FORAMINIFERAL AND GEOCHEMICAL EVIDENCE OF ENVIRONMENTAL CHANGE IN RESPONSE TO AQUACULTURE IN THE SETIU ESTUARINE-LAGOONAL SYSTEM, TERENGGANU, MALAYSIA

by

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April 2013

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In many coastal communities, aquaculture is an important part of the local economy, though fish and shrimp farms may threaten habitats in these coastal systems. Aquaculture was introduced to the Setiu estuarine-lagoonal system (SEL) in Terengganu, Malaysia in the mid-1970s. As fish farm densities increase and the mangroves are cleared, excess nutrients and fish waste are supplied to the water column and sediments below. In order for the aquaculture industry in Terengganu, Malaysia to be successful, estuarine-lagoonal environmental health should be monitored. Analyses of foraminiferal assemblages, sedimentological analyses, and $\delta^{13}C$, $\delta^{15}N$, and C:N ratios are used here to determine how aquaculture in the SEL affects benthic communities, sources of organic matter, and grain size and sediment composition.

Three cores were collected beneath fish cage sites, two (S43 and S40) from the northern lagoon region and one (S9A) from the southern estuary region. Cores S43 and S40 contain both calcareous and agglutinated foraminifera, though calcareous are dominant. Agglutinated specimens increase in abundance near the top of S43 and S40,which is likely in response to an increase in organic matter.. *Ammonia* aff. *A. aoteana* and *Ammobaculites exiguus* are the most abundant species in the middle and upper sections of S43, and *Ammonia* aff. *A. aoteana* and *Rosalina globularis* are the most abundant in the bottom of S43. *Ammonia* aff. *A aoteana* is

most abundant throughout all of S40. Core S9A contains only agglutinated foraminifera, with *Trochammina amnicola*, *Ammotium directum*, and *Miliammina fusca* as the most abundant species. The percent of live specimens is relatively low in all three cores. The densities of dead foraminifera at S43 and S40 are extremely high at the onset of aquaculture and near the surface of S40 where the amount of organic matter is less. These high densities are attributed to a baffling effect created by the fish cages as tidal currents push sediments north in the lagoon.

$\delta^{13}C$ and $\delta^{15}N$ signatures in the sediments beneath fish cages do not show trends through time and are similar to signatures of terrestrial sources, including mangroves. Percent carbon, percent nitrogen, and percent mud increase through time throughout S43 and S40, though patterns reverse in core S40. The reversal of patterns in core S40 is possibly related to the closure of a southern inlet in 2003. Throughout S9A, these same measurements first increase through time but then decrease, probably corresponding to the abandonment of fish farms.

In summary, aquaculture has affected organic matter content, sediment characteristics, and foraminiferal distributions in the SEL. However, rapid return to pre-aquaculture conditions after the abandonment of S9A and a slower return to pre-aquaculture conditions in S40, likely as a result of tidal flushing, suggest that environmental health of the SEL is not particularly compromised by the current scale of floating fish cage aquaculture.

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A Thesis/Dissertation

Presented To the Faculty of the Department of Geological Sciences

East Carolina University

In Partial Fulfillment of the Requirements for the Degree

Master of Science in Geological Sciences

by

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April, 2013

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ACKNOWLEDGMENTS

I would like to first thank my advisor, Dr. Stephen Culver, for all of his help and support on this thesis project. I am so grateful that he was so readily available to give advice at all times. I would also like to thank my other committee members, Dr. Reide Corbett, Dr. David Mallinson, and Dr. Martin Buzas for all of their advice and support in analyzing and interpreting data.

I would like to thank East Carolina University and the Universiti Malaysia Terengganu for funding. Thank you also to Dr. Noor Shazili at the Universiti Malaysia Terengganu for assisting with sample collection and planning in Malaysia. Also thanks to Dr. Mohd Lokman Husain, Director of the Institute of Oceanography at the Universiti Malaysia Terengganu, for all of the help received with this project.

To the rest of the Department of Geological Sciences at East Carolina University, I would like to say thank you for all of their guidance and support throughout my entire graduate school experience. I would especially like to thank Dr. Terri Woods for all of her help in working through the graduate program and for being so supportive. Additionally, thanks to Jim Watson and John Woods for providing me with working computers and the programs necessary to complete my thesis as well as a safe laboratory space.

Alisha Ellis provided one of the greatest support systems I had while working on this project. I would not have been nearly as productive or as confident in my labwork, data analysis, and writing without her. For that, I am very grateful. I would really like to thank David Young, Kim Scalise, Stephanie Balbuena, Megan Javonovich, and Jaimi Flynn for guidance and assistance with labwork. I really appreciate all of their help. Additionally, thank you to the rest of my micropaleontology lab mates, including Kelli Moran, Ray Tichenor, Caitlin Lauback, and

Anna Lee Woodson for guidance in foraminiferal labwork and for providing a great support system.

Finally, I would like to thank my family, especially my parents, Jayne and Dan Thornberg, for all of their support and guidance over the years, which influenced me to choose the path to graduate school and ultimately a career in geology.

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INTRODUCTION

Aquaculture is a growing industry throughout the world, especially in Asia (Dey and Ahmed, 2005). In Malaysia, in particular, fish cage farming practices have been increasing dramatically (Alongi and others, 2003). Many have shown that this practice is altering benthic environments in coastal zones (e.g., Clark, 1971; Scott, and others, 1995; Tarasova and Preobrazhenskaya, 2007). Both finfish and shellfish farms are important to the local economy in many coastal communities. However, there is likely a limit to this industry's expansion if it is to remain environmentally sustainable.

The input of excess nutrients and organic matter, such as those from aquaculture operations, to bottom sediments can result in changes to water quality, benthic communities, geochemistry of the sediments, and sediment characteristics (e.g., Clark, 1971; Grant and others, 1995; Scott and others, 1995; Tarasova, 2006; Yokoyama and others, 2006; Tarasova and Preobrazhenskaya, 2007). The extent of the environmental impact of aquaculture is dependent on the amount of nutrients and organic matter released (Ackefors and Enell, 1994; Wu, 1995). Major impacts to the water column and bottom sediments may include low levels of dissolved oxygen, the production of toxic gases, and increased levels of nitrogen and phosphorous. Poor water quality results in an unsustainable environment for fish farms (Wu, 1995; Axler and others, 1996).

The Setiu estuarine-lagoonal system (SEL), located in Terengganu, Malaysia, is separated from the South China Sea by a barrier island which contains one small inlet at present (Fig. 1). The southern, estuarine end of the system receives freshwater discharge from the Setiu and Caluk Rivers. Salinity at this end ranges from <1 to about 2. Estuarine salinity in the vicinity of the inlet reaches 32. The northern, lagoonal end of the SEL has salinity ranging from 19 to 32. Water depths range from 0.5 to 3 m throughout the SEL. Studies of sediment grain size distributions in the Setiu estuary-lagoon undertaken over the past 15 years show that seasonal physical changes (in wind, wave, tide, and current patterns) occur in the estuary-lagoon and as a result, sediment distribution patterns are complicated (Rosnan, 1988; Rosnan and others, 1995; Rosnan and Mustapa, 2010). In the estuary region, the movement of water is characterized by a combination of tidal and riverine currents, but in the lagoon region, tidal currents are dominant (Rosnan and others, 1995; Rosnan and Mustapa, 2010). On the ocean side of the barrier island, the mean spring tidal range is 1.8 m (Phillips, 1985) and slightly less within the lagoon (Culver and others, 2012). Both the estuary and lagoon regions have a range of grain sizes from mud and fine sand to very coarse sand (Culver and others, 2012), though the estuary has higher percentages of sand and the lagoon has higher percentages of silt (Rosnan and others, 1995). Sediments in the lower lagoon are well-sorted, while sediments in the upper lagoon and estuary are more poorly sorted (Culver and others, 2012). Sediments throughout the estuary-lagoon exhibit negative skewness, indicating that there is more coarse sediment present than fine sediment; skewness is shown to decrease as grain size increases (Rosnan and others, 2010).

Finfish and shellfish aquaculture operations were first introduced throughout the Setiu back-barrier system in the mid-1970s. Although the industry has grown dramatically, environmental changes in the estuary-lagoon as a result of aquaculture have not previously been evaluated. Mangrove swamps, containing mostly C_3 plants, have been partially cleared to construct aquaculture pens, and the number of fish pens and floating cages has increased. As a result, excess nutrients, fish waste, and fish feed waste are added to the SEL. Analyses of benthic foraminiferal assemblages, geochemistry, sedimentology, and geochronology are used here to determine how the foraminiferal community, sources of organic matter, and sediment characteristics have changed since aquaculture was introduced to the SEL.

