically *Ammonia*, as depicted by Poag (2015).

Previously published data indicate that miliolids tend to prefer normal to elevated salinities (Murray, 2006), while stress-tolerant species like *Ammonia* are eurytopic. The spring-fed freshwater entering the coastal waters are high alkalinity and highly saturated with respect to calcium carbonate (Beckwith et al., 2019), which may account for this atypical distribution.

Miliolids are more vulnerable to lower alkalinity than rotaliids due to differences in their calcification mechanisms (Bentov & Erez, 2006; de Nooijer et al., 2009). The hi-Mg-calcite tests produced by miliolids are more susceptible to dissolution when calcite saturation declines, which it typically does under lower temperature and reduced salinity. However, the high alkalinity and saturation state in the Springs Coast waters reported by Beckwith (2016) may be the dominant abiotic factor controlling miliolid distributions, rather than salinity and temperature. Evidence in support of this interpretation includes the positive correlation of smaller miliolids with increasing pH and dissolved oxygen, and negative correlation with salinity (Fig. 22). While I did not have alkalinity data from my sample sites, only pH and salinity, the significant correlation between

higher pH and abundance of smaller miliolids supports the hypothesis that increased alkalinity is a major factor regarding the foraminiferal distribution in the Springs Coast, including the prominent occurrence of *Ar. angulatus*.

Two additional parameters that apparently influence the distributions of foraminiferal tests in the Springs Coast sediments are seagrass cover and sediment texture, which themselves negatively co-vary. Seagrasses and associated macroalgae and filamentous algae are important habitat for benthic foraminifers. This relationship is demonstrated by the positive relationships of foraminiferal-test abundance and diversity with seagrass cover (Appendix Fig. B3). Seagrass and algal cover also baffle water motion, allowing finer sediments, including small foraminiferal tests, to accumulate. The opposite effect was seen in the abundance of *Ar. angulatus* at Site 159, which was characterized by very coarse sediment (> 2 mm). Most of the *Archaias* specimens found at this site were dead at the time of collection, as indicated by lack of residual green color from their chlorophyte symbionts. This observation was not surprising for two reasons. First, the larger *Archaias* tests will be concentrated where finer sediments have been winnowed out. At the same time, seagrass and associated algae provide optimum habitat for *Archaias* (e.g., Fujita & Hallock, 1999). Thus, the abundance of *Archaias* tests in individual samples increases with sediment sorting that can occur where there is limited seagrass cover.

The majority of the sites clustered into either a nearshore group (D in Fig. 21) or an offshore group (E). Group D included 19 sites with relatively low salinities, including 13 brackish sites. These sites were dominated by small miliolids, with *Quinqueloculina* as the most abundant genus, followed by *Triloculina*. These sites were also characterized by fine sediments and had the highest foraminiferal densities, but not the highest diversities (Table 3).

As a whole, the Group E sites had relatively high diversity indices, relatively similar percentages of smaller miliolids and rotaliids, high percent seagrass coverage, and were mud-rich (Table 3). This group included 15 sites, all of which had normal marine salinities except Site 135, closest to the mouth of the Homosassa River, which had a salinity of 22.5. Unlike the other brackish sites in the Springs Coast, this site was dominated by stress-tolerant species *Haynesina germanica* and *Elphidium discoidale*. Armynot du Châtelet et al. (2004) suggested that *H. germanica* may be a bio-indicator of pollutants. An influx in such contaminants via the Homosassa River could be an explanatory factor for this foraminiferal assemblage. More likely, *H. germanica* is inversely correlated with dissolved oxygen concentrations, and Site 135 had one of the lowest oxygen concentrations of the sites included in this study.

The SIMPROF cluster analyses identified two additional small groups. Group B was represented only at Site 205, which was characterized by high diversity, despite having the lowest density of foraminifers (Table 3). Of the 58 different species found at Site 205, 44 of them had a raw abundance of less than 5, and 17 species occurred only once. Group C consisted of five samples predominately from the southwestern region of the Springs Coast. This group was characterized by having a relatively even distribution of small miliolids and stress-tolerant taxa. The dominant genera were *Quinqueloculina* and *Ammonia*. This group had intermediate species richness, diversity indices, and percent mud composition (Table 3).

Foraminiferal assemblages within the Springs Coast of Florida have not previously been well documented. In a study by Parker (1954), the distribution of foraminifers in the northeastern Gulf of Mexico included one transect extending offshore from Cedar Key (Parker, 1954, fig. 1). Sites along her transect had a salinity of 36, indicating there was not a strong influence from the freshwater input of the springs. Her site closest to shore (depth = 12 m) was dominated by

foraminifers of the family Miliolidae (42%). All of my sample sites were well inshore of the 12 m isobath; the deepest site (177) was 8.05 m and was where the highest salinity was recorded (34.6). Although the most inshore sites in my study were dominated by miliolids, the salinity differences between the sample areas do not allow for a conclusive comparison. The second most abundant family of foraminifers found by Parker (1954) was Peneroplidae (16%). In contrast, I recorded four peneroplid species, none of which exceeded 2% of the assemblage. The family Peneroplidae includes algal symbiont-bearing foraminifers, but does not include *Ar. angulatus*. Foraminifers belonging to these two families had relatively high abundances extending offshore to sites with a depth of approximately 60 m. Parker (1954) also noted an abundance of *Ammonia beccarii* at the inner end of the transect, similar to the findings of Poag (1981) and the dominance of stress-tolerant rotaliids in the more offshore sites sampled for my study. Poag (1981) documented *Ammonia* as the dominant biofacies extending 30 km off shore, and then a transition to miliolids for about 20 km. In the southern half of the Springs Coast area, Poag (1981) illustrates *Archaias* as a dominant biofacies approximately 20 km offshore.

Bandy (1956) also documented foraminifers in the northeastern Gulf of Mexico, including a transect south of the Springs Coast, extending offshore from Tarpon springs (Bandy, 1956, fig. 25). In contrast to the findings of my study, Bandy (1956) documented hyaline species dominating brackish bay areas, with *Ammonia* [previously named *Streblus* (Fischer de Waldheim, 1817)] being most abundant at the mouth of rivers. In the Springs Coast, high abundances of *Ammonia* were found in the more offshore sites while *Haynesina* was the dominant inshore stress-tolerant genus. *Archaias angulatus* was found abundantly off Tarpon Springs in a depth range of 5–32 m and Bandy (1954) noted that where *Archaias* was present, *Ammonia* was found in very low abundances or was absent. I also observed this inverse

relationship; *Ammonia* specimens were absent in the three sites with the highest abundance of *Archaias* (Sites 159, 180, and 120), and Figures 17 and 18 show *Ammonia* and *Archaias* plotting opposite of each other.

### *Species richness and diversity*

Murray (2006, p. 109, fig. 4.16) plotted the Shannon diversity index (H) and Fisher's alpha ( $\alpha$ ) index for the Gulf of Mexico for sites with brackish, normal-marine, and hypersaline salinities. The highest diversities were found in normal-marine environments, with a maximum H value of 3.0 and Fisher's alpha of about 14.0. The maximum H value documented for a brackish site was 1.5. Consistent with Murray's synthesis, the Springs Coast sites with near normal marine salinity had the highest diversity. However, the H values and  $\alpha$  values in the Springs Coast are higher than what was documented by Murray for both the normal marine salinity and brackish sites. The H values of brackish sites in the Spring Coast had a maximum of 3.45 (Site 94) and a minimum of 2.79 (Site 61). Murray stated that "regardless of salinity all marshes and mangals have low diversity" and that "estuaries and lagoons also have low diversity." Salinity is having an effect on foraminiferal diversity in the Spring Coast, as seen in Figure 8, but this marsh/estuarine environment does not have a low diversity of foraminifers.

The unusually high diversity in the Springs Coast, coupled with sites having low species repetition, suggests an influence of foraminiferal propagule dispersion. Alve & Goldstein (2002, 2003) have suggested that passive transport of propagules may be an efficient means of dispersal in many shallow-water species. Some species of shallow subtidal foraminifers can be passively transported to environments with favorable conditions and grow after surviving in a cryptic state

for months (Alves & Goldstein, 2009). The smallest and lightest propagules have the highest potential for passive dispersion.

Alve & Goldstein (2009) documented small rotaliid and agglutinated genera that are dispersed through propagule transportation, three of which were found in low abundances among the Springs Coast sites. These genera include *Textularia*, *Bolivina*, and *Planorbulina*. More abundant genera found in the Springs Coast, such as *Haynesina* and *Ammonia*, have also been documented utilizing propagule dispersion (Alve & Goldstein, 2002, 2003; Weinmann & Goldstein, 2017). Weinmann & Goldstein (2017) experimentally demonstrated that propagules of foraminiferal species with normal-marine salinity requirements are transported by tidal currents deep into marsh habitats where their recruitment is prevented by low-salinity conditions. They proposed that, with rising sea level, the propagules of species from normal salinity environments will be able to recruit as salinities rise within the flooding marsh habitats.

Weinmann & Goldstein (2017) also concluded that propagule dispersal is a major mode of transport in shallow-water environments. Based on their documentation of propagule dispersal, combined with the high diversity of rare taxa found in my samples, I suspect that propagule dispersal is influencing the foraminiferal assemblages within the Springs Coast. This environmental setting, with its range of salinities and relatively strong seasonality in temperature, rainfall and wind direction, may allow the recruitment of propagules from around the Gulf of Mexico, but not provide sufficient persistence of suitable environmental conditions to allow many of the species to establish viable populations. To further assess this hypothesis, the <32 µm-sized fraction of sediments from the Springs Coast should be tested for foraminiferal recruitment using the “propagule methods” proposed by Alve & Goldstein (2009).



## **Test Surface Degradation of *Archaias angulatus***

*Archaias angulatus* is often found in abundance in warm-water carbonate sediments where seagrass is present (Martin, 1986; Martin & Wright, 1988; Buchan & Lewis, 2009). This robust foraminifer is relatively resistant to destruction. In my study *Ar. angulatus* was the third most abundant foraminiferal species and was found in varying stages of dissolution and breakage. However, tests in pristine condition were the most common. Buchan & Lewis (2009) found that sites with high vegetation density had a higher quality of preservation. Across all Springs Coast sites for which *Archaias* taphonomy was analyzed, Site 81 was the only site with 100% seagrass coverage. This site also had the highest percent of pristine *Archaias* tests in both dissolution and breakage taphonomy analyses. Buchan & Lewis (2009) suggested that sites with sparse vegetation cover allow foraminifer tests to be broken and abraded over time. In my study, sites with seagrass coverage ranging from 15–60% had the highest percent of Stage 5 broken tests. It is important to note that all *Archaias* tests used in this analysis were dead at the time of collection and were therefore subject to sorting and differential preservation, and may not accurately represent the living populations on vegetation (Martin & Wright, 1988).

The majority of *Archaias* tests in the Springs Coast were in excellent condition, however the data do exhibit bimodality. Stage 1 and 2 tests (pristine/near pristine) accounted for 62% of the *Archaias* tests for both dissolution and breakage. Stage 5 degradation was also common, accounting for 25% of Stage 5 dissolution and 15% of Stage 5 breakage. Tests in stages 3 and 4 degradation were less common. The high percentage of tests in excellent conditions may be associated with the high carbonate saturation state, while the elevated presence of Stage 5 tests may be a consequence of low sedimentation rates along the West Florida shelf. In this study area, carbonate sediments are predominantly heterozoan carbonates, with low accumulation rates of

centimeters per 1,000 years (Beck, 2010). The abundance of Stage 5 tests may represent specimens that have been in the sediment for years or decades.

The causes of dissolution and breakage of *Ar. angulatus* in the Springs Coast are unclear. Sediment grain size did not have a significant effect on *Archaias* test degradation. To further investigate the cause of test degradation, it would be useful to determine the percent quartz and calcium carbonate of the sediment at each site. A higher percentage of quartz sand is abrasive to the tests, which could induce breakage and abrasion that could mimic dissolution.

The data presented in this research shows that sediment sorting has a significant effect on the abundance of *Ar. angulatus* tests. The environmental energy required to sort the sediment in the Springs Coast region may influence the breakage and dissolution of the tests analyzed, as high-energy environments have been linked to increased abrasion and breakage by previous studies (Cotter & Hallock, 1988; Martin & Wright, 1988).

The influence of the high alkalinity, high carbonate-saturation state ( $\Omega$ ) spring water in the Springs Coast area (Beckwith et al., 2019) is likely limiting dissolution rates of *Ar. angulatus*. Collecting  $\Omega$  data from all sites in this study could provide insight into the dissolution and breakage rates, as well as the abundance of *Archaias* at specific sites. Beckwith et al. (2019) hypothesized that there is a calcification “sweet spot” within the Springs Coast, referring to an ideal calcification environment. Comparing *Archaias* taphonomy within and outside the “sweet spot” could provide information about the influence of  $\Omega$  on test dissolution and breakage, and on calcifying organisms as a whole.

## CONCLUSIONS

1. In 41 sediment samples from seagrass beds in the Florida Springs Coast, 152 species were identified; *Quinqueloculina seminula* and *Haynesina germanica* were the dominant species.
2. Diversities of benthic foraminiferal assemblages in the Springs Coast sediments were higher than previously reported for coastal waters of the Gulf of Mexico.
3. The unusually high number of species, coupled with relatively few individuals representing more than 90% of the specimens identified, suggest that a continuous influx of foraminiferal propagules can produce recruits that do not establish viable populations.
4. The inshore sites, most of which were influenced by brackish salinities, were dominated by small miliolids. These sites also were characterized by fine sediments and had the highest foraminiferal densities, but not the highest diversities.
5. The more offshore sites, characterized by normal-marine salinities, high seagrass coverage, and mud-rich sediments, had relatively high densities and diversities with relatively similar percentages of smaller miliolids and rotaliids.
6. The significant positive correlation between pH and abundance of smaller miliolids supports the hypothesis that increased alkalinity is a major factor regarding the foraminiferal distribution in the Springs Coast, including the prominent occurrence of *Ar. angulatus*.