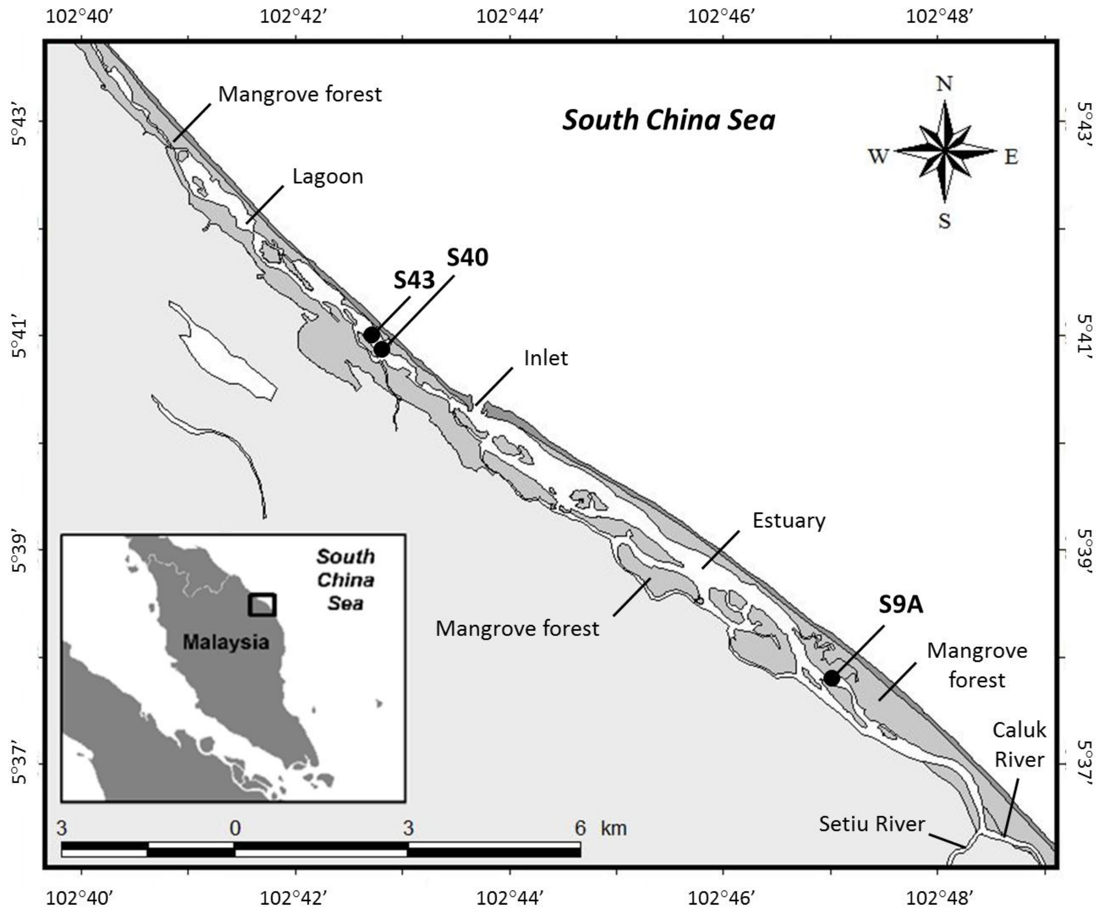

Figure 1. Setiu estuary-lagoon in Terengganu, Malaysia. Closed circles are sites where cores were collected. The lagoon and estuary are located to the north and south of the inlet, respectively.

BACKGROUND

Geochronology: ^{210}Pb

Sediment accumulation rates and a downcore chronology can be determined through the measurement of radioisotopes such as ^{210}Pb (e.g., Nittrouer and others, 1979; Corbett and others, 2006; Corbett and others, 2007; Palinkas and Nittrouer, 2007; Zaborska and others, 2007). ^{210}Pb is part of the ^{238}U series and is added to estuarine environments through atmospheric deposition, runoff, and in situ decay of ^{226}Ra (Nittrouer and others, 1979).

Methods of measuring ^{210}Pb include gamma spectroscopy, a direct measurement of ^{210}Pb, and alpha spectroscopy, a measurement of ^{210}Po that assumes secular equilibrium with ^{210}Pb (Zaborska and others, 2007). Corbett and others (2007) used gamma spectroscopy to measure ^{210}Pb and ^{137}Cs in the Albemarle Sound estuary in North Carolina in order to determine sediment accumulation rates. Results showed that rates of accumulation varied throughout the estuary and through time. Alpha spectroscopy was used by Palinkas and Nittrouer (2007) to measure sediment accumulation rates on the Po shelf in the Adriatic Sea. The character of ^{210}Pb profiles can demonstrate whether sediment accumulation is steady state, transitional, or non-steady state. The ^{210}Pb profiles produced from Po shelf samples demonstrated rapid non-steady state accumulation. Palinkas and Nittrouer (2007) suggested that this means that sediment accumulation on the Po shelf is the result of floods.

The use of ^{210}Pb typically requires an independent tracer, such as ^{137}Cs, to corroborate the sediment accumulation and geochronology results (Corbett, 2006, 2007). However, ^{137}Cs, an anthropogenically introduced radionuclide, has low deposition rates in the southern hemisphere and closer to the equator. This makes substantiating the ^{210}Pb results difficult.

FORAMINIFERA

Foraminifera are excellent indicators of environmental conditions because they have a widespread geographic distribution (Murray, 1978, 2006; Culver and Buzas, 1999; Scott and others, 2001; Hayek and Buzas, 2006; Tarasova and Preobrazhenskaya, 2007), have varying test morphologies (Loeblich and Tappan, 1964; Tarasova, 2006), short life cycles (Alve, 1995, Tarasova, 2006), are abundant in small sample sizes (Schafer, 2000; Scott and others, 2001; Hallock, 2003), and are sensitive to many environmental variables (Sen Gupta, 1999; Scott and others, 2001; Murray, 2006). Changes in the marine environment can therefore be identified through the analysis of foraminiferal assemblages (e.g., Culver and Buzas, 1995; Alve, 1995; Cearetta and others, 2000, 2002; Scott and others, 2001; Hallock, 2003; Tarasova and Preobrazhenskaya, 2007). For example, variations in species composition, abundance, diversity, population density, etc., may reflect the input of pollutants, excess nutrients, and/or organic matter (Alve, 1995; Culver and Buzas, 1995).

Some studies have shown that high levels of organic matter in bottom sediments may alter foraminiferal communities (e.g., Hald and Steinsund, 1992; Angel and others, 2000; Luan and Debenay, 2005; Debenay and others, 2009a, 2009b), but other studies suggest that foraminifera are unaffected by excess organic matter (e.g., Grant and others, 1995; Scott, 1995). Schafer and others (1995) found that the relationship between live foraminiferal abundances and organic matter loading vary with species and with season. Although there are various opinions on whether the amount of organic matter affects foraminiferal assemblage composition and distribution, there is an inverse relationship between organic carbon content and total foraminiferal abundance (Tarasova, 2006).

Aquacultural operations, including finfish and shellfish farms, are often responsible for the addition of excess organic matter to bottom sediments (Alve, 1995; Scott and others, 1995; Grant and others, 1995; Tarasova, 2006; Tarasova and Preobrazhenskaya, 2007). Much of this excess organic matter is derived from fish feed waste and fish feces (Clark, 1971). Angel and others (2000) used loss on ignition (LOI) to determine the amount of organic matter present beneath a fish farm in the Gulf of Eilat and found that as LOI increased, the total number of individuals of foraminifera and species richness decreased.

A number of studies have demonstrated that the presence of aquaculture operations alters benthic foraminiferal communities. At a finfish farm in Clam Bay, Nova Scotia, Clark (1971) found that when usage of the farm increased, the number of individual foraminifera decreased. Similarly, foraminiferal abundance was lower beneath a fish farm relative to abundances measured at reference sites in the Gulf of Eilat (Angel and others, 2000). At a scallop aquaculture site in Minonosok Bay in the Sea of Japan, Tarasova and Preobrazhenskaya (2007) found that foraminifera directly below cages exhibited the smallest number of species, the lowest population density and the smallest percent of live foraminifera. This may be because the composition and distribution of the foraminiferal community reflect sediment characteristics, which are associated with the amount and type of organic matter present (Tarasova, 2006).

Other studies, however, have shown that foraminifera can be unaffected or exhibit minimal changes as a result of aquaculture. Results from a study done on a shellfish farm and a salmon farm in eastern Canada suggest that aquaculture had little to no effect on foraminiferal assemblages (Scott and others, 1995). Similar results were found at a mussel farm in Nova Scotia (Grant and others, 1995).

The presence of aquaculture often results in an increase in organic matter loading to the sediments beneath fish cages. This increase in organic matter, estimated by measurements of LOI or percent carbon, may result in a decrease in densities of the total foraminiferal assemblage, percent live foraminifera, and species richness of the total assemblage.

SEDIMENTOLOGY

Finfish aquaculture, such as that of salmon, results in a decrease in sediment grain size and an increase in sediment organic content (e.g., Mojica and Nelson, 1993) in the vicinity of the aquaculture. At a clam farm in Indian River Lagoon, Florida, Mojica and Nelson (1993) found that the mean grain size was significantly smaller, the percent of silt and clay was higher, and the percent of volatile solids beneath the farm was significantly higher in relation to nearby reference sites. The smaller grain size was attributed to the deposition of feces or pseudofeces (masses of particles rejected as food and wrapped in mucus) from the filter-feeding clams.

GEOCHEMISTRY: CARBON AND NITROGEN

Organic matter and organic carbon in estuarine environments have a variety of sources, including river inflow, marine input from nearby coastal waters, atmospheric input, primary production, and anthropogenic sources (Matson and Brinson, 1990; Thornton and McManus, 1994; Maksymowska and others, 2000). Carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopic composition of organic matter, in addition to C:N ratios, are widely used to determine the source of organic matter (Matson and Brinson, 1990; Maksymowska and others, 2000). The isotopic composition of organic matter varies depending on its source (Figure 2).

For instance, the $\delta^{13}C$ of C_3 plants is between -30‰ and -23‰ and for C_4 plants, $\delta^{13}C$ is between -17‰ and -9‰ (Smith and Epstein, 1971; Fry and Sherr, 1984; Peterson and Fry, 1987; Cai and others, 1988; Boutton, 1991; Maksymowska and others, 2000). The $\delta^{13}C$ of marine algae ranges from -24‰ to -18‰ and the $\delta^{13}C$ of river/estuarine algae ranges between -35‰ and -25‰ (Fry and Sherr, 1984; Tucker and others, 1999; Maksymowska and others, 2000; Sampaio and others, 2010).

The $\delta^{15}N$ of C_3 plants is between -5‰ and 18‰ and for C_4 plants, $\delta^{15}N$ is between 3‰ and 6‰ (Peters and others, 1978; Sweeney and Kaplan, 1980; Owens, 1987; Maksymowska and others, 2000). The $\delta^{15}N$ of marine algae is between 4‰ and 9‰ and the $\delta^{15}N$ of river/estuarine algae is near 5‰ (Owens, 1987; Maksymowska and others, 2000).

The C:N ratio of C_3 plants and C_4 plants is greater than 15 (Meyers, 1997; Maksymowska and others, 2000; Kuramoto and Minagawa, 2001; Hu and others, 2006). The C:N ratio of marine algae is between 5 and 8 (Meyers, 1997; Maksymowska and others, 2000; Hu and others, 2006). River/estuarine algae have a C:N ratio between 5 and 14 (Matson and Brinson, 1990; Thornton and McManus, 1994; Maksymowska and others, 2000).

In the Tay Estuary in Scotland, Thornton and McManus (1994) used $\delta^{13}C$, $\delta^{15}N$, and C:N ratios to find that the upper estuary receives organic matter primarily by river input, and the middle to lower estuary is more influenced by marine-derived organic matter. Maksymowska and others (2000) used $\delta^{13}C$, $\delta^{15}N$, and C:N ratios to identify the source of organic matter in the Gulf of Gdansk and found the main sources (autochthonous primary production and river inflow) were distinguishable based only on their carbon isotopic compositions. $\delta^{15}N$ is seasonally variable and C:N ratios between marine and river sources were undistinguishable in the Gulf. Corbett and others (2007) used $\delta^{13}C$, $\delta^{15}N$, and C:N ratios to analyze environmental change in the Albemarle Sound estuary in North Carolina, USA. They found that $\delta^{13}C$ decreased over time, while $\delta^{15}N$ increased over time, suggesting a change from a marine-influenced environment in the past to a modern terrestrially-influenced environment.

Carbon and nitrogen isotopic values have been measured in some estuaries in order to determine the influence of mangrove forests on the type of organic matter present. In the Guayas River estuarine ecosystem in Ecuador, deforestation of mangrove swamps for the development of shrimp ponds may be responsible for the input of excess organic matter to the estuary (Cifuentes and others, 1996). Cifuentes and others (1996) measured the $\delta^{13}C$ and $\delta^{15}N$ of suspended particulate matter in the estuary and found that it matched that of reported values for mangrove leaves from the estuary. The C:N ratio value was low (14:1), suggesting an enrichment in nitrogen, possibly due to the bacterial immobilization of nitrogen onto detritus. Xue and others (2009) measured the $\delta^{13}C$ and C:N ratio of organic matter in the Zhangjiang Estuary mangrove wetland in China in order to characterize mangrove swamp-derived organic matter in the estuary. Values measured in the estuary ($\delta^{13}C$ range = -21.6‰ to -25.5‰, average C:N = 8:1) did not match those measured from mangrove plant samples (average $\delta^{13}C$ = -29.8‰, average C:N = 15:1), suggesting that much of the organic matter in the estuary is not derived from the mangroves.

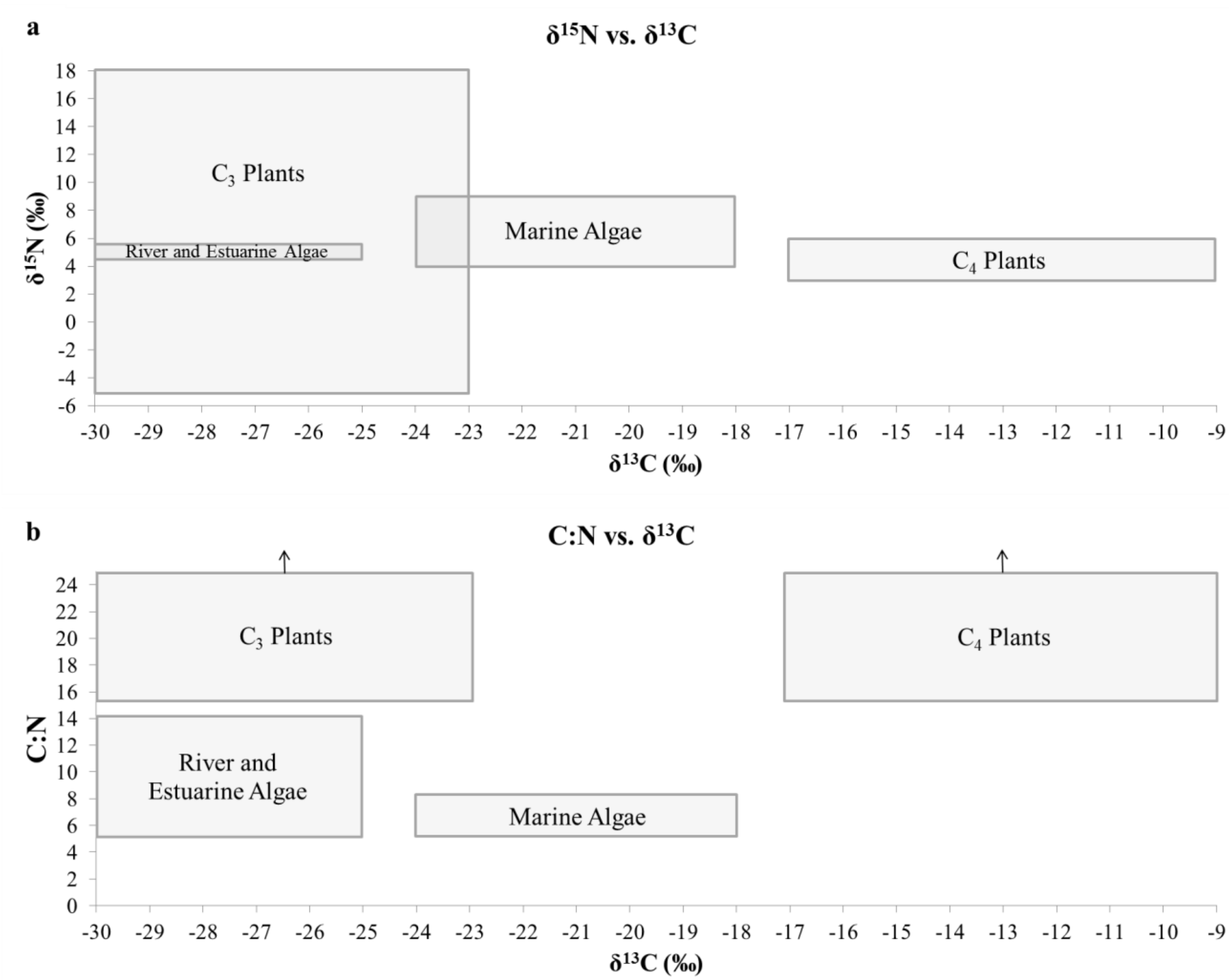

Figure 2. $\delta^{13}C$, $\delta^{15}N$, and C:N ratio ranges for end member sources of organic matter.

Carroll and others (2003) analyzed data from environmental survey samples taken near salmon cage farms in Norway and found that the total organic carbon present in the sediments closest to the cages was much higher than in sediments farther from the cages. Yokoyama and others (2006) found similar results at a fish farm in Gokasho Bay, Japan; both organic carbon and nitrogen were higher beneath cages than at locations farther away. Grant and others (1995) and Scott and others (1995) reported layers of black, organic matter-rich, sandy mud associated with the onset of aquaculture in a mussel farm in Nova Scotia and a salmon farm in eastern Canada, respectively. Karakassis and others (1998) found increased %LOI in near-surface sediments collected beneath fish farms in Cephalonia Bay in Greece. They associated this with the increased amount of organic matter collecting beneath the cages.

Yokoyama and others (2006) determined the values of $\delta^{13}C$ and $\delta^{15}N$ for fish feed and fish feces, in addition to sedimentary organic matter beneath and away from the influence of the Gokasho Bay, Japan, fish cages. Organic matter near the aquaculture site exhibited depleted of $\delta^{13}C$ values ($\Delta\ \delta^{13}C$ = -0.4‰) compared to reference sites ($\delta^{13}C$ = -21‰), which corresponded to the accumulation of fecal matter ($\delta^{13}C$ = -24.3‰) (Yokoyama and others, 2006). Yokoyama and others (2006) found enriched $\delta^{15}N$ ($\Delta\ \delta^{15}N$ = +0.9‰) near the cages, which was likely the result of the accumulation of waste feed $\delta^{15}N$ (9.7‰). The enriched $\delta^{15}N$ values also may have been the result of denitrification, which occurs when oxygen is depleted; decomposition of fish feed may have led to deoxygenation in the sediments (Yokoyama and others, 2006). Yamada and others (2003) also compared values of $\delta^{13}C$ and $\delta^{15}N$ throughout cores beneath the fish cages in Gokasho Bay with different types of fish feed. Yamada and others (2003) found decreasing levels of $\delta^{13}C$ upcore (-20.5‰ to -21.5‰). They also found that $\delta^{15}N$ increased up-core (5.5‰ to 7‰) and demonstrated that changes reflected the type of type of fish feed used.

Additionally, a relationship has been found between other sediment characteristics and geochemistry within estuaries. For example, data gathered by Thornton and McManus (1994) in the Tay Estuary show that coarse grained sediment samples have higher C:N ratios than fine grained samples. Corbett and others (2007) found an inverse relationship between grain size and percent organic matter in the Albemarle Sound estuary, USA, with grain size decreasing through time and percent organic matter increasing; gradational trends of $\delta^{13}C$ and $\delta^{15}N$ occurred in the cores as well.

The presence of aquaculture often results in an increase in organic matter in the sediments beneath the fish cages. $\delta^{13}C$ and $\delta^{15}N$ signatures and C:N ratios in the sediments can be evaluated to determine if the source of this organic matter is from the fish cages. Additionally, percent carbon and percent nitrogen can be used to estimate the amount of organic matter present beneath the cages.