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## APPENDICES

APPENDIX A: ENVIRONMENTAL DATA FOR EACH SITE

**Table A1:** Environmental data for each site, collected by SIMM.

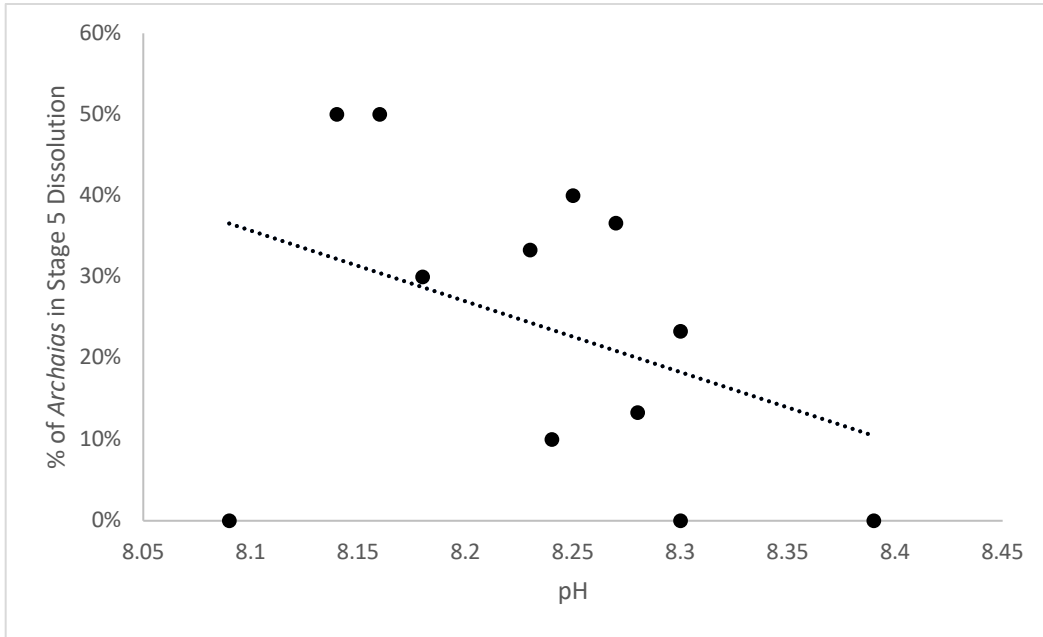
SITE	DATE	LAT	LONG	DEPTH (cm)	SECCHI (cm)	BW-		BW-DO		TYPE	
						Temp (°C)	pH	SAL	% saturation		% COVER
34	9/7/13	28.32507	82.78002	300	999	30.63	8.23	29.26	116.5	75	SAND/MUD
40	9/7/13	28.31541	82.80241	370	999	30.53	8.17	30.49	108.9	80	SAND/MUD
46	9/7/13	28.32438	82.85762	465	999	30.63	8.23	31.75	113.8	100	SAND/MUD
52	9/7/13	28.32244	82.88636	490	999	30.55	8.19	33.28	116.2	10	SAND
59	9/7/13	28.33886	82.85973	450	999	30.65	8.23	31.84	114.7	100	.
88	9/14/13	28.49054	82.72325	230	999	29.36	8.35	25.06	101.9	5	SAND
94	9/14/13	28.50257	82.77539	245	999	30.37	8.39	27.19	121.4	75	SAND
100	9/14/13	28.48981	82.81221	295	999	30.41	8.33	30.48	120.4	100	SAND
106	9/14/13	28.49752	82.86526	350	999	30.28	8.28	33.64	115.1	100	SAND
81	9/14/13	28.48129	82.75882	355	999	29.5	8.3	28.82	102.6	100	SAND
93	9/14/13	28.47405	82.81736	400	999	29.63	8.25	33.04	101	100	SAND
135	9/15/13	28.65549	82.70056	300	999	29.71	8.22	22.47	81	25	MUD/HARD
141	9/15/13	28.66445	82.74128	285	999	29.65	8.27	27.94	87.8	100	MUD
147	9/15/13	28.66175	82.77791	335	999	29.83	8.39	30.11	101.3	5	HARD
159	9/20/13	28.66359	82.86007	365	999	28.45	8.23	34.4	104	25	SAND
165	9/20/13	28.677	82.92	580	999	29	8.16	33.98	106.3	50	SAND
177	9/20/13	28.67442	82.99698	805	999	29.13	8.14	34.58	106.4	50	SAND
140	9/15/13	28.63588	82.78877	360	999	29.59	8.28	30.63	93.7	50	HARD
153	9/20/13	28.65904	82.82857	290	999	28.09	8.25	31.14	95.6	15	SAND
166	9/20/13	28.6822	82.84768	390	999	28.34	8.25	31.97	96.6	80	SAND
178	9/20/13	28.70689	82.92265	485	999	29.13	8.18	33.33	107.3	60	SAND
61	9/8/13	28.41954	82.73444	225	999	30.51	8.32	28.92	116.3	100	.
67	9/8/13	28.41664	82.78037	350	999	30.38	8.16	30.76	108.7	60	SAND/MUD
73	9/8/13	28.41436	82.84248	570	999	30.23	8.18	33.15	101.9	100	MUD
85	9/8/13	28.41637	82.9151	400	999	30.08	8.25	33.23	105.2	5	SAND
114	9/13/13	28.56433	82.75871	300	999	29.37	8.32	25.56	101.7	50	SAND
120	9/13/13	28.56832	82.80086	335	999	29.28	8.27	27.41	102.3	40	SAND
128	9/15/13	28.62288	82.73248	265	999	29.41	8.36	25.54	94.4	5	SAND/HARD
132	9/15/13	28.56648	82.88017	390	999	30.15	8.3	31.67	110.2	100	SAND
95	9/13/13	28.54137	82.71541	305	999	29.1	8.38	24.08	103	100	SAND
113	9/15/13	28.54133	82.82426	430	999	29.91	8.3	31.12	107	100	SAND/MUD
41	9/8/13	28.35702	82.74802	185	999	30.61	8.42	28.25	124.9	100	SAND/MUD
47	9/7/13	28.35824	82.8006	.	.	26.69	8.09	30.42	82.2	90	MUD
48	9/8/13	28.38922	82.71263	110	999	30.6	8.46	23.53	126.9	100	MUD
54	9/7/13	28.36348	82.76942	225	999	29.46	8.22	28.94	83.5	80	MUD/HARD
66	9/7/13	28.37377	82.83604	335	999	29.74	8.14	31.14	89	100	MUD
72	9/8/13	28.38849	82.89281	510	460	30.07	8.17	33.29	97.3	10	SAND
174	9/20/13	28.74957	82.74832	120	999	26.99	8.12	28.85	74.9	100	MUD
180	9/21/13	28.75948	82.81132	280	180	28.58	8.3	31.33	124	30	SAND

**Table A1 (Continued)**

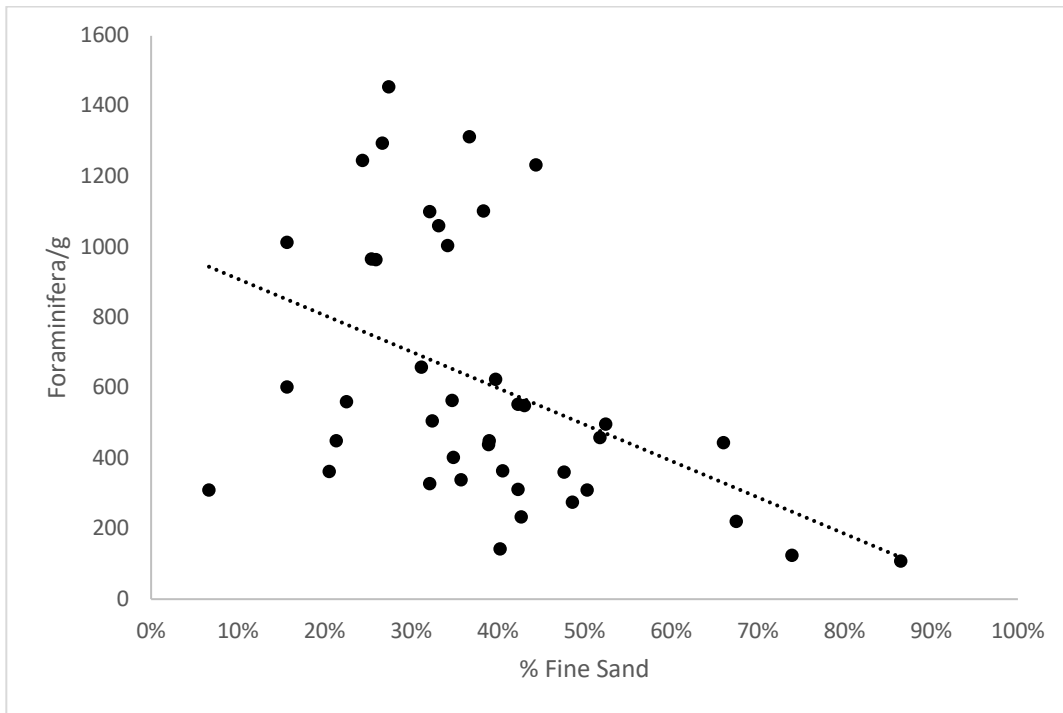
SITE	DATE	LAT	LONG	DEPTH (cm)	SECCHI (cm)	BW-		BW-DO		TYPE	
						Temp (°C)	pH	SAL	% saturation		% COVER
204	9/21/13	28.76678	82.97772	605	380	28.66	8.15	34.28	100.4	100	SAND
205	9/21/13	28.76872	82.91183	350	280	28.17	8.24	32.69	98	5	HARD

*Note:* A Secchi disk reading of 999 indicates the water column was clear to the bottom.

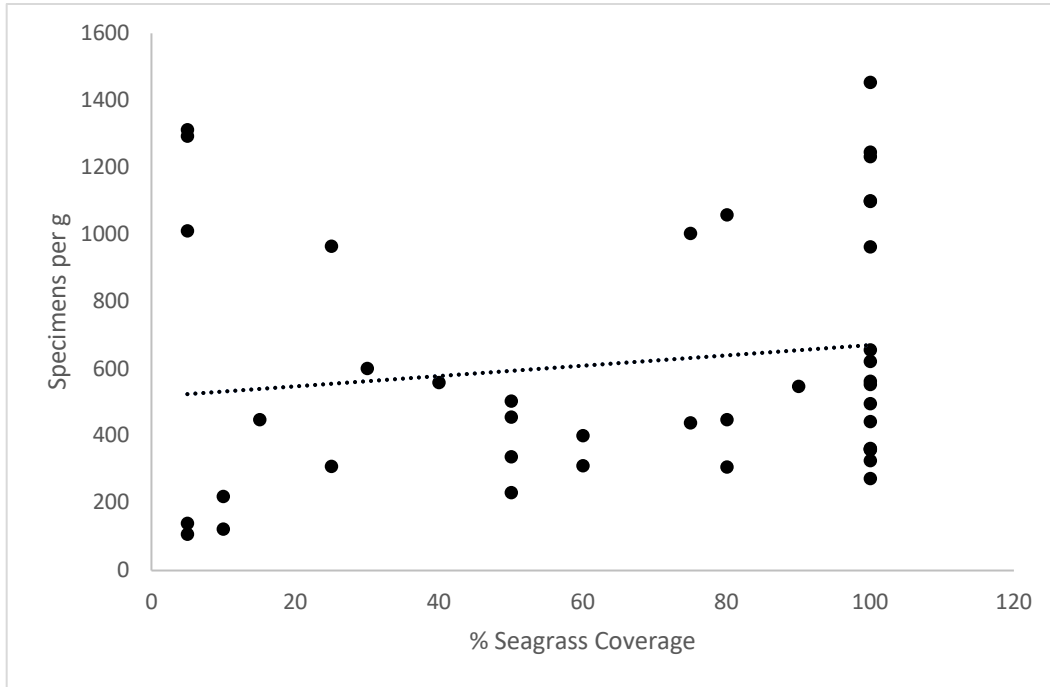
APPENDIX B: STATISTICAL ANALYSES OF FORAMINIFERAL ASSEMBLAGES



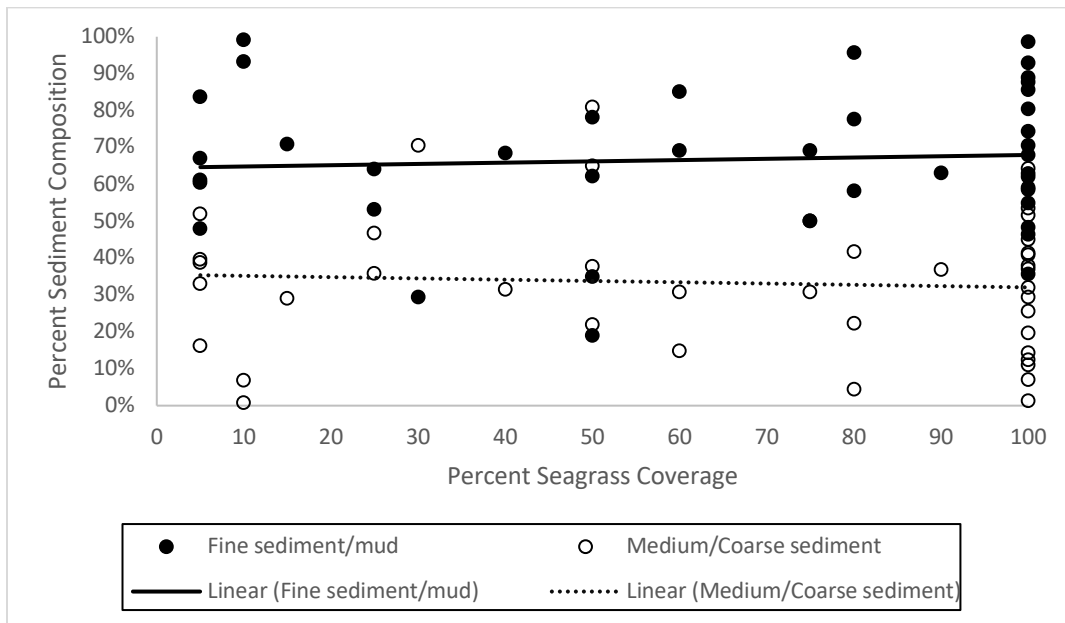
**Figure B1:** Relative abundance of *Archaias* in Stage 5 dissolution plotted against pH.  $R^2 = 0.1442$ .