METHODS

FIELD

In the summer of 2011, three 10.16-cm diameter push cores (S43, S40, S9A) were collected beneath fish cages at three locations in the Setiu estuary-lagoon (Table 1; Figs. 1, 3). S43 and S40 are located in the northern lagoon region, where salinity was 23 and 27, respectively. S9A is located in the southern estuary region, where salinity was <1. The cores penetrated into sediments considered to precede the installment of fish farms (mid 1970s). S43 extends to 72 cm, S40 extends to 56 cm, and S9A extends to 30 cm. In the field, the cores were sectioned into contiguous 2-cm intervals, each divided into four subsamples for foraminiferal, geochemical, sedimentological, and geochronological analyses. Foraminiferal samples were standardized to 20 ml in a measurement cup.

Table 1. Location of cores and values of environmental variables.

Site	Latitude (N)	Longitude (E)	Water Depth (m)	Salinity	DO (mg/L)	pH	Length of core (cm)	Status of fish cage complex
S43	5.69071	102.70319	1.4	23.4	4.02	7.25	72	active
S40	5.68221	102.71170	2.3	27.1	4.42	7.94	56	active
S9A	5.62813	102.78669	2.0	1.0	4.15	6.84	30	abandoned

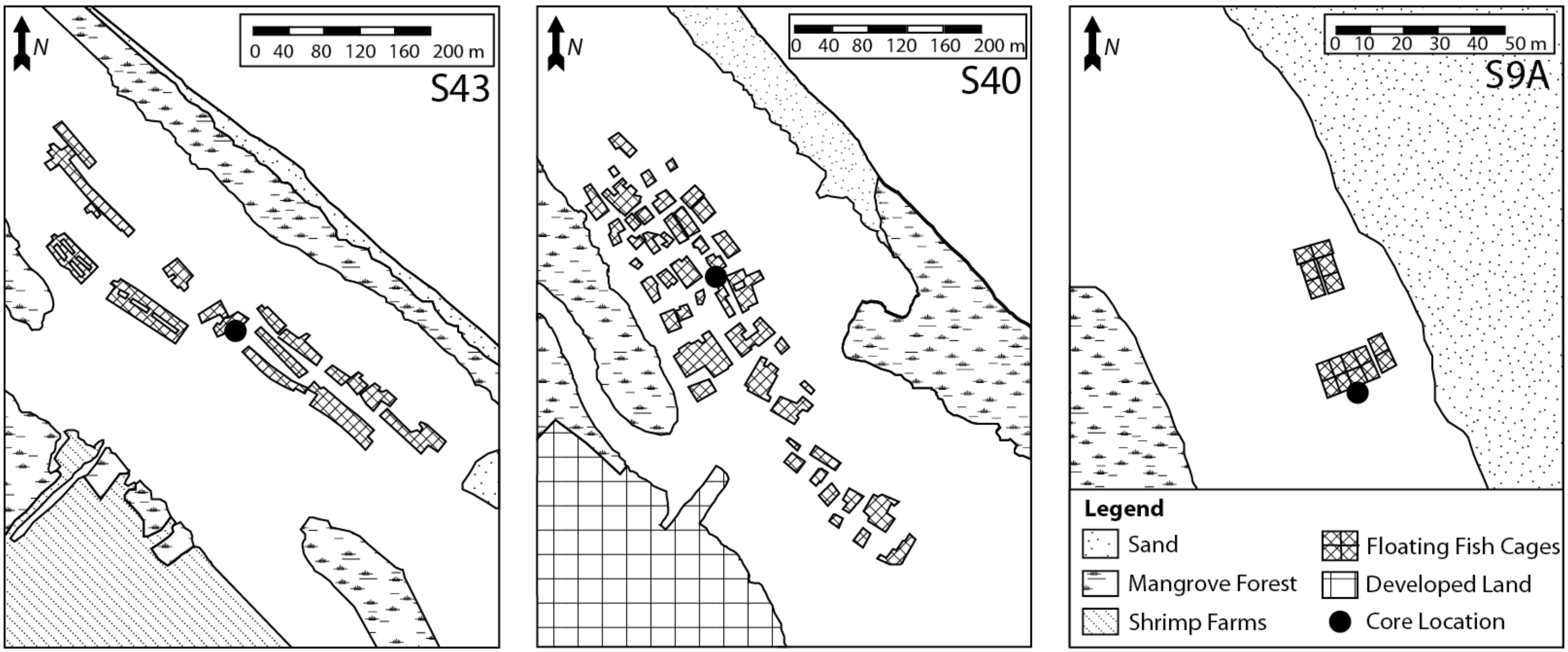

Figure 3. Core locations within each fish cage complex.

GEOCHRONOLOGY : ^{210}PB

Activities of ^{210}Pb were determined through alpha and gamma spectroscopy. Each sample was first dried at 60°C and then homogenized with a mortar and pestle. For alpha spectroscopy, methods were similar to those used by Nittrouer and others (1979). Approximately 1–1.5 g of each sample was treated with 1.0 ml of ^{209}Po and 15 ml of 8M HNO_3. Samples were then dried in a microwave and transferred to centrifuge tubes with approximately 45–50 ml of DI water. Tubes were centrifuged at 2500 rpm for 2 minutes and the supernate was transferred to Teflon beakers on a hot plate. Centrifuge tubes were rinsed with 5 ml of 8M HNO_3 and centrifuged again at 2500 rpm for 2 minutes. The supernate was again added to the appropriate beakers with 1–2 ml of H_2O_2. The samples were taken to near dryness and diluted with approximately 25–30 ml of DI water. While solutions were rapidly stirred, NH_4OH was added until the pH reached 8, when iron precipitated out. Solutions were then transferred to centrifuge tubes, topped off with DI water, and centrifuged at 2500 rpm for 2 minutes. The supernate was decanted and discarded. Precipitates were rinsed with approximately 25 ml of DI water and centrifuged again. This process was repeated one additional time. The precipitates were dissolved by adding 3.75 ml of HCl and then diluted with DI water. The solutions were poured onto nickel discs in Teflon beakers (Corbett and others, 2006; modified from Flynn, 1968). Ascorbic acid was added until the color of the solutions became clear. The solutions were spun for 20–40 hours. The plated discs were rinsed with DI water, patted dry, and transferred to alpha spectroscopy detectors for counting.

For gamma spectroscopy, dried, homogenized samples were packed into petri dishes and sealed. After 3 weeks, gamma counting was performed on a low-background, high-efficiency, high-purity Germanium detector coupled with a multi-channel analyzer. Activities were corrected for self absorption using a direct transmission method (Cable and others, 2001). Gamma spectroscopy was also used to indirectly determine ^{226}Ra activities by counting the gamma emissions of its granddaughters, ^{214}Pb (295 and 351 keV) and ^{214}Bi (609 keV). Excess ^{210}Pb activities were determined by subtracting total ^{210}Pb (46.5 keV) from that supported by ^{226}Ra.

Foraminifera

Foraminiferal samples (20 ml) were preserved in 70% alcohol and stained with rose Bengal to determine which specimens were alive or recently dead at the time of collection (Walton, 1952). Each 20-ml sample was washed over 710-µm and 63-µm sieves to remove silt and clay and coarse grained material. Foraminifera were separated from quartz sand by floatation with sodium polytungstate (Munsterman and Kerstholt, 1996). Samples were dried at 60°C and separated into aliquots using a microsplitter. Approximately 200 specimens per sample (unless the total number of specimens in the sample was less than 200) were picked from randomly selected squares on a gridded picking tray. Specimens were identified to the species level by comparison with published literature (e.g., Brönnimann and others, 1992; Jones, 1994; Loeblich and Tappan, 1994) including work undertaken previously in the SEL (Culver and others, 2012). Identifications were verified by comparison with collections housed in the Smithsonian Institution, Washington, D.C. Foraminiferal densities, species richness, and species composition were examined.

Q-mode cluster analysis (Mello and Buzas, 1968) of the data set composed of dead abundances (79 samples) was used to identify changes in foraminiferal assemblages through time and between cores. All taxa that made up 2% or more of the total abundance in any one sample were included in the analysis. Species proportions were transformed to 2 arc sin square root of

p_i, where p_i is the proportion of the *i*th species within the sample (Bartlett, 1947). A cluster analysis of the transformed data was run on SYSTAT version 13.0 using Ward's linkage method and Euclidean distances. A similar analysis was run on the data set that included only live abundances. Many samples contained no live specimens and those that did contained relatively few; the cluster analysis, therefore, revealed no patterns within or between the three cores, so these results will not be discussed further. For the analysis run on the data set that included both live and dead abundances, the results were near identical to that of the analysis of dead taxa only, so they will also not be discussed further.

Species richness (S), density, and Fisher's alpha index were also analyzed throughout each core to evaluate foraminiferal assemblages. Fisher's alpha index was determined for the total assemblage (live + dead foraminifera). This index is the parameter of the log series distribution (Fisher and others, 1943). It is essentially the number of species expected with one individual.

SEDIMENTOLOGY

Sedimentological samples were first dried overnight at 50°C and soaked in 0.05% Calgon solution. They were then wet-sieved over 63-µm sieves in order to separate the sand and mud fractions. The Ro-Tap method was used to separate the sand fraction. Sieves ranged from -2.0 to 4.0 phi in increments of 0.5 phi. Average grain size for each 2–cm interval was determined through weight percentages.

GEOCHEMISTRY: CARBON AND NITROGEN

Samples for bulk organic carbon and nitrogen stable isotope analyses were dried at 60°C over a period of three days at the Institute of Oceanography, Universiti Malaysia Terengganu before being transported to the United States for analysis. They were then homogenized using a mortar and pestle. Approximately 1–5 g of sediment was placed in a desiccator overnight to remove excess moisture. After weighing the samples the following morning (initial mass), they were placed in a furnace for four hours at 550°C. They were then placed in a desiccator overnight and weighed the following morning (final mass). The percent LOI was calculated with the equation below (Dean, 1974) in order to determine the amount of sediment required for isotopic analysis of each sample.

$$\text{LOI (\%)} = ((\text{initial mass} - \text{final mass})/\text{initial mass}) \times 100$$

Dried sediment was then packed in an 8 x 5 mm silver capsule. Fifty microliters of deionized water was added to each silver capsule. To remove inorganic carbon, the 96-well plastic tray containing the samples was placed in a desiccator with a beaker containing 100 ml of 12M HCl for 8 hours. Samples were then dried at 60°C for an additional 6 hours. Samples were sent to the UC Davis Stable Isotope Facility for continuous flow isotope ratio mass spectroscopy (IRMS) of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$). Four samples of fish feed (two pellets and two fish heads) were prepared in the same manner and sent to Yale Earth System Center for Stable Isotopic Studies for analysis. Isotopic values are reported relative to international standards (Vienna PeeDee Belemnite for carbon and atmospheric nitrogen gas for nitrogen).

RESULTS

GEOCHRONOLOGY: ^{210}Pb

Surface activity of ^{210}Pb was highest (~8 dpm/g) at S43 compared to ~2 dpm/g at S40 and ~1 dpm/g at S9A (Fig. 4). ^{210}Pb activity strongly reflects changes in grain size (e.g., He and Walling, 1996; Goodbred and Kuehl, 1998). Excess ^{210}Pb values were corrected for grain size changes by dividing by the fraction of mud present in each sample (Fig. 5). Sediment accumulation rates for S43 and S40 were then calculated from the corrected excess ^{210}Pb values using the CF:CS model (Appleby and Oldfield, 1992). Due to the varying ^{210}Pb profile of S9A, whether corrected for grain size or not, sediment accumulation rates and therefore ages could not be determined.

The ^{210}Pb profile for the upper 30 cm of S43 (Fig.5) is near vertical and represents a mixed layer. The sediment accumulation rate (1.17 ± 0.16 cm/y) was calculated using excess ^{210}Pb values between 30 and 72 cm. The 1970s, representing the onset of aquaculture in the SEL, are represented at a depth between 66 and 72 cm.

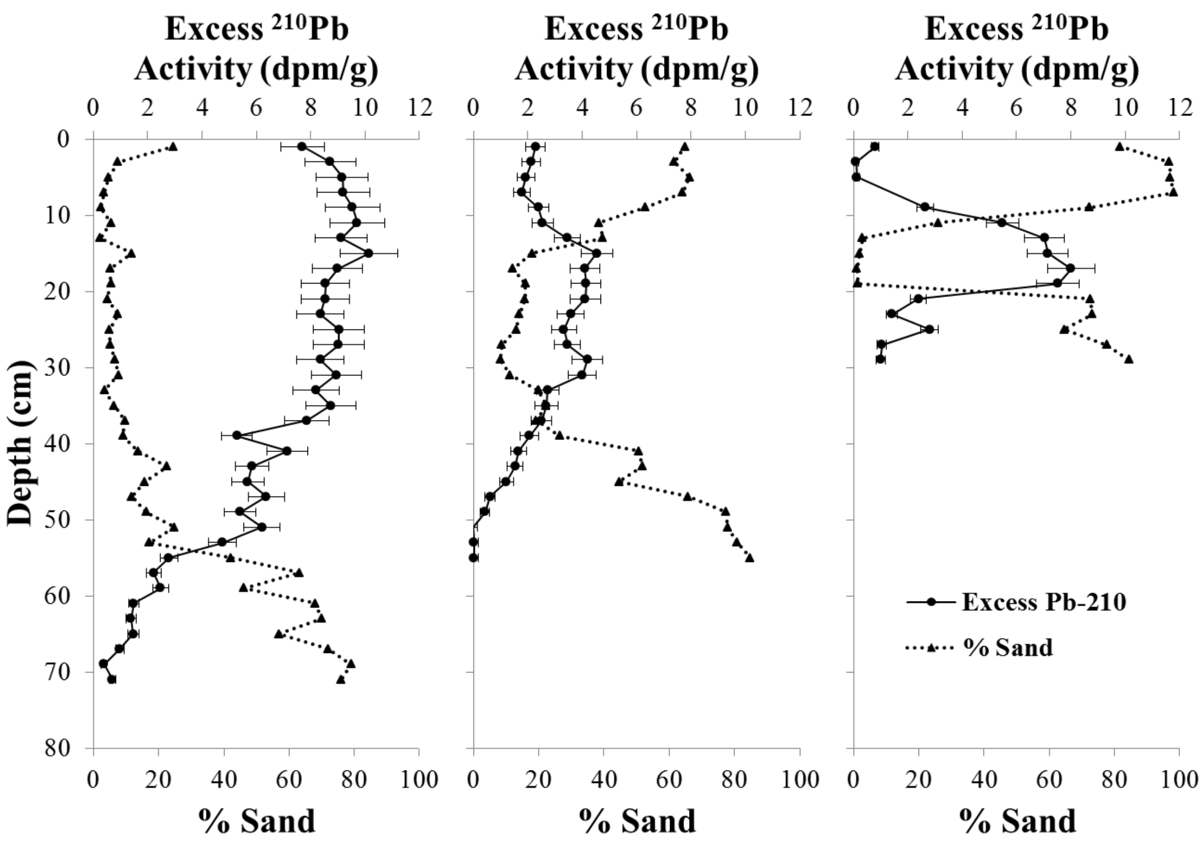

Figure 4. Down-core profiles of excess ^{210}Pb activity and percent sand. Dashed horizontal lines on plots for S43 and S40 indicate 1975, the approximate year fish farming began in the SEL. Ages could not be determined for S9A.

In S40, the sediment accumulation rate (1.52 ± 0.12 cm/y) was calculated using excess ^{210}Pb values from the top of the core down to 49 cm (Fig. 5). Below 49 cm, the profile for corrected values of ^{210}Pb is near vertical. The 1970s are represented at a depth between 42 and 56 cm. In 2003, a second inlet that was located approximately 4 km south of the current inlet closed. The early 2000s are represented at a depth between 8 and 16 cm in core S40.

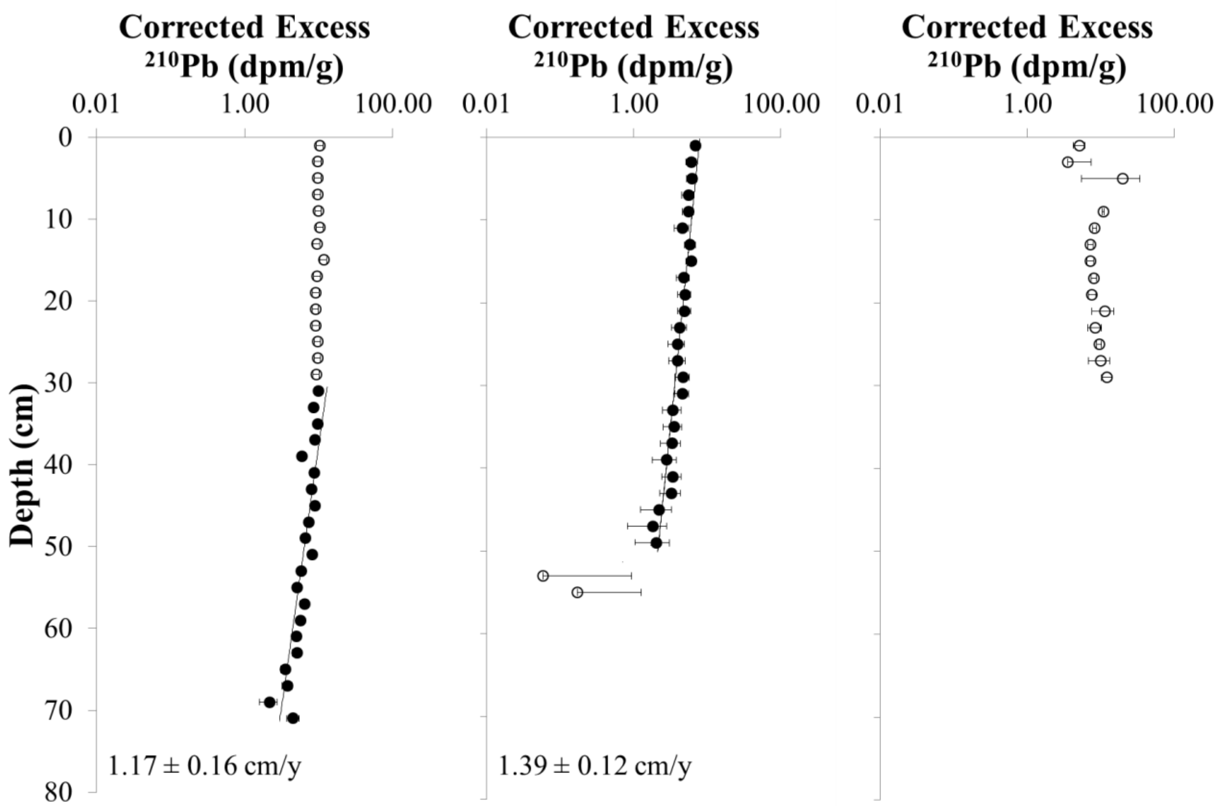

Figure 5. Downcore profiles of corrected ^{210}Pb activities. Closed circles are samples used to calculate sediment accumulation rates.

FORAMINIFERA

A total of 104 foraminiferal taxa was identified within 79 samples. A dendrogram based on the cluster analysis of the dead abundances shows nine distinct groups of samples at a Euclidean distance of 0.3 (groups 2 and 3 are separated at a distance of 0.25) (Fig. 6). The nine groups are referred to as thanatofacies 1–9. Thanatofacies 1–3 and thanatofacies 4–6 are most similar to each other; thanatofacies 7–9 are similar to each other but are distinct from thanatofacies 1–6.