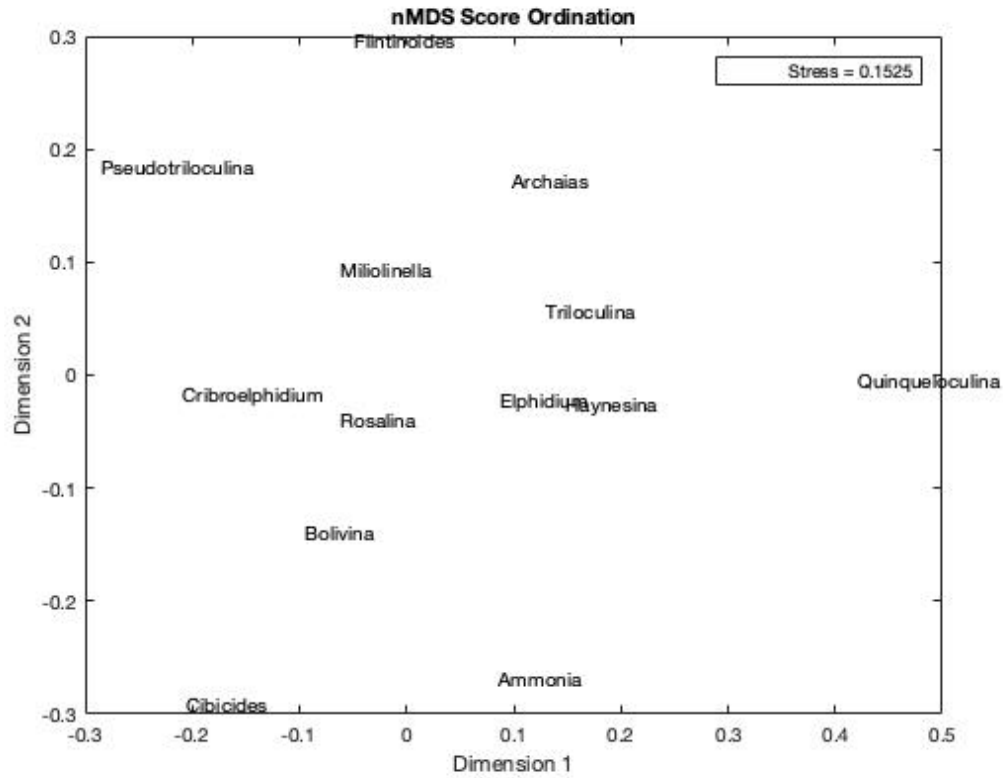
**Figure B2:** Absolute foraminiferal abundances plotted against the percent of fine sand ( $\Phi=3$ ) for all sites ( $n=41$ ).  $R^2 = 0.19$ .



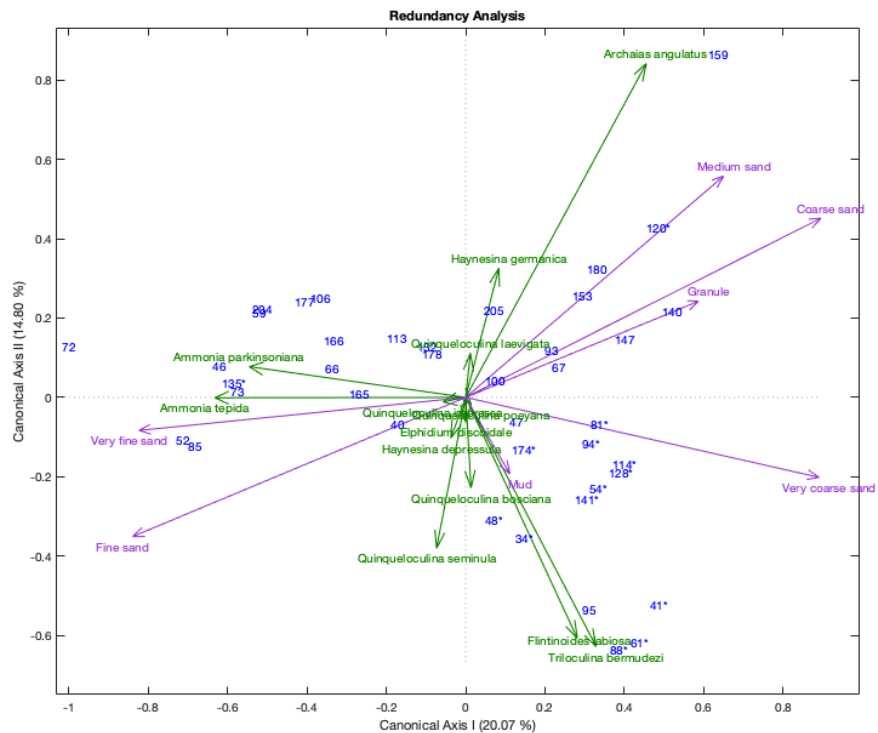
**Figure B3:** Foraminiferal density plotted against seagrass coverage ( $R^2 = 0.02$ ).



**Figure B4:** Fine sediment/mud ( $0.125 \text{ mm} < X \leq 0.063$ ) and medium/coarse sediment ( $X \geq 0.25 \text{ mm}$ ) plotted against seagrass coverage.



**Figure B5:** nMDS plot of the genera making up  $\geq 2\%$  of total relative abundance.



**Figure B6:** Distance-based redundancy analysis of all Springs Coast sites using the abundance data of genera with a total abundance  $\geq 2\%$  and grain size distribution.  $R^2 = 0.44$ ,  $p = 0.001$ .

APPENDIX C: LIST OF ALL SPECIES, GENERA, FAMILIES, AND ORDERS PRESENT IN THE SPRINGS  
COAST SAMPLES

**Table C1:** List of all species, genera, families, and orders present in the Springs Coast samples.

<u>Species</u>	<u>Genus</u>	<u>Family</u>	<u>Order</u>
<i>Archaias angulatus</i>	<i>Archaias</i>	Soritidae	Miliolida
<i>Broeckina orbitolitoides</i>	<i>Broeckina</i>	Cornuspiridae	Rotaliida
<i>Cyclorbiculina compressa</i>	<i>Cyclorbiculina</i>	Peneroplidae	Textulariida
<i>Laevipeneroplis proteus</i>	<i>Laevipeneroplis</i>	Ammoniidae	Lituolida
<i>Peneroplis bradyi</i>	<i>Peneroplis</i>	Textulariidae	Spirillinida
<i>Peneroplis pertusus</i>	<i>Ammonia</i>	Bolivinitidae	
<i>Peneroplis proteus</i>	<i>Bigenerina</i>	Buliminidae	
<i>Ammonia beccarii</i>	<i>Bolivina</i>	Buliminellidae	
<i>Ammonia parkinsoniana</i>	<i>Bolivinita</i>	Elphidiidae	
<i>Ammonia takanabensis</i>	<i>Bulimina</i>	Haynesinidae	
<i>Ammonia tepida</i>	<i>Buliminella</i>	Nonionidae	
<i>Bigenerina irregularis</i>	<i>Criboelphidium</i>	Cibicididae	
<i>Bigenerina</i> sp.	<i>Elphidium</i>	Cymbaloporetta	
<i>Bolivina alata</i>	<i>Haynesina</i>	Discorbidae	
<i>Bolivina albatrossi</i>	<i>Nonionoides</i>	Pseudoparrellidae	
<i>Bolivina barbata</i>	<i>Cibicides</i>	Eponididae	
<i>Bolivina lanceolata</i>	<i>Cibicidoides</i>	Turriliniidae	
<i>Bolivina lowmani</i>	<i>Cymbaloporetta</i>	Cassidulinidae	
<i>Bolivina ordinaria</i>	<i>Discorbis</i>	Anomalinidae	
<i>Bolivina striatula</i>	<i>Epistominella</i>	Rosalinidae	
<i>Bolivina translucens</i>	<i>Eponides</i>	Epistomariidae	
<i>Bolivinita quadrilatera</i>	<i>Eubuliminella</i>	Glabratellidae	
<i>Bulimina marginata</i>	<i>Fursenkoina</i>	Planorbulinidae	
<i>Buliminella elegantissima</i>	<i>Globocassidulina</i>	Uvigerinidae	
<i>Criboelphidium excavatum</i>	<i>Hanzawaia</i>	Cancrisidae	
<i>Criboelphidium incertum</i>	<i>Lobatula</i>	Hauerinidae	
<i>Criboelphidium poeyanum</i>	<i>Neoconorbina</i>	Miliamminidae	
<i>Elphidium advenum</i>	<i>Palmerinella</i>	Spiroloculinidae	
<i>Elphidium crispum</i>	<i>Paracassidulina</i>	Fischerinidae	
<i>Elphidium discoideale</i>	<i>Planoglabratella</i>	Valvulinidae	
<i>Elphidium fimbriatulum</i>	<i>Planorbulina</i>	Ammosphaeroidinidae	
<i>Elphidium galvestonense</i>	<i>Rosalina</i>	Lituolidae	
<i>Elphidium gunteri</i>	<i>Uvigerina</i>	Haplophragmoididae	
<i>Elphidium lanieri</i>	<i>Valvulineria</i>	Trochamminidae	
<i>Elphidium mexicanum</i>	<i>Affinetrina</i>	Spiroplectamminidae	
<i>Haynesina depressula</i>	<i>Articularia</i>	Ammodiscidae	
<i>Haynesina germanica</i>	<i>Articulina</i>		
<i>Nonionoides grateloupii</i>	<i>Cornuspira</i>		
<i>Cibicides io</i>	<i>Cycloforina</i>		
<i>Cibicides kullenbergi</i>	<i>Flintinoides</i>		
<i>Cibicides mayori</i>	<i>Miliammina</i>		
<i>Cibicides mollis</i>	<i>Miliolinella</i>		

**Table C1 (Continued)**

<i>Cibicides rugosus</i>	<i>Monalysidium</i>
<i>Cibicides corpulentus</i>	<i>Neopateoris</i>
<i>Cibicidoides pachyderma</i>	<i>Pseudotriloculina</i>
<i>Cibicidoides robertsoniana</i>	<i>Pyrgo</i>
<i>Cibicidoides umbonata</i>	<i>Quinqueloculina</i>
<i>Cibicidoides wuellerstorfi</i>	<i>Siphonaperta</i>
<i>Cymbaloporeta atlantica</i>	<i>Spiroloculina</i>
<i>Discorbis aguayoi</i>	<i>Triloculina</i>
<i>Discorbis mira</i>	<i>Vertebrasigmoilina</i>
<i>Discorbis rosea</i>	<i>Wiesnerella</i>
<i>Discorbis vilardeboanus</i>	<i>Clavulina</i>
<i>Epistominella vitrea</i>	<i>Cribrostomoides</i>
<i>Eponides repandus</i>	<i>Eratidus</i>
<i>Eponides turgidus</i>	<i>Haplophragmoides</i>
<i>Eubuliminella morgani</i>	<i>Paratrochammina</i>
<i>Fursenkoina compressa</i>	<i>Trochammina</i>
<i>Fursenkoina mexicana</i>	<i>Spirotextularia</i>
<i>Fursenkoina pontoni</i>	<i>Textularia</i>
<i>Fursenkoina punctata</i>	<i>Tritaxis</i>
<i>Globocassidulina parva</i>	<i>Ammodiscus</i>
<i>Hanzawaia concentrica</i>	
<i>Lobatula</i> sp.	
<i>Neoconorbina terquemi</i>	
<i>Palmerinella palmerae</i>	
<i>Paracassidulina minuta</i>	
<i>Planoglabratella opercularis</i>	
<i>Planorbulina mediterraneensis</i>	
<i>Rosalina</i> sp.	
<i>Rosalina bahamaensis</i>	
<i>Rosalina floridensis</i>	
<i>Rosalina subarucana</i>	
<i>Uvigerina laevis</i>	
<i>Valvulineria araucana</i>	
<i>Affinetrina planciana</i>	
<i>Articularia sagra</i>	
<i>Articulina antillarum</i>	
<i>Articulina mucronata</i>	
<i>Articulina pacifica</i>	
<i>Cornuspira involvens</i>	
<i>Cycloforina sidebottomi</i>	
<i>Flintinoides labiosa</i>	
<i>Miliammina fusca</i>	
<i>Miliolinella circularis</i>	
<i>Miliolinella fichteliana</i>	
<i>Miliolinella suborbicularis</i>	
<i>Miliolinella subrotunda</i>	
<i>Monalysidium politum</i>	



## Table C1 (Continued)

*Neopateoris* sp.  
*Pseudotriloculina granulocostata*  
*Pseudotriloculina linneiana*  
*Pseudotriloculina rotunda*  
*Pseudotriloculina subgranulata*  
*Pyrgo elongata*  
*Pyrgo sarsi*  
*Pyrgo subsphaerica*  
*Pyrgo williamsoni*  
*Quinqueloculina agglutinans*  
*Quinqueloculina bassensis*  
*Quinqueloculina bicarinata*  
*Quinqueloculina bicostata*  
*Quinqueloculina bosciana*  
*Quinqueloculina candeiana*  
*Quinqueloculina carinata*  
*Quinqueloculina collumosa*  
*Quinqueloculina compta*  
*Quinqueloculina crassa*  
*Quinqueloculina impressa*  
*Quinqueloculina laevigata*  
*Quinqueloculina lamarckiana*  
*Quinqueloculina linneiana*  
*Quinqueloculina parkeri*  
*Quinqueloculina poeyana*  
*Quinqueloculina seminula*  
*Quinqueloculina* sp.  
*Quinqueloculina striata*  
*Quinqueloculina subpoeyana*  
*Quinqueloculina tenagos*  
*Quinqueloculina tipswordi*  
*Quinqueloculina triangularis*  
*Quinqueloculina vulgaris*  
*Siphonaperta distorta*  
*Spiroloculina antillarum*  
*Spiroloculina attenuata*  
*Spiroloculina soldanii*  
*Triloculina affinis*  
*Triloculina bermudezi*  
*Triloculina elongata*  
*Triloculina fiterrei*  
*Triloculina inflata*  
*Triloculina oblonga*  
*Triloculina rotunda*  
*Triloculina* sp.  
*Triloculina tricarinata*  
*Triloculina trigonula*

**Table C1 (Continued)**

*Triloculina variolata*

*Vertebrasigmoilina mexicana*

*Wiesnerella auriculata*

*Clavulina* sp.

*Cribrostomoides* sp.

*Eratidus foliaceus*

*Haplophragmoides wilberti*

*Paratrochammina challengerii*

*Trochammina squamata*

*Spirotextularia floridana*

*Textularia* sp.

*Textularia agglutinans*

*Textularia candeiana*

*Tritaxis fusca*

*Ammodiscus tenuis*

APPENDIX D: LIST OF ALL SPECIES FOUND IN THE SPRINGS COAST, THE SPECIES AUTHOR, AND THE YEAR IT WAS NAMED

**Table D1:** List of all species found in the Springs Coast, the species author, and the year it was named.

<b>Species</b>	<b>Discovered by:</b>
<i>Affinetrina planciana</i>	d'Orbigny 1839
<i>Ammodiscus tenuis</i>	Brady 1884
<i>Ammonia beccarii</i>	Linnaeus 1758
<i>Ammonia parkinsoniana</i>	d'Orbigny 1839
<i>Ammonia takanabensis</i>	Ishizaki 1948
<i>Ammonia tepida</i>	Cushman 1926
<i>Archaias angulatus</i>	Fichtel & Moll 1798
<i>Articularia sagra</i>	d'Orbigny 1839
<i>Articulina antillarum</i>	Cushman 1922
<i>Articulina mucronata</i>	d'Orbigny 1839
<i>Articulina pacifica</i>	Cushman 1944
<i>Bigenerina irregularis</i>	Phleger & Parker 1951
<i>Bigenerina</i> sp.	
<i>Bolivina alata</i>	Seguenza 1862
<i>Bolivina albatrossi</i>	Cushman 1922
<i>Bolivina barbata</i>	Phleger & Parker 1951
<i>Bolivina lanceolata</i>	Parker 1954
<i>Bolivina lowmani</i>	Phleger & Parker 1951
<i>Bolivina ordinaria</i>	Phleger & Parker 1952
<i>Bolivina striatula</i>	Cushman 1922
<i>Bolivina translucens</i>	Phleger & Parker 1951
<i>Bolivinita quadrilatera</i>	Schwager 1866
<i>Broeckina orbitolitoides</i>	Hofker 1930
<i>Bulimina marginata</i>	d'Orbigny 1826
<i>Buliminella elegantissima</i>	d'Orbigny 1839
<i>Cibicides io</i>	Cushman 1931
<i>Cibicides kullenbergi</i>	Parker 1953
<i>Cibicides mayori</i>	Cushman 1924
<i>Cibicides mollis</i>	Phleger & Parker 1951
<i>Cibicides rugosus</i>	Phleger & Parker 1951
<i>Cibicides corpulentus</i>	Phleger & Parker 1952
<i>Cibicidoides pachyderma</i>	Rzehak 1886
<i>Cibicidoides robertsoniana</i>	Brady 1881
<i>Cibicidoides umbonata</i>	Phleger & Parker 1951
<i>Cibicidoides wuellerstorfi</i>	Schwager 1866
<i>Clavulina</i> sp.	
<i>Cornuspira involvens</i>	Reuss 1850
<i>Criboelphidium excavatum</i>	Terquem 1875
<i>Criboelphidium incertum</i>	Williamson 1858
<i>Criboelphidium poeyanum</i>	d'Orbigny 1839

**Table D1 (Continued)**

<i>Cribrostomoides</i> sp.	Cushman 1910
<i>Cycloforina sidebottomi</i>	Rasheed 1971
<i>Cyclorbiculina compressa</i>	d'Orbigny 1839
<i>Cymbaloporetta atlantica</i>	Cushman 1934
<i>Discorbis aguayoi</i>	Bermudez 1935
<i>Discorbis mira</i>	Cushman, 1922
<i>Discorbis rosea</i>	d'Orbigny 1839
<i>Discorbis vilardeboanus</i>	d'Orbigny 1839
<i>Eggerelloides mississippiensis</i>	Parker
<i>Elphidium advenum</i>	Cushman 1922
<i>Elphidium crispum</i>	Linnaeus 1758
<i>Elphidium discoidale</i>	d'Orbigny 1839
<i>Elphidium fimbriatulum</i>	Cushman 1918
<i>Elphidium galvestonense</i>	Kornfeld 1931
<i>Elphidium gunteri</i>	Cole 1931
<i>Elphidium lanieri</i>	d'Orbigny 1839
<i>Elphidium mexicanum</i>	Kornfeld 1931
<i>Epistominella vitrea</i>	Parker 1953
<i>Eponides repandus</i>	Fichtel & Moll 1798
<i>Eponides turgidus</i>	Phleger & Parker 1951
<i>Eratidus foliaceus</i>	Brady 1881
<i>Eubuliminella morgani</i>	Andersen 1961
<i>Flintinoides labiosa</i>	d'Orbigny 1839
<i>Fursenkoina compressa</i>	Bailey 1851
<i>Fursenkoina mexicana</i>	Cushman 1922
<i>Fursenkoina pontoni</i>	Cushman 1932
<i>Fursenkoina punctata</i>	d'Orbigny 1839
<i>Globocassidulina parva</i>	Asano & Nakamura 1937
<i>Hanzawaia concentrica</i>	Cushman 1918
<i>Haplophragmoides wilberti</i>	Andersen 1953
<i>Haynesina depressula</i>	Walker & Jacob 1798
<i>Haynesina germanica</i>	Ehrenberg 1840
<i>Laevipeneroplis proteus</i>	d'Orbigny 1839
<i>Lobatula</i> sp.	
<i>Miliammina fusca</i>	Brady 1870
<i>Miliolinella circularis</i>	Bornemann 1855
<i>Miliolinella fichteliana</i>	d'Orbigny 1839
<i>Miliolinella suborbicularis</i>	d'Orbigny 1839
<i>Miliolinella subrotunda</i>	Montagu 1803
<i>Monalysidium politum</i>	Chapman 1900
<i>Neoconorbina terquemi</i>	Rzehak 1888
<i>Neopateoris</i> sp.	
<i>Nonionoides grateloupii</i>	d'Orbigny 1839
<i>Palmerinella palmerae</i>	Bermudez 1934
<i>Paracassidulina minuta</i>	Cushman 1933
<i>Paratrochammina challengeri</i>	Bronnimann & Whittaker 1988

**Table D1 (Continued)**

<i>Peneroplis bradyi</i>	Cushman 1930
<i>Peneroplis pertusus</i>	Forskal 1775
<i>Peneroplis proteus</i>	d'Orbigny 1839
<i>Planoglabratella opercularis</i>	d'Orbigny 1839
<i>Planorbulina mediterranensis</i>	d'Orbigny 1826
<i>Pseudotriloculina granulocostata</i>	Germeraad 1946
<i>Pseudotriloculina linneiana</i>	d'Orbigny 1839
<i>Pseudotriloculina rotunda</i>	d'Orbigny 1893
<i>Pseudotriloculina subgranulata</i>	Cushman 1918
<i>Pyrgo elongata</i>	d'Orbigny 1826
<i>Pyrgo sarsi</i>	Schlumberger 1891
<i>Pyrgo subsphaerica</i>	d'Orbigny 1839
<i>Pyrgo williamsoni</i>	Silvestri 1923
<i>Quinqueloculina agglutinans</i>	d'Orbigny 1839
<i>Quinqueloculina bassensis</i>	Parr 1945
<i>Quinqueloculina bicarinata</i>	d'Orbigny 1878
<i>Quinqueloculina bicostata</i>	d'Orbigny 1839
<i>Quinqueloculina bosciiana</i>	d'Orbigny 1839
<i>Quinqueloculina candeiana</i>	d'Orbigny 1839
<i>Quinqueloculina carinata</i>	d'Orbigny 1850
<i>Quinqueloculina collumnosa</i>	Cushman 1922
<i>Quinqueloculina compta</i>	Cushman 1947
<i>Quinqueloculina crassa</i>	d'Orbigny 1850
<i>Quinqueloculina impressa</i>	Reuss 1851
<i>Quinqueloculina laevigata</i>	d'Orbigny 1839
<i>Quinqueloculina lamarckiana</i>	d'Orbigny 1839
<i>Quinqueloculina linneiana</i>	d'Orbigny 1839
<i>Quinqueloculina parkeri</i>	Brady 1881
<i>Quinqueloculina poeyana</i>	d'Orbigny 1839
<i>Quinqueloculina seminula</i>	Linnaeus 1758
<i>Quinqueloculina sp.</i>	
<i>Quinqueloculina striata</i>	d'Orbigny 1832
<i>Quinqueloculina subpoeyana</i>	Cushman 1922
<i>Quinqueloculina tenagos</i>	Parker 1962
<i>Quinqueloculina tipswordi</i>	Andersen 1961
<i>Quinqueloculina triangularis</i>	d'Orbigny 1826
<i>Quinqueloculina vulgaris</i>	d'Orbigny 1826
<i>Rosalina sp.</i>	
<i>Rosalina bahamaensis</i>	Todd & Low 1971
<i>Rosalina floridensis</i>	Cushman 1930
<i>Rosalina subaraucana</i>	Cushman 1922
<i>Siphonaperta distortaqueata</i>	Cushman 1954
<i>Trochammina squamata</i>	Jones & Parker 1860
<i>Spiroloculina antillarum</i>	d'Orbigny 1839
<i>Spiroloculina attenuata</i>	Cushman & Todd 1944
<i>Spiroloculina soldanii</i>	Fornasini 1886

**Table D1 (Continued)**

<i>Spirotextularia floridana</i>	Cushman 1922
<i>Textularia</i> sp.	
<i>Textularia agglutinans</i>	d'Orbigny 1839
<i>Textularia candeiana</i>	d'Orbigny 1839
<i>Triloculina affinis</i>	d'Orbigny 1852
<i>Triloculina bermudezi</i>	Acosta 1940
<i>Triloculina elongata</i>	d'Orbigny 1905
<i>Triloculina fiterrei</i>	Acosta 1940
<i>Triloculina inflata</i>	d'Orbigny 1826
<i>Triloculina oblonga</i>	Montagu 1803
<i>Triloculina rotunda</i>	d'Orbigny 1893
<i>Triloculina</i> sp.	
<i>Triloculina tricarinata</i>	d'Orbigny 1832
<i>Triloculina trigonula</i>	Lamarck 1804
<i>Triloculina variolata</i>	d'Orbigny 1826
<i>Tritaxis fusca</i>	Williamson 1858
<i>Uvigerina laevis</i>	Ehrenberg 1845
<i>Valvulineria araucana</i>	d'Orbigny 1839
<i>Vertebrasigmoidina mexicana</i>	Cushman 1922
<i>Wiesnerella auriculata</i>	Egger 1893

APPENDIX E: RAW ABUNDANCE DATA FOR ALL SITES

**Table E1:** Raw abundance data for sites 34, 40, 46, 52, 59, 88, 94, 100, and 106

Species	SC34	SC40	SC46	SC52	SC59	SC88	SC94	SC100	SC106
<i>Affinetrina planciana</i>	0	0	0	5	2	0	3	0	0
<i>Ammodiscus tenuis</i>	0	0	0	0	0	0	0	0	0
<i>Ammonia beccarii</i>	0	3	28	1	0	0	0	0	5
<i>Ammonia parkinsoniana</i>	1	2	37	20	22	0	1	0	12
<i>Ammonia takanabensis</i>	0	1	0	0	0	0	0	0	0
<i>Ammonia tepida</i>	4	9	27	11	48	0	1	1	6
<i>Archaias angulatus</i>	6	1	7	0	9	0	9	3	5
<i>Articularia sagra</i>	0	0	0	0	0	0	0	0	0
<i>Articulina antillarum</i>	0	0	0	0	0	0	0	0	0
<i>Articulina mucronata</i>	0	0	0	0	0	0	0	0	0
<i>Articulina pacifica</i>	0	0	0	0	0	0	0	0	0
<i>Bigenerina irregularis</i>	0	0	0	0	0	0	2	1	0
<i>Bigenerina sp.</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina alata</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina albatrossi</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina barbata</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina lanceolata</i>	0	0	0	0	0	0	0	2	0
<i>Bolivina lowmani</i>	0	0	1	0	2	0	1	1	2
<i>Bolivina ordinaria</i>	0	0	3	1	2	0	1	1	2
<i>Bolivina striatula</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina translucens</i>	0	3	0	0	0	0	1	3	5
<i>Bolivinita quadrilatera</i>	0	0	0	0	0	0	0	0	0
<i>Broeckina orbitolitoides</i>	0	1	0	0	0	1	3	0	0
<i>Bulimina marginata</i>	0	0	0	0	0	0	0	0	0
<i>Buliminella elegantissima</i>	0	0	0	0	0	0	0	0	1
<i>Cibicides io</i>	0	0	0	2	0	0	0	0	0
<i>Cibicides kullenbergi</i>	0	0	0	0	0	0	1	2	1
<i>Cibicides mayori</i>	0	0	0	0	0	0	0	0	0
<i>Cibicides mollis</i>	0	0	0	0	0	0	0	1	0
<i>Cibicides rugosus</i>	0	0	1	0	0	0	0	0	1
<i>Cibicides corpulentus</i>	0	0	0	0	0	0	0	1	0
<i>Cibicidoides pachyderma</i>	1	0	0	0	0	0	0	0	0
<i>Cibicidoides robertsoniana</i>	0	0	0	0	0	0	0	0	0
<i>Cibicidoides umbonata</i>	0	0	0	0	0	0	0	0	0
<i>Cibicidoides wuellerstorfi</i>	0	0	0	0	0	0	0	1	2
<i>Clavulina sp.</i>	0	0	0	0	0	0	0	0	0
<i>Cornuspira involvens</i>	1	1	1	0	2	0	0	2	1
<i>Criboelphidium excavatum</i>	4	1	1	4	0	0	1	1	0
<i>Criboelphidium incertum</i>	1	0	0	0	0	0	0	0	0
<i>Criboelphidium poeyanum</i>	7	8	11	9	7	0	3	9	8
<i>Cribrostomoides sp.</i>	0	0	0	0	0	0	0	0	0
<i>Cycloforina sidebottomi</i>	0	0	0	0	0	1	1	0	0

**Table E1 (Continued)**

Species	SC34	SC40	SC46	SC52	SC59	SC88	SC94	SC100	SC106
<i>Cyclorbiculina compressa</i>	0	0	0	0	0	0	0	0	0
<i>Cymbaloporetta atlantica</i>	0	0	0	0	0	0	1	0	0
<i>Discorbis aguayoi</i>	0	0	0	1	0	0	2	0	0
<i>Discorbis mira</i>	1	0	1	0	2	0	3	6	7
<i>Discorbis rosea</i>	1	0	0	0	0	0	0	0	0
<i>Discorbis vilardeboanus</i>	0	0	0	0	0	0	0	0	0
<i>Eggerelloides mississippiensis</i>	0	0	0	0	0	0	0	0	0
<i>Elphidium advenum</i>	0	0	1	1	1	0	0	5	11
<i>Elphidium crispum</i>	0	0	0	0	0	0	0	0	0
<i>Elphidium discoideale</i>	3	6	3	0	0	0	0	1	3
<i>Elphidium fimbriatulum</i>	0	2	2	0	0	0	0	0	0
<i>Elphidium galvestonense</i>	2	6	0	0	2	0	0	0	5
<i>Elphidium gunteri</i>	1	1	0	0	0	0	1	2	0
<i>Elphidium lanieri</i>	0	0	0	0	0	0	0	2	0
<i>Elphidium mexicanum</i>	0	3	0	3	1	2	3	0	0
<i>Epistominella vitrea</i>	0	0	0	0	0	0	0	1	0
<i>Eponides repandus</i>	0	0	0	0	0	0	0	0	0
<i>Eponides turgidus</i>	0	0	0	0	0	0	0	0	1
<i>Eratidus foliaceus</i>	0	0	0	0	0	0	0	0	0
<i>Eubuliminella morgani</i>	0	0	0	0	0	0	0	0	1
<i>Flintinoides labiosa</i>	5	2	1	2	1	16	13	3	0
<i>Fursenkoina compressa</i>	0	0	0	0	0	0	0	0	1
<i>Fursenkoina mexicana</i>	0	0	0	0	0	0	0	0	0
<i>Fursenkoina pontoni</i>	0	0	0	0	0	0	0	0	0
<i>Fursenkoina punctata</i>	0	0	0	0	0	0	0	0	0
<i>Globocassidulina parva</i>	0	0	0	0	0	0	0	0	1
<i>Hanzawaia concentrica</i>	0	0	0	0	0	0	0	0	0
<i>Haplophragmoides wilberti</i>	0	2	0	0	0	0	0	0	0
<i>Haynesina depressula</i>	6	3	3	16	1	2	4	11	3
<i>Haynesina germanica</i>	13	18	5	4	15	2	23	31	37
<i>Laevipeneroplis proteus</i>	0	0	0	0	0	0	0	0	0
<i>Lobatula sp.</i>	0	0	0	0	0	0	0	0	0
<i>Miliammina fusca</i>	0	4	0	0	0	0	0	0	0
<i>Miliolinella circularis</i>	10	2	3	2	3	2	3	2	3
<i>Miliolinella fichteliana</i>	2	0	0	0	0	0	0	0	0
<i>Miliolinella suborbicularis</i>	0	0	0	0	0	1	0	0	1
<i>Miliolinella subrotunda</i>	7	6	1	1	1	0	0	8	1
<i>Monalysidium politum</i>	0	0	0	0	0	0	0	0	0
<i>Neoconorbina terquemi</i>	2	0	0	0	0	0	0	0	0
<i>Neopateoris sp.</i>	2	0	0	0	0	0	0	0	0
<i>Nonionoides grateloupii</i>	0	0	0	0	0	0	0	0	3
<i>Palmerinella palmerae</i>	3	3	0	0	0	8	10	3	0
<i>Paracassidulina minuta</i>	1	1	0	0	1	0	0	0	0
<i>Paratrochammina challengerii</i>	0	0	1	0	0	0	0	1	0