Thanatofacies 1–3 are composed entirely of samples from core S40. Thanatofacies 1 contains 11 samples from the middle 22 cm (12–34 cm) of core S40. This thanatofacies contains 37 calcareous and 12 agglutinated taxa. *Ammonia* aff. *A. aoteana* (26%) and *Ammobaculites exiguus* (13%) are the two most abundant taxa (Table 2). Thanatofacies 2 is composed of the top six samples (0–12 cm) from core S40. Thirty-nine calcareous and eight agglutinated taxa comprise Thanatofacies 2. The most abundant taxa are *Ammonia* aff. *A. aoteana* (19%) and *Sagrinella lobata* (10%) (Table 2). Thanatofacies 3 contains 11 samples from the bottom 22 cm (34–56cm) of the S40 core. This thanatofacies contains 41 calcareous taxa and 10 agglutinated. *Ammonia* aff. *A. aoteana* (18%) and *Quinqueloculina* spp. (15%) are the two most abundant taxa (Table 2).

Thanatofacies 4–6 are composed entirely of samples from core S43. Thanatofacies 4 is composed of 14 samples that make up the bottom 28 cm (44–72 cm) of core S43. Forty-two calcareous taxa and eight agglutinated taxa comprise this thanatofacies. *Ammonia* aff. *A. aoteana* (45%) and *Rosalina globularis* (10%) are the most abundant taxa (Table 2). Thanatofacies 5 contains 10 samples that make up the middle (26–44 cm) of core S43 with one additional sample (18–20 cm). This thanatofacies is composed of 37 calcareous and 12 agglutinated taxa. The most abundant taxa are *Ammonia* aff. *A. aoteana* (46%) and *Ammobaculites exiguus* (12%) (Table 2). Thanatofacies 6 is composed of the top 12 samples (0–26 cm) from core S43 except for the sample from 18–20 cm. Thirty-two calcareous taxa and twelve agglutinated taxa comprise this thanatofacies. The most abundant taxa are *Ammonia* aff. *A. aoteana* (35%) and *Ammobaculites exiguus* (31%) (Table 2).

Thanatofacies 7–9 are composed of samples from S9A. Thanatofacies 7 contains four samples from the bottom of the core and two additional samples from a shallower depth. All 10 taxa are agglutinated. The most abundant taxa are *Trochammina amnicola* (56%), *Ammotium directum* (16%), and *Ammobaculites exiguus* (14%) (Table 2). Thanatofacies 8 is composed of six samples, four of which come from the middle of the core, one from near the top, and one from near the bottom. Nine agglutinated taxa are present in this thanatofacies and the most abundant are *Trochammina amnicola* (29%), *Ammotium directum* (23%), and *Ammobaculites exiguus* (18%) (Table 2). Three samples near the top of the core comprise thanatofacies 9. The same nine agglutinated taxa present in thanatofacies 8 are present in thanatofacies 9. *Miliammina fusca* (46%), *Ammotium directum* (31%), and *Trochammina amnicola* (12%) are the most abundant taxa in thanatofacies 9 (Table 2).

Patterns in foraminiferal densities (the calculated number of dead foraminifera/20 ml sample) are different throughout each core. In S43, the abundance of dead foraminifera (Fig. 7b) decreases through time from >40,000 at the bottom of the core to <300 near the top of the core. The number of dead specimens in S40 (Fig. 8b) decreases from the bottom of the core (56 cm) to ~32 cm and then increases to the top of the core. Dead abundances near the bottom of the core are >30,000 and even surpass 57,000 in one sample (44-46 cm). At 32 cm, the number of dead foraminifera is <3000. Near the top of the core, abundances are closer to 30,000 with one sample (8–10 cm) >53,000. In S9A, the only site where aquaculture had been abandoned prior to coring, dead abundances (Fig. 9b) are greatest (>1200) in the bottom 8 cm of the core and in the top 2 cm. At 6-8 cm and 16-18 cm, abundances are <20.

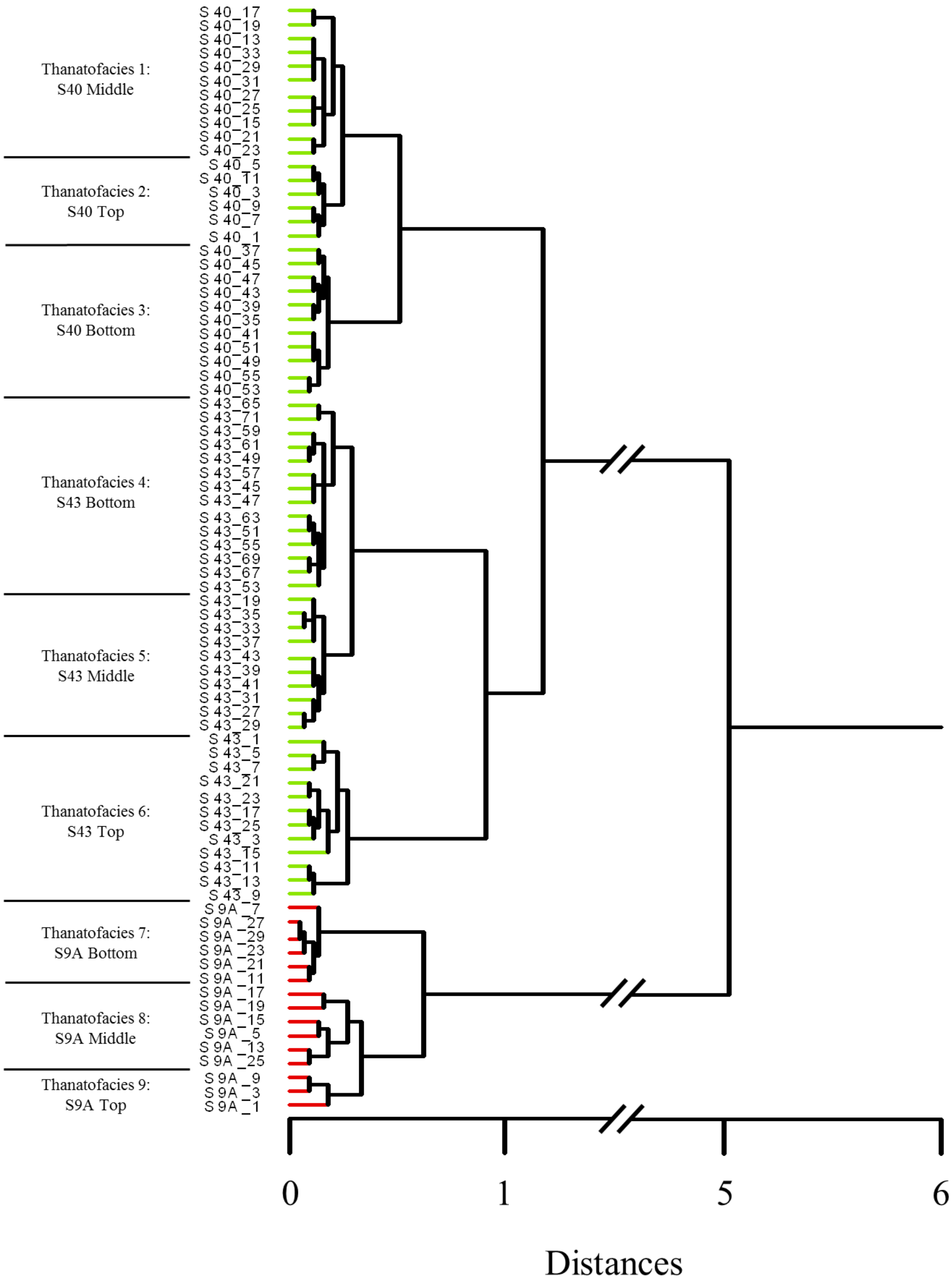

Figure 6. Cluster analysis dendrogram of dead foraminiferal assemblages. Nine thanatofacies (1–9) are recognized. The three cores are distinguished from each other and all three have three thanatofacies. Cores S40 and S43 are more similar to each other than to core S9A.

Table 2. Mean percent abundance of taxa in each thanatofacies defined by cluster analysis of all dead taxa comprising 2% or more of the assemblage in at least one sample.