**Table E1 (Continued)**

Species	SC34	SC40	SC46	SC52	SC59	SC88	SC94	SC100	SC106
<i>Peneroplis bradyi</i>	0	0	0	0	0	0	0	0	0
<i>Peneroplis pertusus</i>	0	0	0	0	0	2	2	0	0
<i>Peneroplis proteus</i>	0	0	0	0	0	0	0	0	0
<i>Planoglabratella opercularis</i>	0	0	2	0	0	0	0	0	0
<i>Planorbulina mediterraneensis</i>	0	0	0	0	0	0	0	2	0
<i>Pseudotriloculina granulocostata</i>	1	0	0	0	0	0	0	0	0
<i>Pseudotriloculina linneiana</i>	0	1	1	45	5	5	2	0	0
<i>Pseudotriloculina rotunda</i>	0	4	0	0	0	0	0	0	0
<i>Pseudotriloculina subgranulata</i>	0	0	0	0	0	0	0	0	0
<i>Pyrgo elongata</i>	0	1	0	0	0	0	0	0	0
<i>Pyrgo sarsi</i>	0	0	0	0	0	0	0	0	0
<i>Pyrgo subsphaerica</i>	0	0	0	0	0	0	1	0	0
<i>Pyrgo williamsoni</i>	0	0	0	0	0	0	0	0	0
<i>Quinqueloculina agglutinans</i>	3	0	0	0	1	1	5	0	2
<i>Quinqueloculina bassensis</i>	0	0	0	0	0	2	0	0	0
<i>Quinqueloculina bicarinata</i>	1	0	0	0	0	0	3	1	3
<i>Quinqueloculina bicostata</i>	4	4	1	0	0	13	3	1	0
<i>Quinqueloculina bosciiana</i>	14	15	5	10	4	17	12	6	5
<i>Quinqueloculina candeiana</i>	0	6	0	0	0	1	0	6	1
<i>Quinqueloculina carinata</i>	0	5	2	0	2	1	2	0	3
<i>Quinqueloculina collumnosa</i>	0	1	0	0	0	9	4	0	0
<i>Quinqueloculina compta</i>	3	0	1	1	4	1	0	0	1
<i>Quinqueloculina crassa</i>	11	4	0	0	0	14	1	0	13
<i>Quinqueloculina impressa</i>	0	3	4	6	8	6	4	5	1
<i>Quinqueloculina laevigata</i>	0	7	4	25	7	3	10	20	8
<i>Quinqueloculina lamarckiana</i>	2	0	0	0	0	2	3	1	0
<i>Quinqueloculina linneiana</i>	6	1	3	2	0	16	3	11	0
<i>Quinqueloculina parkeri</i>	0	0	0	0	0	0	0	0	17
<i>Quinqueloculina poeyana</i>	1	9	6	14	10	8	15	13	11
<i>Quinqueloculina seminula</i>	25	8	23	21	16	33	9	25	17
<i>Quinqueloculina sp.</i>	0	0	0	0	0	0	1	0	1
<i>Quinqueloculina striata</i>	0	2	4	1	2	0	1	0	2
<i>Quinqueloculina subpoeyana</i>	1	3	0	0	0	0	0	0	0
<i>Quinqueloculina tenagos</i>	4	5	1	1	1	6	2	1	1
<i>Quinqueloculina tipswordi</i>	2	0	0	0	0	1	0	0	0
<i>Quinqueloculina triangularis</i>	3	0	0	0	0	0	0	0	0
<i>Quinqueloculina vulgaris</i>	1	1	1	0	0	0	5	0	0
<i>Rosalina sp.</i>	0	0	0	0	0	0	0	0	0
<i>Rosalina bahamaensis</i>	1	2	0	0	0	0	3	0	0

**Table E1 (Continued)**

<b>Species</b>	<b>SC34</b>	<b>SC40</b>	<b>SC46</b>	<b>SC52</b>	<b>SC59</b>	<b>SC88</b>	<b>SC94</b>	<b>SC100</b>	<b>SC106</b>
<i>Rosalina floridensis</i>	0	2	0	0	2	1	1	3	2
<i>Rosalina subaraucana</i>	1	1	1	1	1	0	1	6	2
<i>Siphonaperta distorta</i>	0	0	0	0	0	0	0	0	0
<i>Trochammina squamata</i>	0	0	0	0	0	0	1	0	4
<i>Spiroloculina antillarum</i>	1	0	0	0	0	13	0	0	0
<i>Spiroloculina attenuata</i>	0	0	0	0	0	0	0	0	0
<i>Spiroloculina soldanii</i>	0	1	0	0	0	0	0	0	1
<i>Spirotextularia floridana</i>	0	0	0	0	0	0	0	0	0
<i>Textularia</i> sp.	0	0	0	0	0	0	0	0	0
<i>Textularia agglutinans</i>	0	0	0	0	0	0	0	0	0
<i>Textularia candeiana</i>	0	0	1	0	0	0	0	0	5
<i>Triloculina affinis</i>	0	0	0	0	0	0	0	0	0
<i>Triloculina bermudezi</i>	18	11	1	2	4	37	17	3	2
<i>Triloculina elongata</i>	0	0	0	0	0	0	0	0	0
<i>Triloculina fiterrei</i>	0	0	0	0	0	0	0	0	0
<i>Triloculina inflata</i>	0	2	0	0	0	0	0	0	0
<i>Triloculina oblonga</i>	9	5	6	0	5	4	3	1	5
<i>Triloculina rotunda</i>	0	1	0	0	1	0	0	0	0
<i>Triloculina</i> sp.	0	0	0	0	0	2	0	0	0
<i>Triloculina tricarinata</i>	8	2	0	0	0	0	0	0	0
<i>Triloculina trigonula</i>	2	3	0	9	5	5	1	1	6
<i>Triloculina variolata</i>	0	0	0	0	0	0	1	0	0
<i>Tritaxis fusca</i>	0	0	0	0	0	0	0	0	0
<i>Uvigerina laevis</i>	0	0	0	0	0	0	0	0	0
<i>Valvulineria araucana</i>	0	0	0	0	0	0	0	0	0
<i>Vertebrasigmoilina mexicana</i>	0	0	0	0	0	0	0	0	0
<i>Wiesnerella auriculata</i>	0	0	0	1	0	0	0	0	1

**Table E2:** Raw abundance data for sites 135, 141, 147, 159, 165, 177, 61, 67, and 73.

Species	SC135	SC141	SC147	SC159	SC165	SC177	SC61	SC67	SC73
<i>Affinetrina planciana</i>	0	0	0	0	0	0	0	0	0
<i>Ammodiscus tenuis</i>	0	0	0	0	0	0	0	0	0
<i>Ammonia beccarii</i>	0	0	0	0	0	1	0	1	9
<i>Ammonia parkinsoniana</i>	14	0	0	0	6	8	0	1	12
<i>Ammonia takanabensis</i>	0	0	0	0	0	0	0	0	0
<i>Ammonia tepida</i>	11	0	0	0	2	21	0	1	14
<i>Archaias angulatus</i>	0	0	13	101	2	14	1	21	1
<i>Articularia sagra</i>	0	0	0	0	0	0	0	0	0
<i>Articulina antillarum</i>	0	0	0	0	0	0	0	0	0
<i>Articulina mucronata</i>	0	0	0	0	0	0	0	0	0
<i>Articulina pacifica</i>	0	0	1	0	0	2	0	0	0
<i>Bigenerina irregularis</i>	0	0	0	0	1	0	0	0	0
<i>Bigenerina sp.</i>	0	0	0	0	0	0	0	0	1
<i>Bolivina alata</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina albatrossi</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina barbata</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina lanceolata</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina lowmani</i>	0	0	1	0	0	0	0	0	1
<i>Bolivina ordinaria</i>	1	1	0	1	2	1	0	0	3
<i>Bolivina striatula</i>	0	0	0	0	1	0	0	0	0
<i>Bolivina translucens</i>	0	0	1	2	3	5	0	1	3
<i>Bolivinita quadrilatera</i>	0	0	0	0	0	0	0	0	0
<i>Broeckina orbitolitoides</i>	0	0	0	0	1	0	0	9	1
<i>Bulimina marginata</i>	0	0	0	0	0	0	0	0	0
<i>Buliminella elegantissima</i>	0	0	0	0	0	0	0	0	0
<i>Cibicides io</i>	0	0	2	5	14	5	1	0	1
<i>Cibicides kullenbergi</i>	2	2	15	12	38	4	0	1	2
<i>Cibicides mayori</i>	0	0	0	0	0	0	0	0	0
<i>Cibicides mollis</i>	0	0	0	0	0	0	0	0	0
<i>Cibicides rugosus</i>	0	0	0	0	0	0	0	0	0
<i>Cibicides corpulentus</i>	0	0	1	2	0	0	0	0	0
<i>Cibicidoides pachyderma</i>	0	0	0	1	0	0	0	0	0
<i>Cibicidoides robertsoniana</i>	0	0	0	0	6	1	0	2	0
<i>Cibicidoides umbonata</i>	0	0	1	0	0	0	0	0	0
<i>Cibicidoides wuellerstorfi</i>	0	0	4	7	3	2	0	0	0
<i>Clavulina sp.</i>	0	0	0	0	0	0	0	0	0
<i>Cornuspira involvens</i>	1	0	1	4	1	0	0	2	6
<i>Criboelphidium excavatum</i>	3	0	0	0	0	0	0	0	0
<i>Criboelphidium incertum</i>	0	0	0	0	0	0	0	0	0
<i>Criboelphidium poeyanum</i>	24	2	2	0	0	5	1	0	5
<i>Cribrostomoides sp.</i>	0	0	0	0	0	0	0	0	0
<i>Cycloforina sidebottomi</i>	0	1	0	0	0	0	0	1	0
<i>Cyclorbiculina compressa</i>	0	0	0	1	0	0	0	0	0
<i>Cymbaloporetta atlantica</i>	0	0	1	1	0	1	0	0	0

**Table E2 (Continued)**

Species	SC135	SC141	SC147	SC159	SC165	SC177	SC61	SC67	SC73
<i>Discorbis aguayoi</i>	0	0	0	0	0	0	0	0	0
<i>Discorbis mira</i>	2	0	2	2	2	4	0	1	0
<i>Discorbis rosea</i>	0	1	0	0	0	0	0	0	0
<i>Discorbis vilardeboanus</i>	0	0	0	0	0	0	0	0	0
<i>Eggerelloides mississippiensis</i>	0	0	0	0	0	0	0	0	0
<i>Elphidium advenum</i>	3	2	3	2	2	2	0	1	8
<i>Elphidium crispum</i>	0	1	0	0	0	0	0	0	0
<i>Elphidium discoidale</i>	11	9	7	1	6	15	10	5	18
<i>Elphidium fimbriatulum</i>	0	2	1	0	0	4	0	3	7
<i>Elphidium galvestonense</i>	1	1	2	0	0	0	0	1	2
<i>Elphidium gunteri</i>	28	1	0	0	0	1	0	0	0
<i>Elphidium lanieri</i>	0	0	0	0	0	0	0	0	0
<i>Elphidium mexicanum</i>	0	0	1	0	0	0	0	0	0
<i>Epistominella vitrea</i>	7	0	0	0	0	0	0	0	0
<i>Eponides repandus</i>	0	0	0	0	0	0	0	0	0
<i>Eponides turgidus</i>	0	0	0	0	0	0	0	0	0
<i>Eratidus foliaceus</i>	0	0	0	0	0	0	0	0	0
<i>Eubuliminella morgani</i>	0	0	0	0	1	0	0	0	0
<i>Flintinoides labiosa</i>	2	11	4	0	3	2	39	9	0
<i>Fursenkoina compressa</i>	0	0	0	0	0	0	0	0	0
<i>Fursenkoina mexicana</i>	0	0	0	0	0	1	0	0	0
<i>Fursenkoina pontoni</i>	0	0	0	1	0	0	0	0	0
<i>Fursenkoina punctata</i>	0	0	0	0	0	0	0	0	0
<i>Globocassidulina parva</i>	0	0	0	0	0	0	0	0	0
<i>Hanzawaia concentrica</i>	0	0	0	0	0	0	0	0	0
<i>Haplophragmoides wilberti</i>	0	0	0	0	0	0	0	0	0
<i>Haynesina depressula</i>	5	1	2	0	2	2	4	6	3
<i>Haynesina germanica</i>	43	23	22	5	8	10	1	11	12
<i>Laevipeneroplis proteus</i>	0	0	0	1	0	0	0	0	0
<i>Lobatula</i> sp.	0	0	0	0	0	0	0	0	0
<i>Miliammina fusca</i>	2	2	0	0	2	0	0	1	0
<i>Miliolinella circularis</i>	1	5	5	1	0	0	3	3	11
<i>Miliolinella fichteliana</i>	0	0	0	0	0	0	0	0	0
<i>Miliolinella suborbicularis</i>	0	0	0	0	0	0	0	0	0
<i>Miliolinella subrotunda</i>	3	3	1	3	3	0	1	5	0
<i>Monalysidium politum</i>	0	0	0	0	0	0	0	0	0
<i>Neoconorbina terquemi</i>	0	0	0	0	0	0	0	0	0
<i>Neopateoris</i> sp.	0	0	0	0	0	0	0	0	0
<i>Nonionoides grateloupii</i>	1	0	0	0	1	0	0	0	2
<i>Palmerinella palmerae</i>	9	3	1	0	2	1	1	2	0
<i>Paracassidulina minuta</i>	0	0	0	0	2	1	0	0	0
<i>Paratrochammina challengerii</i>	0	0	0	0	0	0	0	0	0
<i>Peneroplis bradyi</i>	0	0	0	0	0	0	0	0	0
<i>Peneroplis pertusus</i>	0	0	0	0	1	0	0	1	0

**Table E2 (Continued)**

Species	SC135	SC141	SC147	SC159	SC165	SC177	SC61	SC67	SC73
<i>Peneroplis proteus</i>	0	0	0	0	0	0	0	0	0
<i>Planoglabratella opercularis</i>	0	0	0	0	0	1	0	0	0
<i>Planorbulina mediterranensis</i>	0	0	0	0	0	0	0	0	0
<i>Pseudotriloculina granulocostata</i>	0	0	0	0	0	0	0	0	0
<i>Pseudotriloculina linneiana</i>	0	0	3	0	0	0	13	10	2
<i>Pseudotriloculina rotunda</i>	0	2	0	0	0	0	0	0	0
<i>Pseudotriloculina subgranulata</i>	0	0	0	0	0	0	0	0	0
<i>Pyrgo elongata</i>	0	0	0	2	0	0	0	0	0
<i>Pyrgo sarsi</i>	0	0	1	1	0	0	0	0	0
<i>Pyrgo subsphaerica</i>	0	0	0	0	4	0	0	3	0
<i>Pyrgo williamsoni</i>	0	0	0	0	0	0	0	0	0
<i>Quinqueloculina agglutinans</i>	0	3	1	4	4	1	0	0	0
<i>Quinqueloculina bassensis</i>	0	0	0	0	0	0	0	0	0
<i>Quinqueloculina bicarinata</i>	1	5	14	8	4	10	0	15	2
<i>Quinqueloculina bicostata</i>	1	2	0	0	3	0	12	11	3
<i>Quinqueloculina bosciiana</i>	0	6	4	3	12	9	27	7	10
<i>Quinqueloculina candeiana</i>	0	3	2	2	0	4	0	2	2
<i>Quinqueloculina carinata</i>	0	0	2	0	7	0	1	1	0
<i>Quinqueloculina collumnosa</i>	0	0	1	0	0	0	1	1	1
<i>Quinqueloculina compta</i>	0	1	7	1	0	9	17	1	2
<i>Quinqueloculina crassa</i>	1	1	0	2	0	1	7	6	1
<i>Quinqueloculina impressa</i>	11	27	5	1	3	8	13	3	4
<i>Quinqueloculina laevigata</i>	5	17	14	5	6	4	5	8	3
<i>Quinqueloculina lamarckiana</i>	0	0	0	0	0	0	6	2	1
<i>Quinqueloculina linneiana</i>	2	3	2	3	2	2	4	1	3
<i>Quinqueloculina parkeri</i>	0	0	0	0	0	0	0	0	0
<i>Quinqueloculina poeyana</i>	8	13	15	2	3	1	2	11	11
<i>Quinqueloculina seminula</i>	13	19	9	5	16	7	38	10	13
<i>Quinqueloculina sp.</i>	0	0	0	0	0	0	0	0	0
<i>Quinqueloculina striata</i>	0	0	1	3	0	0	0	0	0
<i>Quinqueloculina subpoeyana</i>	0	0	0	0	0	0	0	0	0
<i>Quinqueloculina tenagos</i>	0	4	1	2	8	6	9	0	2
<i>Quinqueloculina tipswordi</i>	0	0	0	0	0	0	1	1	2
<i>Quinqueloculina triangularis</i>	0	0	0	0	0	0	0	0	0
<i>Quinqueloculina vulgaris</i>	0	0	4	0	0	1	3	0	0
<i>Rosalina sp.</i>	0	0	0	1	0	0	0	0	0
<i>Rosalina bahamaensis</i>	0	0	2	0	0	0	0	0	1
<i>Rosalina floridensis</i>	0	2	3	1	3	4	1	1	5
<i>Rosalina subaraucana</i>	0	1	4	4	3	8	0	2	5

**Table E2 (Continued)**

Species	SC135	SC141	SC147	SC159	SC165	SC177	SC61	SC67	SC73
<i>Siphonaperta distorta</i>	0	0	0	0	0	0	0	0	0
<i>Trochammia squamata</i>	0	0	0	0	1	0	0	0	0
<i>Spiroloculina antillarum</i>	0	0	0	0	0	0	0	0	0
<i>Spiroloculina attenuata</i>	0	0	0	0	0	0	0	0	0
<i>Spiroloculina soldanii</i>	0	0	0	0	0	0	0	0	0
<i>Spirotentaria floridana</i>	0	0	0	0	4	0	0	0	0
<i>Textularia</i> sp.	0	0	0	1	0	1	0	0	0
<i>Textularia agglutinans</i>	0	0	0	0	0	0	0	0	0
<i>Textularia candeiana</i>	0	0	0	0	1	2	0	2	0
<i>Triloculina affinis</i>	0	0	0	0	0	0	0	0	0
<i>Triloculina bermudezi</i>	4	15	11	0	0	1	35	7	4
<i>Triloculina elongata</i>	0	0	0	2	0	0	0	0	0
<i>Triloculina fiterrei</i>	0	0	0	0	0	0	0	0	0
<i>Triloculina inflata</i>	0	0	0	0	0	0	3	0	0
<i>Triloculina oblonga</i>	3	2	10	2	2	0	6	1	5
<i>Triloculina rotunda</i>	0	0	1	0	0	0	0	0	0
<i>Triloculina</i> sp.	0	0	0	0	0	0	0	0	0
<i>Triloculina tricarinata</i>	0	0	0	0	0	0	0	0	1
<i>Triloculina trigonula</i>	8	5	4	3	1	0	1	4	2
<i>Triloculina variolata</i>	0	0	0	0	0	1	0	6	0
<i>Tritaxis fusca</i>	0	0	0	0	0	0	0	0	0
<i>Uvigerina laevis</i>	0	0	0	0	0	0	0	0	0
<i>Valvulineria araucana</i>	0	0	0	0	0	0	0	0	0
<i>Vertebrasigmoilina mexicana</i>	0	0	7	3	1	0	0	0	0
<i>Wiesnerella auriculata</i>	0	0	0	0	2	7	0	0	0

**Table E3:** Raw abundance data for sites 85, 114, 120, 128, 132, 81, 93, 95, and 113.

Species	SC85	SC114	SC120	SC128	SC132	SC81	SC93	SC95	SC113
<i>Affinetrina planciana</i>	0	0	0	0	0	0	0	2	0
<i>Ammodiscus tenuis</i>	0	0	0	0	0	0	0	0	0
<i>Ammonia beccarii</i>	2	0	0	0	0	0	3	0	0
<i>Ammonia parkinsoniana</i>	6	0	0	0	0	0	0	1	1
<i>Ammonia takanabensis</i>	0	0	0	0	0	0	0	0	0
<i>Ammonia tepida</i>	6	0	0	0	3	1	0	0	1
<i>Archaias angulatus</i>	0	7	61	3	1	10	5	0	0
<i>Articularia sagra</i>	0	0	0	0	0	0	0	0	0
<i>Articulina antillarum</i>	0	0	0	0	0	0	0	0	0
<i>Articulina mucronata</i>	0	0	0	0	0	0	0	0	0
<i>Articulina pacifica</i>	0	0	5	1	0	0	0	0	0
<i>Bigenerina irregularis</i>	0	0	0	0	0	0	0	0	0
<i>Bigenerina sp.</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina alata</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina albatrossi</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina barbata</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina lanceolata</i>	0	0	0	0	1	0	0	0	0
<i>Bolivina lowmani</i>	0	0	0	0	2	0	0	0	2
<i>Bolivina ordinaria</i>	1	0	0	0	3	0	6	1	5
<i>Bolivina striatula</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina translucens</i>	0	0	2	0	4	0	2	0	7
<i>Bolivinita quadrilatera</i>	0	0	0	0	0	0	0	0	0
<i>Broeckina orbitolitoides</i>	0	7	1	11	0	5	0	0	0
<i>Bulimina marginata</i>	0	0	0	0	0	0	0	0	0
<i>Buliminella elegantissima</i>	0	0	0	0	0	0	0	0	0
<i>Cibicides io</i>	1	0	0	0	3	0	0	0	0
<i>Cibicides kullenbergi</i>	0	0	0	4	2	0	0	0	0
<i>Cibicides mayori</i>	0	0	0	0	0	0	0	0	0
<i>Cibicides mollis</i>	0	0	0	0	0	0	0	0	0
<i>Cibicides rugosus</i>	0	0	0	0	0	0	0	0	0
<i>Cibicides corpulentus</i>	0	0	0	0	0	0	0	0	0
<i>Cibicidoides pachyderma</i>	0	0	0	0	0	0	0	0	0
<i>Cibicidoides robertsoniana</i>	0	0	0	0	2	0	0	0	0
<i>Cibicidoides umbonata</i>	0	0	0	0	0	0	0	0	0
<i>Cibicidoides wuellerstorfi</i>	0	0	0	1	0	0	0	0	0
<i>Clavulina sp.</i>	0	0	0	0	1	0	0	0	0
<i>Cornuspira involvens</i>	0	1	1	0	5	1	5	0	3
<i>Criboelphidium excavatum</i>	0	0	0	0	0	0	0	0	0
<i>Criboelphidium incertum</i>	0	0	0	0	0	0	0	0	0
<i>Criboelphidium poeyanum</i>	4	1	0	2	2	2	1	6	4
<i>Cribrostomoides sp.</i>	0	0	0	0	0	0	0	0	0
<i>Cycloforina sidebottomi</i>	0	0	0	1	0	0	0	0	0
<i>Cyclorbiculina compressa</i>	0	0	0	0	0	0	0	0	0

**Table E3 (Continued)**

Species	SC85	SC114	SC120	SC128	SC132	SC81	SC93	SC95	SC113
<i>Cymbaloporeta atlantica</i>	0	0	0	0	0	0	0	0	0
<i>Discorbis aguayoi</i>	0	0	1	1	2	0	0	0	0
<i>Discorbis mira</i>	3	1	3	0	2	4	0	1	1
<i>Discorbis rosea</i>	0	0	0	0	0	0	0	0	0
<i>Discorbis vilardeboanus</i>	0	0	0	0	0	0	0	0	0
<i>Eggerelloides mississippiensis</i>	0	1	0	0	0	0	0	0	0
<i>Elphidium advenum</i>	1	1	2	2	6	4	11	2	6
<i>Elphidium crispum</i>	0	0	0	0	0	0	0	0	0
<i>Elphidium discoideale</i>	7	12	7	5	18	9	10	4	11
<i>Elphidium fimbriatulum</i>	1	1	5	4	4	0	0	0	5
<i>Elphidium galvestonense</i>	0	0	0	0	4	0	0	0	0
<i>Elphidium gunteri</i>	0	0	0	0	0	1	0	0	0
<i>Elphidium lanieri</i>	0	0	0	0	0	0	1	0	0
<i>Elphidium mexicanum</i>	0	0	0	0	0	0	0	0	0
<i>Epistominella vitrea</i>	0	0	0	0	0	0	0	0	0
<i>Eponides repandus</i>	0	0	0	0	0	0	0	0	0
<i>Eponides turgidus</i>	0	0	0	0	0	0	0	0	0
<i>Eratidus foliaceus</i>	0	0	0	0	0	0	0	0	0
<i>Eubuliminella morgani</i>	0	0	0	0	0	0	0	0	0
<i>Flintinoides labiosa</i>	0	12	1	20	0	12	1	40	0
<i>Fursenkoina compressa</i>	0	0	0	0	0	0	0	0	0
<i>Fursenkoina mexicana</i>	0	0	0	0	0	0	0	0	2
<i>Fursenkoina pontoni</i>	0	0	0	0	0	0	0	0	0
<i>Fursenkoina punctata</i>	0	0	0	0	0	0	0	0	0
<i>Globocassidulina parva</i>	0	0	0	0	0	0	0	0	0
<i>Hanzawaia concentrica</i>	0	0	0	0	0	0	0	0	0
<i>Haplophragmoides wilberti</i>	0	0	0	0	1	0	0	0	0
<i>Haynesina depressula</i>	3	6	1	0	10	2	7	4	11
<i>Haynesina germanica</i>	6	17	11	6	33	11	46	5	47
<i>Laevipeneroplis proteus</i>	0	0	0	0	0	0	0	0	0
<i>Lobatula</i> sp.	0	0	0	0	0	0	0	0	0
<i>Miliammina fusca</i>	0	0	3	0	0	0	0	0	3
<i>Miliolinella circularis</i>	1	9	5	9	3	4	0	7	1
<i>Miliolinella fichteliana</i>	0	0	0	0	0	0	0	0	0
<i>Miliolinella suborbicularis</i>	0	0	0	0	0	0	0	0	0
<i>Miliolinella subrotunda</i>	0	6	1	1	3	5	3	18	1
<i>Monalysidium politum</i>	0	1	0	0	0	0	0	0	0
<i>Neoconorbina terquemi</i>	0	0	0	0	0	0	0	0	0
<i>Neopateoris</i> sp.	0	0	0	0	0	0	0	0	0
<i>Nonionoides grateloupii</i>	0	0	0	0	7	0	2	0	2
<i>Palmerinella palmerae</i>	0	3	0	0	0	6	4	3	1
<i>Paracassidulina minuta</i>	0	0	0	0	1	0	1	0	1
<i>Paratrochammina challengeri</i>	0	0	0	0	0	0	0	0	0
<i>Peneroplis bradyi</i>	0	1	0	0	0	0	0	0	0
<i>Peneroplis pertusus</i>	0	0	3	2	0	1	0	0	0