Facies 1: S40 Middle 11 samples, 49 taxa	**Mean %**	**Facies 2: S40 Top** 6 samples, 47 taxa	**Mean %**	**Facies 3: S40 Bottom** 11 samples, 51 taxa	**Mean %**
Ammonia aff. *A. aoteana*	25.66	*Ammonia* aff. *A. aoteana*	19.13	*Ammonia* aff. *A. aoteana*	17.51
Ammobaculites exiguus	12.90	*Sagrinella lobata*	9.63	*Quinqueloculina* spp.	14.84
Gavelinopsis praegeri	7.53	*Ammobaculites exiguus*	8.49	*Rosalina globularis*	8.03
Rosalina globularis	6.34	*Bolivina* spp.	7.39	*Reussella pulchra*	6.57
Quinqueloculina spp.	6.08	*Reussella pulchra*	7.14	*Gavelinopsis praegeri*	6.26
indeterminate rotaliids	5.69	*Rosalina globularis*	5.08	*Sagrinella lobata*	6.24
Sagrinella lobata	5.24	indeterminate rotaliids	5.07	*Bolivina* spp.	5.04
Reussella pulchra	3.93	*Gavelinopsis praegeri*	5.03	*Sagrina zanzibarica*	3.86
Bolivina spp.	3.72	*Quinqueloculina* spp.	4.96	indeterminate rotaliids	3.75
Schackoinella globosa	3.18	*Sagrina zanzibarica*	3.80	*Ammobaculites exiguus*	3.16
Nonion sp. B	2.75	*Cibicides* cf. *C. fletcheri*	3.14	*Amphistegina lessonii*	1.71
Sagrina zanzibarica	1.80	*Ammotium morenoi*	2.60	*Peneroplis pertusus*	1.66
Cibicides cf. *C. fletcheri*	1.40	*Schackoinella globosa*	2.48	*Cibicides* sp. 1	1.46
Cibicides sp. 1	1.28	*Cibicides* sp. 1	1.78	*Spirolina cylindracea*	1.38
Elphidium cf. *E. reticulosum*	1.06	*Elphidium* cf. *E. simplex*	1.68	*Planorbulina acervalis*	1.33
Amphistegina lessonii	1.02	*Amphistegina lessonii*	1.57	*Cibicides* cf. *C. fletcheri*	1.27
Bolivina striatula	0.89	*Reussella spinulosa*	0.89	*Cibicides* sp. 2	1.24
Elphidium cf. *E. simplex*	0.82	*Nonion* sp. B	0.75	*Nonion* sp. B	1.22
Caronia exilis	0.74	*Bolivina striatula*	0.62	*Dyocibicides primitivus*	1.03
Murrayinella murrayi	0.67	*Elphidium* sp. L	0.61	*Quinqueloculina* sp. 3	1.01
Spirolina cylindracea	0.64	*Caronia exilis*	0.58	*Elphidium* cf. *E. simplex*	0.99
Ammotium morenoi	0.60	*Murrayinella murrayi*	0.51	*Murrayinella murrayi*	0.86
Asterigerinata sp. A	0.60	*Asterigerinata* sp. A	0.50	*Elphidium* cf. *E. reticulosum*	0.79
Paratrochammina stoeni	0.45	*Pararotalia nipponica*	0.48	*Elphidium* spp.	0.66
Elphidium spp.	0.40	*Elphidium* cf. *E. neosimplex*	0.48	*Nonion* sp. A	0.65
Dyocibicides primitivus	0.40	*Trochammina* sp. E	0.47	*Pararotalia nipponica*	0.60
Cibicides sp. 2	0.39	*Cibicides* sp. 2	0.45	*Asterorotalia pulchella*	0.55
Trochammina sp. E	0.38	*Elphidium* cf. *E. reticulosum*	0.37	*Schackoinella globosa*	0.52
Elphidium sp. 4	0.30	*Elphidium* spp.	0.35	*Bolivina striatula*	0.51
Nonion sp. A	0.29	*Elphidium* sp. 4	0.35	*Agglutinella* sp. A	0.51
Trochammina amnicola	0.24	*Trochammina amnicola*	0.34	*Elphidium advenum* s.l.	0.49
Planorbulina acervalis	0.24	*Paratrochammina stoeni*	0.30	*Bolivina* sp. 8	0.43
Quinqueloculina sp. 3	0.24	*Cibicides* sp. 4	0.30	*Reussella spinulosa*	0.41
Elphidium advenum s.l.	0.24	*Dyocibicides primitivus*	0.28	*Elphidium* sp. 4	0.41
Reussella spinulosa	0.21	*Planorbulina acervalis*	0.28	*Elphidium* sp. Q	0.38
Asterorotalia pulchella	0.21	*Asterorotalia pulchella*	0.28	*Elphidium* cf. *E. neosimplex*	0.36
Nonion sp. C	0.20	*Nonion* sp. C	0.26	*Nonion* sp. C	0.36
Peneroplis pertusus	0.20	*Spirolina cylindracea*	0.20	*Elphidium indicum*	0.29
Siphotrochammina lobata	0.15	*Quinqueloculina* sp. 3	0.20	*Cibicides* sp. 4	0.26
Pararotalia nipponica	0.14	*Siphotrochammina lobata*	0.20	*Asterigerinata* sp. A	0.24
Elphidium cf. *E. neosimplex*	0.14	indeterminate textulariids	0.19	*Pseudorotalia schroeteriana*	0.23
"Trochammina ochracea"	0.14	*Bolivina* sp. 8	0.18	*Elphidium* sp. L	0.23
Haplophragmoides wilberti	0.14	*Miliammina fusca*	0.18	indeterminate agglutinated	0.19
Bolivina sp. 8	0.10	*Nonion* sp. A	0.16	*Ammotium morenoi*	0.14
Elphidium hyalocostatum	0.06	*Elphidium advenum* s.l.	0.10	*Nonionella* sp. A	0.10
Cibicides sp. 4	0.05	*Peneroplis pertusus*	0.10	*Paratrochammina stoeni*	0.05
indeterminate textulariids	0.05	*Elphidium* sp. Q	0.08	*Trochammina amnicola*	0.05
Agglutinella sp. A	0.05			*Haplophragmoides wilberti*	0.05
Ammotium directum	0.05			*Siphotrochammina lobata*	0.05
				"Trochammina ochracea"	0.04
				Caronia exilis	0.04

Table 2. (continued)

Facies 4: S43 Bottom 14 samples, 50 taxa	**Mean %**	**Facies 5: S43 Middle** 10 samples, 49 taxa	**Mean %**	**Facies 6: S43 Top** 12 samples, 44 taxa	**Mean %**
Ammonia aff. *A. aoteana*	44.50	*Ammonia* aff. *A. aoteana*	45.67	*Ammonia* aff. *A. aoteana*	35.31
Rosalina globularis	9.54	*Ammobaculites exiguus*	12.13	*Ammobaculites exiguus*	30.84
Quinqueloculina spp.	5.27	*Rosalina globularis*	7.46	*Sagrinella lobata*	4.38
Ammobaculites exiguus	4.35	*Quinqueloculina* spp.	5.27	*Paratrochammina stoeni*	3.30
Sagrinella lobata	4.29	indeterminate rotaliids	4.33	*"Trochammina ochracea"*	2.98
indeterminate rotaliids	3.57	*Sagrinella lobata*	3.88	*Gavelinopsis praegeri*	2.88
Reussella pulchra	3.53	*Bolivina* spp.	2.41	indeterminate rotaliids	2.73
Bolivina spp.	3.12	*Gavelinopsis praegeri*	2.02	*Trochammina* sp. E	2.62
Sagrina zanzibarica	2.59	*Sagrina zanzibarica*	1.78	*Rosalina globularis*	2.18
Nonion sp. B	2.46	*Reussella pulchra*	1.68	*Quinqueloculina* spp.	1.89
Murrayinella murrayi	1.51	*Nonion* sp. B	1.62	*Bolivina* spp.	1.05
Gavelinopsis praegeri	1.37	*Cibicides* sp. 1	1.35	*Ammotium morenoi*	1.02
Bolivina striatula	1.28	*Trochammina* sp. E	1.31	*Reussella pulchra*	0.95
Cibicides sp. 1	1.08	*Schackoinella globosa*	0.97	*Nonion* sp. B	0.85
Schackoinella globosa	0.96	*Murrayinella murrayi*	0.83	*Sagrina zanzibarica*	0.58
Pseudorotalia schroeteriana	0.92	*"Trochammina ochracea"*	0.81	*Schackoinella globosa*	0.47
Elphidium sp. 4	0.70	*Elphidium* cf. *E. reticulosum*	0.79	*Cibicides* sp. 1	0.47
Nonion sp. C	0.37	*Bolivina striatula*	0.59	*Trochammina amnicola*	0.42
Elphidium cf. *E. simplex*	0.60	*Paratrochammina stoeni*	0.52	*Siphotrochammina lobata*	0.41
Cibicides cf. *C. fletcheri*	0.51	*Nonion* sp. C	0.46	*Elphidium* cf. *E. reticulosum*	0.40
Elphidium cf. *E. reticulosum*	0.51	*Elphidium* spp.	0.37	*Elphidium hyalocostatum*	0.37
Planorbulina acervalis	0.47	*Elphidium* cf. *E. simplex*	0.36	*Elphidium* cf. *E. simplex*	0.35
Amphistegina lessonii	0.46	*Trochammina amnicola*	0.30	*Cibicides* cf. *C. fletcheri*	0.31
Cibicides sp. 4	0.44	*Ammotium morenoi*	0.27	*Amphistegina lessonii*	0.29
Peneroplis pertusus	0.43	*Cibicides* sp. 2	0.25	*Murrayinella murrayi*	0.29
Elphidium spp.	0.34	*Elphidium hyalocostatum*	0.24	indeterminate agglutinated	0.27
Quinqueloculina sp. 3	0.34	*Amphistegina lessonii*	0.24	*Agglutinella* sp. A	0.27
Cibicides sp. 2	0.32	*Peneroplis pertusus*	0.20	*Caronia exilis*	0.23
Agglutinella sp. A	0.31	*Elphidium indicum*	0.20	*Pseudorotalia schroeteriana*	0.22
Asterorotalia pulchella	0.28	*Dyocibicides primitivus*	0.19	*Miliammina fusca*	0.19
Trochammina sp. E	0.26	*Ammotium directum*	0.14	*Ammotium directum*	0.19
Spirolina cylindracea	0.25	*Pseudorotalia schroeteriana*	0.14	*Elphidium* spp.	0.18
Reussella spinulosa	0.24	*Elphidium* sp. 4	0.14	*Elphidium* cf. *E. neosimplex*	0.18
Nonion sp. A	0.22	*Cibicides* cf. *C. fletcheri*	0.14	*Nonion* sp. C	0.16
Trochammina amnicola	0.22	*Caronia exilis*	0.10	*Asterigerinata* sp. A	0.16
Ammotium morenoi	0.22	*Elphidium advenum* s.l.	0.10	*Elphidium advenum* s.l.	0.13
"Trochammina ochracea"	0.22	*Quinqueloculina* sp. 3	0.10	*Asterorotalia pulchella*	0.09
Pararotalia nipponica	0.21	indeterminate agglutinated	0.10	*Elphidium indicum*	0.09
Elphidium advenum s.l.	0.20	*Pararotalia nipponica*	0.08	*Elphidium* sp. 4	0.08
Nonionella sp. A	0.17	*Siphotrochammina lobata*	0.05	*Pararotalia nipponica*	0.05
Dyocibicides primitivus	0.17	*Reussella spinulosa*	0.05	*Dyocibicides primitivus*	0.04
Elphidium indicum	0.14	*Cibicides* sp. 4	0.05	*Bolivina striatula*	0.04
Paratrochammina stoeni	0.14	*Asterigerinata* sp. A	0.05	*Quinqueloculina* sp. 3	0.04
indeterminate agglutinated	0.14	*Agglutinella* sp. A	0.05	*Cibicides* sp. 2	0.04
Elphidium sp. Q	0.11	*Elphidium* sp. L	0.04		
Elphidium sp. L	0.11	*Elphidium* sp. Q	0.04		
Elphidium cf. *E. neosimplex*	0.11	*Planorbulina acervalis*	0.04		
Asterigerinata sp. A	0.06	*Haplophragmoides wilberti*	0.04		
Bolivina sp. 8	0.04	*Nonion* sp. A	0.04		
Caronia exilis	0.03				