**Table E3 (Continued)**

Species	SC85	SC114	SC120	SC128	SC132	SC81	SC93	SC95	SC113
<i>Peneroplis proteus</i>	0	0	0	0	0	0	0	0	0
<i>Planoglabratella opercularis</i>	0	0	1	0	1	0	0	0	0
<i>Planorbulina mediterranensis</i>	0	0	0	0	0	0	0	0	0
<i>Pseudotriloculina granulocostata</i>	0	0	0	0	0	0	0	0	0
<i>Pseudotriloculina linneiana</i>	14	2	1	4	1	7	2	4	0
<i>Pseudotriloculina rotunda</i>	0	0	0	0	0	0	0	0	0
<i>Pseudotriloculina subgranulata</i>	0	0	0	0	0	0	0	0	0
<i>Pyrgo elongata</i>	0	0	0	0	0	0	0	0	0
<i>Pyrgo sarsi</i>	0	0	0	0	0	0	0	0	0
<i>Pyrgo subsphaerica</i>	0	1	1	0	1	0	0	0	0
<i>Pyrgo williamsoni</i>	0	0	0	0	0	0	0	0	0
<i>Quinqueloculina agglutinans</i>	0	1	0	0	0	4	1	1	1
<i>Quinqueloculina bassensis</i>	0	0	0	0	0	0	0	0	0
<i>Quinqueloculina bicarinata</i>	0	9	13	12	2	1	9	0	3
<i>Quinqueloculina bicostata</i>	4	4	11	15	1	9	7	3	1
<i>Quinqueloculina bosciiana</i>	5	10	1	6	11	3	8	9	13
<i>Quinqueloculina candeiana</i>	0	1	0	0	1	2	0	0	0
<i>Quinqueloculina carinata</i>	1	2	0	3	4	0	0	6	1
<i>Quinqueloculina collumnosa</i>	0	0	0	11	2	0	0	3	0
<i>Quinqueloculina compta</i>	2	3	3	6	1	1	0	5	6
<i>Quinqueloculina crassa</i>	6	1	2	3	1	6	1	0	1
<i>Quinqueloculina impressa</i>	16	8	3	21	5	2	2	2	1
<i>Quinqueloculina laevigata</i>	2	14	8	5	11	26	11	5	7
<i>Quinqueloculina lamarckiana</i>	0	3	4	3	3	2	0	3	0
<i>Quinqueloculina linneiana</i>	0	0	0	2	0	4	2	0	0
<i>Quinqueloculina parkeri</i>	0	0	0	0	0	0	0	0	0
<i>Quinqueloculina poeyana</i>	12	9	17	10	11	26	4	6	10
<i>Quinqueloculina seminula</i>	49	13	13	18	11	21	19	30	6
<i>Quinqueloculina sp.</i>	0	0	0	0	0	0	0	0	0
<i>Quinqueloculina striata</i>	0	0	0	0	2	0	2	0	0
<i>Quinqueloculina subpoeyana</i>	0	0	0	0	7	0	0	22	8
<i>Quinqueloculina tenagos</i>	2	2	1	3	1	3	5	1	1
<i>Quinqueloculina tipswordi</i>	10	0	0	0	0	0	0	4	3
<i>Quinqueloculina triangularis</i>	0	0	0	0	0	0	0	0	0
<i>Quinqueloculina vulgaris</i>	0	0	0	2	0	3	0	0	0
<i>Rosalina sp.</i>	0	0	0	0	0	0	0	0	0
<i>Rosalina bahamaensis</i>	2	0	1	0	3	0	2	0	1
<i>Rosalina floridensis</i>	0	0	3	0	5	0	4	1	8
<i>Rosalina subaraucana</i>	1	1	2	2	4	5	2	0	6
<i>Siphonaperta distortaqueata</i>	0	0	0	0	0	0	0	0	0
<i>Trochammmina squamata</i>	0	0	0	0	0	0	0	0	3
<i>Spiroloculina antillarum</i>	0	0	0	1	0	1	0	0	0
<i>Spiroloculina attenuata</i>	0	0	0	0	0	0	0	0	0
<i>Spiroloculina soldanii</i>	0	0	0	0	0	0	0	0	0

**Table E3 (Continued)**

Species	SC85	SC114	SC120	SC128	SC132	SC81	SC93	SC95	SC113
<i>Spirotextularia floridana</i>	0	0	0	0	0	0	0	0	0
<i>Textularia</i> sp.	0	0	0	0	0	0	0	0	0
<i>Textularia agglutinans</i>	0	0	0	0	0	0	0	0	0
<i>Textularia candeiana</i>	0	0	0	0	2	0	3	0	2
<i>Triloculina affinis</i>	1	0	0	0	0	0	0	0	0
<i>Triloculina bermudezi</i>	0	23	6	12	3	15	4	43	1
<i>Triloculina elongata</i>	0	0	0	0	0	0	0	0	0
<i>Triloculina fiterrei</i>	0	0	0	0	0	0	0	0	0
<i>Triloculina inflata</i>	10	3	1	2	0	0	0	0	0
<i>Triloculina oblonga</i>	2	2	11	4	4	4	2	3	2
<i>Triloculina rotunda</i>	0	0	0	0	0	0	0	0	0
<i>Triloculina</i> sp.	0	0	0	0	0	0	0	0	0
<i>Triloculina tricarinata</i>	0	1	0	1	0	0	0	1	0
<i>Triloculina trigonula</i>	7	1	4	9	0	7	3	3	0
<i>Triloculina variolata</i>	10	0	0	0	0	0	0	0	0
<i>Tritaxis fusca</i>	0	0	0	0	0	0	0	0	0
<i>Uvigerina laevis</i>	0	0	0	0	0	0	0	0	0
<i>Valvulineria araucana</i>	0	0	0	0	0	0	0	0	0
<i>Vertebrasmolima mexicana</i>	0	0	10	0	0	0	0	0	0
<i>Wiesnerella auriculata</i>	2	0	0	0	0	0	0	0	0

**Table E4:** Raw abundance data for sites 140, 153, 166, 178, 41, 47, 48, 54, and 66.

Species	SC140	SC153	SC166	SC178	SC41	SC47	SC48	SC54	SC66
<i>Affinetrina planciana</i>	0	0	0	0	0	0	0	0	0
<i>Ammodiscus tenuis</i>	0	0	0	2	0	0	0	0	0
<i>Ammonia beccarii</i>	0	0	1	0	1	0	0	1	5
<i>Ammonia parkinsoniana</i>	0	0	2	1	0	1	0	0	4
<i>Ammonia takanabensis</i>	0	0	0	0	0	0	0	0	0
<i>Ammonia tepida</i>	0	0	3	5	0	4	2	2	19
<i>Archaias angulatus</i>	34	12	0	13	3	12	0	8	3
<i>Articularia sagra</i>	0	0	0	0	0	0	0	0	0
<i>Articulina antillarum</i>	0	0	0	0	0	0	0	0	0
<i>Articulina mucronata</i>	1	0	0	0	0	0	0	0	0
<i>Articulina pacifica</i>	3	0	0	0	0	0	0	0	0
<i>Bigenerina irregularis</i>	0	0	0	0	0	0	0	0	2
<i>Bigenerina sp.</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina alata</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina albatrossi</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina barbata</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina lanceolata</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina lowmani</i>	2	3	13	0	0	0	0	0	0
<i>Bolivina ordinaria</i>	0	7	6	5	0	3	0	0	4
<i>Bolivina striatula</i>	0	0	0	0	0	0	0	0	0
<i>Bolivina translucens</i>	0	4	11	1	0	4	0	0	3
<i>Bolivinita quadrilatera</i>	0	0	0	0	0	0	0	0	0
<i>Broeckina orbitolitoides</i>	0	0	0	4	2	1	0	4	1
<i>Bulimina marginata</i>	0	0	0	0	0	1	0	0	0
<i>Buliminella elegantissima</i>	0	0	0	0	0	0	0	0	0
<i>Cibicides io</i>	0	0	1	3	0	0	0	0	0
<i>Cibicides kullenbergi</i>	1	14	8	9	0	0	0	0	0
<i>Cibicides mayori</i>	0	0	0	0	0	0	0	0	0
<i>Cibicides mollis</i>	0	0	0	0	0	0	0	0	0
<i>Cibicides rugosus</i>	0	0	0	0	0	0	0	0	0
<i>Cibicides corpulentus</i>	0	0	0	0	0	0	0	0	0
<i>Cibicidoides pachyderma</i>	0	0	0	0	0	0	0	0	0
<i>Cibicidoides robertsoniana</i>	0	0	0	0	0	0	0	0	0
<i>Cibicidoides umbonata</i>	0	0	0	0	0	0	0	0	0
<i>Cibicidoides wuellerstorfi</i>	0	0	0	0	0	0	0	0	0
<i>Clavulina sp.</i>	0	0	0	0	0	0	0	0	0
<i>Cornuspira involvens</i>	1	0	0	3	0	1	0	1	0
<i>Criboelphidium excavatum</i>	0	0	0	0	0	0	0	0	0
<i>Criboelphidium incertum</i>	0	0	0	0	0	0	0	0	0
<i>Criboelphidium poeyanum</i>	0	1	2	0	1	3	1	3	3
<i>Cribrostomoides sp.</i>	0	0	1	0	0	0	0	0	0
<i>Cycloforina sidebottomi</i>	1	0	0	0	1	1	0	0	0
<i>Cyclorbiculina compressa</i>	0	0	0	0	0	0	0	0	0

**Table E4 (Continued)**

Species	SC140	SC153	SC166	SC178	SC41	SC47	SC48	SC54	SC66
<i>Cymbaloporeta atlantica</i>	1	0	0	0	0	2	0	0	1
<i>Discorbis aguayoi</i>	0	0	0	0	0	0	0	0	0
<i>Discorbis mira</i>	0	0	2	0	0	0	0	0	0
<i>Discorbis rosea</i>	0	0	3	3	0	0	0	0	0
<i>Discorbis vilardeboanus</i>	0	0	0	0	0	0	0	0	0
<i>Eggerelloides mississippiensis</i>	0	0	0	0	0	0	0	0	0
<i>Elphidium advenum</i>	0	1	4	1	0	10	0	0	11
<i>Elphidium crispum</i>	0	0	0	0	0	0	0	0	0
<i>Elphidium discoideale</i>	16	13	21	8	0	13	12	12	11
<i>Elphidium fimbriatulum</i>	3	1	1	3	0	4	0	0	1
<i>Elphidium galvestonense</i>	0	0	0	0	1	2	1	0	1
<i>Elphidium gunteri</i>	1	1	0	0	0	0	1	0	1
<i>Elphidium lanieri</i>	0	0	0	0	0	0	0	0	0
<i>Elphidium mexicanum</i>	0	0	0	0	0	0	0	0	0
<i>Epistominella vitrea</i>	0	0	0	0	0	0	0	0	0
<i>Eponides repandus</i>	0	0	0	0	0	0	0	0	0
<i>Eponides turgidus</i>	0	0	0	0	0	0	0	0	0
<i>Eratidus foliaceus</i>	0	0	0	0	0	2	1	0	2
<i>Eubuliminella morgani</i>	0	0	1	0	0	0	0	0	0
<i>Flintinoides labiosa</i>	5	2	0	3	23	8	5	14	3
<i>Fursenkoina compressa</i>	0	0	0	0	0	0	0	0	1
<i>Fursenkoina mexicana</i>	0	1	4	2	0	0	0	0	2
<i>Fursenkoina pontoni</i>	0	0	0	0	0	0	0	0	0
<i>Fursenkoina punctata</i>	0	0	1	0	0	0	0	0	0
<i>Globocassidulina parva</i>	0	1	0	0	0	0	0	0	0
<i>Hanzawaia concentrica</i>	0	0	0	0	0	0	0	0	1
<i>Haplophragmoides wilberti</i>	0	0	0	0	0	0	0	0	0
<i>Haynesina depressula</i>	8	18	11	7	1	4	0	5	3
<i>Haynesina germanica</i>	24	42	51	8	0	31	5	13	30
<i>Laevipeneroplis proteus</i>	0	0	0	0	0	0	0	0	0
<i>Lobatula</i> sp.	0	0	0	1	0	0	0	0	0
<i>Miliammina fusca</i>	3	0	0	1	0	0	0	0	0
<i>Miliolinella circularis</i>	3	0	1	5	7	1	3	4	1
<i>Miliolinella fichteliana</i>	0	0	0	0	0	0	0	0	0
<i>Miliolinella suborbicularis</i>	0	0	0	0	0	0	0	0	0
<i>Miliolinella subrotunda</i>	1	1	2	3	4	3	0	9	0
<i>Monalysidium politum</i>	0	0	0	0	0	0	0	0	0
<i>Neoconorbina terquemi</i>	0	0	0	0	0	0	0	0	0
<i>Neopateoris</i> sp.	0	0	0	0	0	0	0	0	0
<i>Nonionoides grateloupii</i>	0	3	2	1	0	0	0	0	3
<i>Palmerinella palmerae</i>	1	1	1	1	6	2	2	3	0
<i>Paracassidulina minuta</i>	0	0	1	2	0	0	0	0	2
<i>Paratrochammina challengeri</i>	0	0	0	0	0	0	0	0	0
<i>Peneroplis bradyi</i>	0	0	0	0	0	0	0	0	0
<i>Peneroplis pertusus</i>	0	0	0	1	0	0	0	1	0

**Table E4 (Continued)**

Species	SC140	SC153	SC166	SC178	SC41	SC47	SC48	SC54	SC66
<i>Peneroplis proteus</i>	0	0	0	0	0	0	0	0	0
<i>Planoglabratella opercularis</i>	0	0	0	2	0	0	0	0	0
<i>Planorbulina mediterranensis</i>	0	0	0	0	0	0	0	0	0
<i>Pseudotriloculina granulocostata</i>	0	0	0	0	0	0	0	0	0
<i>Pseudotriloculina linneiana</i>	1	0	2	0	9	0	7	1	1
<i>Pseudotriloculina rotunda</i>	0	0	0	0	0	0	0	1	0
<i>Pseudotriloculina subgranulata</i>	0	0	0	0	0	0	0	0	0
<i>Pyrgo elongata</i>	1	0	0	1	0	0	0	1	0
<i>Pyrgo sarsi</i>	0	0	0	0	0	0	0	0	0
<i>Pyrgo subsphaerica</i>	1	1	0	1	0	0	0	0	0
<i>Pyrgo williamsoni</i>	0	0	0	5	0	0	0	0	0
<i>Quinqueloculina agglutinans</i>	1	3	1	1	1	1	0	0	2
<i>Quinqueloculina bassensis</i>	0	0	0	0	0	0	0	0	0
<i>Quinqueloculina bicarinata</i>	7	1	1	5	0	3	0	3	2
<i>Quinqueloculina bicostata</i>	5	0	0	0	24	1	3	4	2
<i>Quinqueloculina bosciiana</i>	5	8	4	9	16	14	16	3	9
<i>Quinqueloculina candeiana</i>	0	0	0	0	0	0	0	0	1
<i>Quinqueloculina carinata</i>	0	2	4	0	11	0	6	1	0
<i>Quinqueloculina collumnosa</i>	0	0	0	2	0	0	0	0	0
<i>Quinqueloculina compta</i>	12	8	7	6	1	2	4	2	2
<i>Quinqueloculina crassa</i>	1	1	0	1	10	1	9	7	3
<i>Quinqueloculina impressa</i>	7	2	3	2	14	4	7	1	2
<i>Quinqueloculina laevigata</i>	12	14	7	12	9	4	18	15	11
<i>Quinqueloculina lamarckiana</i>	5	0	1	2	2	2	0	0	0
<i>Quinqueloculina linneiana</i>	0	0	0	0	2	2	8	8	5
<i>Quinqueloculina parkeri</i>	0	0	0	0	0	0	0	0	0
<i>Quinqueloculina poeyana</i>	10	6	10	9	16	16	11	9	11
<i>Quinqueloculina seminula</i>	4	9	17	18	45	13	40	34	15
<i>Quinqueloculina sp.</i>	0	0	0	0	0	0	0	0	0
<i>Quinqueloculina striata</i>	0	0	0	0	0	1	0	0	0
<i>Quinqueloculina subpoeyana</i>	6	7	5	7	0	0	0	0	0
<i>Quinqueloculina tenagos</i>	1	0	4	3	28	3	23	8	5
<i>Quinqueloculina tipswordi</i>	1	0	1	0	2	0	0	2	0
<i>Quinqueloculina triangularis</i>	0	0	0	0	0	0	0	0	0
<i>Quinqueloculina vulgaris</i>	2	2	0	0	1	0	1	0	0
<i>Rosalina sp.</i>	0	0	0	0	0	0	0	0	0
<i>Rosalina bahamaensis</i>	1	0	0	0	1	1	0	0	0
<i>Rosalina floridensis</i>	1	8	9	2	0	1	0	2	2
<i>Rosalina subaraucana</i>	3	4	8	9	0	8	0	1	11
<i>Siphonaperta distorta</i>	0	0	0	0	0	0	0	0	0
<i>Trochammina squamata</i>	0	0	0	3	0	2	0	0	2
<i>Spiroloculina antillarum</i>	0	0	0	0	0	0	0	0	0
<i>Spiroloculina attenuata</i>	0	0	0	0	0	0	0	0	0
<i>Spiroloculina soldanii</i>	0	0	0	0	0	0	0	0	0
<i>Spirotextularia floridana</i>	0	0	0	0	0	0	0	0	0

**Table E4 (Continued)**

<b>Species</b>	<b>SC140</b>	<b>SC153</b>	<b>SC166</b>	<b>SC178</b>	<b>SC41</b>	<b>SC47</b>	<b>SC48</b>	<b>SC54</b>	<b>SC66</b>
<i>Textularia</i> sp.	0	0	0	0	0	0	0	0	0
<i>Textularia agglutinans</i>	0	0	0	0	0	0	0	0	1
<i>Textularia candeiana</i>	0	5	3	0	0	0	0	0	3
<i>Triloculina affinis</i>	0	0	0	0	0	0	0	0	0
<i>Triloculina bermudezi</i>	13	4	1	1	35	13	11	28	2
<i>Triloculina elongata</i>	0	0	0	0	0	0	0	0	0
<i>Triloculina fiterrei</i>	0	0	0	0	0	0	0	0	0
<i>Triloculina inflata</i>	3	1	0	0	0	0	0	0	0
<i>Triloculina oblonga</i>	2	0	2	1	0	4	1	2	2
<i>Triloculina rotunda</i>	0	0	0	0	1	1	0	0	0
<i>Triloculina</i> sp.	0	0	0	0	3	1	0	0	0
<i>Triloculina tricarinata</i>	0	0	0	0	0	0	1	0	0
<i>Triloculina trigonula</i>	3	0	1	4	3	1	8	7	0
<i>Triloculina variolata</i>	4	2	0	2	0	1	0	0	0
<i>Tritaxis fusca</i>	0	0	0	0	0	0	0	0	0
<i>Uvigerina laevis</i>	0	0	0	1	0	0	0	0	0
<i>Valvulineria araucana</i>	0	0	0	0	0	0	0	0	0
<i>Vertebrasigmoidina mexicana</i>	4	2	0	0	0	0	0	0	0
<i>Wiesnerella auriculata</i>	0	0	0	0	0	0	0	0	0

**Table E5:** Raw abundance data for sites 72, 174, 180, 204, and 205.

Species	SC72	SC174	SC180	SC204	SC205
<i>Affinetrina planciana</i>	0	0	0	0	0
<i>Ammodiscus tenuis</i>	0	0	0	0	0
<i>Ammonia beccarii</i>	1	1	0	3	0
<i>Ammonia parkinsoniana</i>	37	1	0	9	1
<i>Ammonia takanabensis</i>	0	0	0	0	0
<i>Ammonia tepida</i>	72	0	0	17	1
<i>Archaias angulatus</i>	1	0	38	6	10
<i>Articularia sagra</i>	0	0	0	0	3
<i>Articulina antillarum</i>	0	0	0	0	2
<i>Articulina mucronata</i>	0	0	0	0	0
<i>Articulina pacifica</i>	0	1	0	0	0
<i>Bigenerina irregularis</i>	0	0	0	0	0
<i>Bigenerina sp.</i>	0	0	0	0	0
<i>Bolivina alata</i>	0	0	0	1	0
<i>Bolivina albatrossi</i>	0	0	0	0	1
<i>Bolivina barbata</i>	0	0	0	1	0
<i>Bolivina lanceolata</i>	0	0	0	2	0
<i>Bolivina lowmani</i>	0	5	2	2	0
<i>Bolivina ordinaria</i>	0	6	9	4	4
<i>Bolivina striatula</i>	0	0	0	0	0
<i>Bolivina translucens</i>	2	0	2	3	0
<i>Bolivinita quadrilatera</i>	0	0	0	1	0
<i>Broeckina orbitolitoides</i>	0	0	1	0	7
<i>Bulimina marginata</i>	0	0	0	0	0
<i>Buliminella elegantissima</i>	0	0	1	1	0
<i>Cibicides io</i>	0	0	0	4	0
<i>Cibicides kullenbergi</i>	0	1	1	12	6
<i>Cibicides mayori</i>	0	0	0	0	1
<i>Cibicides mollis</i>	0	1	0	0	1
<i>Cibicides rugosus</i>	0	0	1	0	3
<i>Cibicides corpulentus</i>	0	0	0	0	0
<i>Cibicidoides pachyderma</i>	0	0	0	0	0
<i>Cibicidoides robertsoniana</i>	0	0	0	1	6
<i>Cibicidoides umbonata</i>	0	0	0	0	0
<i>Cibicidoides wuellerstorfi</i>	0	0	0	12	9
<i>Clavulina sp.</i>	0	0	0	0	0
<i>Cornuspira involvens</i>	0	3	2	2	1
<i>Criboelphidium excavatum</i>	0	0	0	0	0
<i>Criboelphidium incertum</i>	0	0	0	0	0
<i>Criboelphidium poeyanum</i>	2	1	1	3	2
<i>Cribrostomoides sp.</i>	0	0	0	0	0
<i>Cycloforina sidebottomi</i>	0	2	0	0	0
<i>Cyclorbiculina compressa</i>	0	0	0	0	0

**Table E5 (Continued)**

Species	SC72	SC174	SC180	SC204	SC205
<i>Cymbaloporeta atlantica</i>	0	0	0	0	2
<i>Discorbis aguayoi</i>	0	0	0	0	0
<i>Discorbis mira</i>	0	0	0	1	0
<i>Discorbis rosea</i>	0	0	0	0	0
<i>Discorbis vilardeboanus</i>	0	0	0	1	0
<i>Eggerelloides mississippiensis</i>	0	0	0	0	0
<i>Elphidium advenum</i>	7	1	0	4	1
<i>Elphidium crispum</i>	0	0	0	0	0
<i>Elphidium discoideale</i>	3	5	9	9	7
<i>Elphidium fimbriatulum</i>	0	0	2	2	2
<i>Elphidium galvestonense</i>	2	0	0	0	0
<i>Elphidium gunteri</i>	0	4	0	0	0
<i>Elphidium lanieri</i>	0	0	0	0	0
<i>Elphidium mexicanum</i>	2	2	0	0	0
<i>Epistominella vitrea</i>	0	0	0	0	0
<i>Eponides repandus</i>	0	0	0	1	0
<i>Eponides turgidus</i>	0	0	0	0	0
<i>Eratidus foliaceus</i>	0	0	0	0	0
<i>Eubuliminella morgani</i>	0	0	0	0	0
<i>Flintinoides labiosa</i>	0	2	1	0	0
<i>Fursenkoina compressa</i>	0	0	0	0	0
<i>Fursenkoina mexicana</i>	0	0	0	0	0
<i>Fursenkoina pontoni</i>	0	0	0	0	0
<i>Fursenkoina punctata</i>	0	0	0	0	0
<i>Globocassidulina parva</i>	0	0	0	1	0
<i>Hanzawaia concentrica</i>	0	0	0	0	0
<i>Haplophragmoides wilberti</i>	0	0	0	0	0
<i>Haynesina depressula</i>	0	4	0	6	2
<i>Haynesina germanica</i>	2	40	29	10	7
<i>Laevipeneroplis proteus</i>	0	0	0	0	0
<i>Lobatula</i> sp.	0	0	0	0	0
<i>Miliammina fusca</i>	4	0	1	3	10
<i>Miliolinella circularis</i>	1	2	1	1	0
<i>Miliolinella fichteliana</i>	0	1	0	0	0
<i>Miliolinella suborbicularis</i>	0	0	0	0	0
<i>Miliolinella subrotunda</i>	0	8	3	2	7
<i>Monalysidium politum</i>	0	0	0	0	2
<i>Neoconorbina terquemi</i>	0	0	0	0	0
<i>Neopateoris</i> sp.	0	0	0	0	0
<i>Nonionoides grateloupii</i>	1	0	0	2	0
<i>Palmerinella palmerae</i>	0	5	3	0	1
<i>Paracassidulina minuta</i>	0	0	0	0	0
<i>Paratrochammina challengeri</i>	0	0	0	0	2
<i>Peneroplis bradyi</i>	0	0	0	0	0
<i>Peneroplis pertusus</i>	0	0	0	0	0



**Table E5 (Continued)**

Species	SC72	SC174	SC180	SC204	SC205
<i>Peneroplis proteus</i>	0	0	0	0	2
<i>Planoglabratella opercularis</i>	0	0	0	0	0
<i>Planorbulina mediterraneensis</i>	0	0	0	1	0
<i>Pseudotriloculina granulocostata</i>	0	0	0	0	1
<i>Pseudotriloculina linneiana</i>	3	1	2	1	0
<i>Pseudotriloculina rotunda</i>	0	0	0	0	0
<i>Pseudotriloculina subgranulata</i>	0	0	0	0	2
<i>Pyrgo elongata</i>	0	0	3	0	0
<i>Pyrgo sarsi</i>	0	0	1	1	4
<i>Pyrgo subsphaerica</i>	0	0	0	0	3
<i>Pyrgo williamsoni</i>	0	0	0	0	0
<i>Quinqueloculina agglutinans</i>	2	0	1	1	2
<i>Quinqueloculina bassensis</i>	0	0	0	0	0
<i>Quinqueloculina bicarinata</i>	5	7	17	3	5
<i>Quinqueloculina bicostata</i>	12	0	0	3	3
<i>Quinqueloculina bosciana</i>	3	2	10	6	8
<i>Quinqueloculina candeiana</i>	0	0	1	0	1
<i>Quinqueloculina carinata</i>	0	1	0	1	0
<i>Quinqueloculina collumnosa</i>	0	0	3	0	3
<i>Quinqueloculina compta</i>	2	18	2	2	2
<i>Quinqueloculina crassa</i>	10	4	1	1	0
<i>Quinqueloculina impressa</i>	3	27	10	3	3
<i>Quinqueloculina laevigata</i>	6	16	8	11	11
<i>Quinqueloculina lamarckiana</i>	0	0	0	0	1
<i>Quinqueloculina linneiana</i>	5	2	1	2	1
<i>Quinqueloculina parkeri</i>	0	0	0	0	0
<i>Quinqueloculina poeyana</i>	11	6	10	6	4
<i>Quinqueloculina seminula</i>	22	20	23	16	8
<i>Quinqueloculina sp.</i>	0	0	0	0	0
<i>Quinqueloculina striata</i>	0	0	0	1	4
<i>Quinqueloculina subpoeyana</i>	0	0	0	0	1
<i>Quinqueloculina tenagos</i>	7	3	5	8	4
<i>Quinqueloculina tipswordi</i>	0	0	0	0	2
<i>Quinqueloculina triangularis</i>	0	0	0	0	0
<i>Quinqueloculina vulgaris</i>	0	1	0	0	0
<i>Rosalina sp.</i>	0	0	0	0	0
<i>Rosalina bahamaensis</i>	0	1	1	1	1
<i>Rosalina floridensis</i>	1	2	0	2	0
<i>Rosalina subaraucana</i>	1	2	2	1	3
<i>Siphonaperta distorta</i>	0	0	0	0	2
<i>Trochammia squamata</i>	0	0	0	0	0
<i>Spiroloculina antillarum</i>	0	0	0	0	0
<i>Spiroloculina attenuata</i>	0	0	0	0	1
<i>Spiroloculina soldanii</i>	0	0	0	0	0
<i>Spirotextularia floridana</i>	0	0	0	0	0

**Table E5 (Continued)**

<b>Species</b>	<b>SC72</b>	<b>SC174</b>	<b>SC180</b>	<b>SC204</b>	<b>SC205</b>
<i>Textularia</i> sp.	0	0	0	0	0
<i>Textularia agglutinans</i>	0	0	0	0	0
<i>Textularia candeiana</i>	0	0	0	1	1
<i>Triloculina affinis</i>	0	0	0	0	0
<i>Triloculina bermudezi</i>	1	20	3	0	4
<i>Triloculina elongata</i>	0	0	0	0	0
<i>Triloculina fiterrei</i>	1	0	0	0	0
<i>Triloculina inflata</i>	0	0	0	0	0
<i>Triloculina oblonga</i>	4	6	10	4	3
<i>Triloculina rotunda</i>	0	1	2	0	0
<i>Triloculina</i> sp.	3	0	0	0	0
<i>Triloculina tricarinata</i>	0	0	0	0	0
<i>Triloculina trigonula</i>	3	10	2	6	7
<i>Triloculina variolata</i>	0	0	2	0	0
<i>Tritaxis fusca</i>	0	0	0	1	1
<i>Uvigerina laevis</i>	0	0	0	0	0
<i>Valvulineria araucana</i>	0	0	0	5	0
<i>Vertebrasigmoidina mexicana</i>	0	0	0	0	0
<i>Wiesnerella auriculata</i>	0	0	0	3	0