Table 2. (continued)

Facies 7: S9A Bottom 6 samples, 10 taxa	**Mean %**	**Facies 8: S9A Middle** 6 samples, 9 taxa	**Mean %**	**Facies 9: S9A Top** 3 samples, 9 taxa	**Mean %**
Trochammina amnicola	55.60	*Trochammina amnicola*	28.62	*Miliammina fusca*	46.37
Ammotium directum	16.02	*Ammotium directum*	23.24	*Ammotium directum*	30.85
Ammobaculites exiguus	14.48	*Ammobaculites exiguus*	17.88	*Trochammina amnicola*	11.96
indeterminate agglutinated	6.44	*Miliammina fusca*	11.10	*Ammobaculites exiguus*	5.96
Ammotium morenoi	6.30	*Ammotium morenoi*	5.97	*Ammotium morenoi*	2.52
Miliammina fusca	0.62	*Siphotrochammina lobata*	4.62	indeterminate agglutinated	0.98
Siphotrochammina lobata	0.26	*"Trochammina ochracea"*	4.14	*Siphotrochammina lobata*	0.69
Haplophragmoides wilberti	0.11	indeterminate agglutinated	3.76	*"Trochammina ochracea"*	0.46
Paratrochammina stoeni	0.09	*Haplophragmoides wilberti*	0.66	*Haplophragmoides wilberti*	0.22
"Trochammina ochracea"	0.09				

In core S43, the agglutinated taxa *Paratrochammina stoeni*, "*Trochammina ochracea*," and *Trochammina* sp. E are more consistently present and more abundant in the top of the core, especially in Thanatofacies 6 (Fig. 7b). The number of specimens of *Ammobaculites exiguus* also increases towards the top of the core in Thanatofacies 6. *Ammonia* aff. *A. aoteana* shows an up-core decreasing trend in Thanatofacies 6. The calcareous taxon *Rosalina globularis* is more abundant in the middle and bottom of the core, in Thanatofacies 5 and 4.

In core S40, agglutinated taxon *Ammobaculites exiguus* is more abundant in Thanatofacies 1 and 2 (middle and top of core) (Fig. 8b). Similarly, *Ammotium morenoi* is more abundant in the top half of the core (upper part of Thanatofacies 1 and all of Thanatofacies 2). Miliolids (*Quinqueloculina* spp.) are more abundant at the bottom of the core in Thanatofacies 3.

In core S9A, *Miliammina fusca* is more abundant in the middle and top of the core in Thanatofacies 8 and 9 and most abundant in the top sample of the core (Fig. 9b). *Trochammina amnicola* is more abundant in the bottom and middle of the core in Thanatofacies 7 and 8. Patterns for other species are difficult to extract.

The calculated abundances of live foraminifera/20 ml have different patterns throughout each core as well. In all three cores, the numbers of live specimens were small relative to the numbers of dead specimens. In S43, live specimens extend down-core to 42 cm (Fig. 7a; Table

3). The total number of live specimens is <60 between 4 and 42 cm, except at 20–22 cm, where the live abundance is >200. The top sample has a live abundance >300.

In S40, live specimens extend down-core to 34 cm (Fig. 8a; Table 3), although not every sample between 0 and 34 cm contains live specimens. At 34 cm, the number of live specimens is <75. Within the top 12 cm, live abundances are >140, and exceed 1200 at 8–10 cm.

In S9A, live specimens extend to the bottom (30 cm) of the core (Fig. 9a; Table 3). Live abundances are >70 in the bottom three samples (24–30 cm) and range from 2–64 in the samples between 2 and 24 cm. The top sample contains the greatest number of live foraminifera (>860). It is difficult to extract patterns amongst individual species because live abundances are low.

Species Richness

Species richness (of dead assemblage) decreases slightly up-core in cores S43 and S40 and does not show any trend in core S9A (Figs. 7–9). Core S40 contains the greatest average number of dead species per sample (34). The average number of dead species per sample in S43 is 27 and the average of 7 for S9A is the lowest.

In S43 and S40, the greatest number of live species is near the top of these cores. The number of live species near the top of S43 is nine and decreases down-core (Fig. 7a; Table 3). The number of live species varies between 0 and 3 throughout most of S40, with no live species below 34 cm (Fig. 8a; Table 3). The number of live species varies between 1 and 6 throughout the entire S9A core (Fig. 9a; Table 3).

Fisher's Alpha (α)

Fisher's alpha values (of total assemblage) follow similar trends up-core as the species richness of the dead assemblage (Fig. 10; Table 4). In core S43, alpha decreases up-core. The average alpha value for the samples in Thanatofacies 4 (bottom of core) is 10.46. The

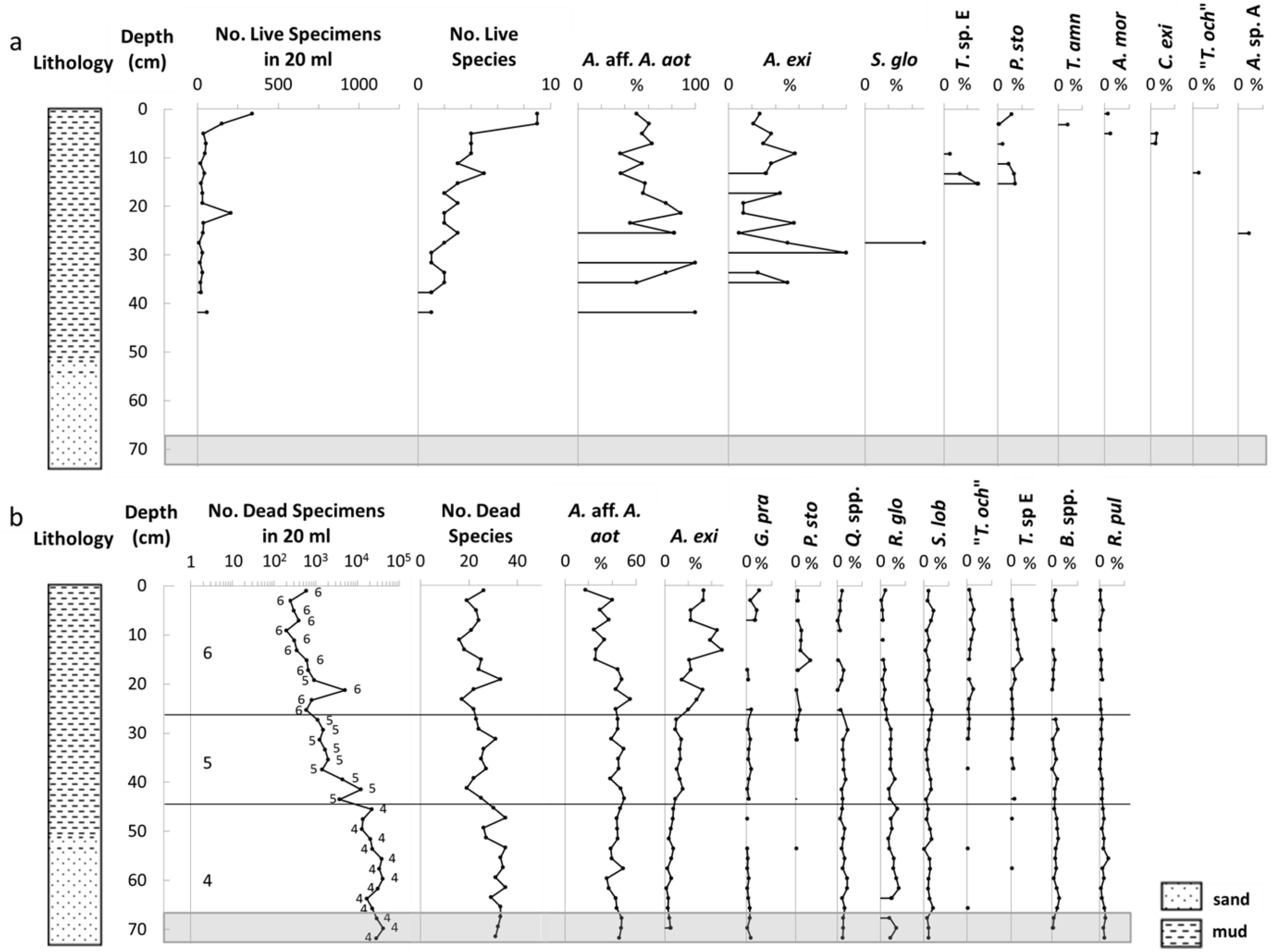

Figure 7. Relative abundance of all taxa comprising 5% or more of the live assemblage (a) and of the dead assemblage (b) in core S43. Numbers on No. Dead Specimens in 20 ml plot represent cluster groups and are separated by solid horizontal lines. The one sample (18-20 cm) that does not cluster with samples from similar depths is noted in the text. Key to abbreviated taxon names given in Appendix A. Shaded regions represent the 1970s.

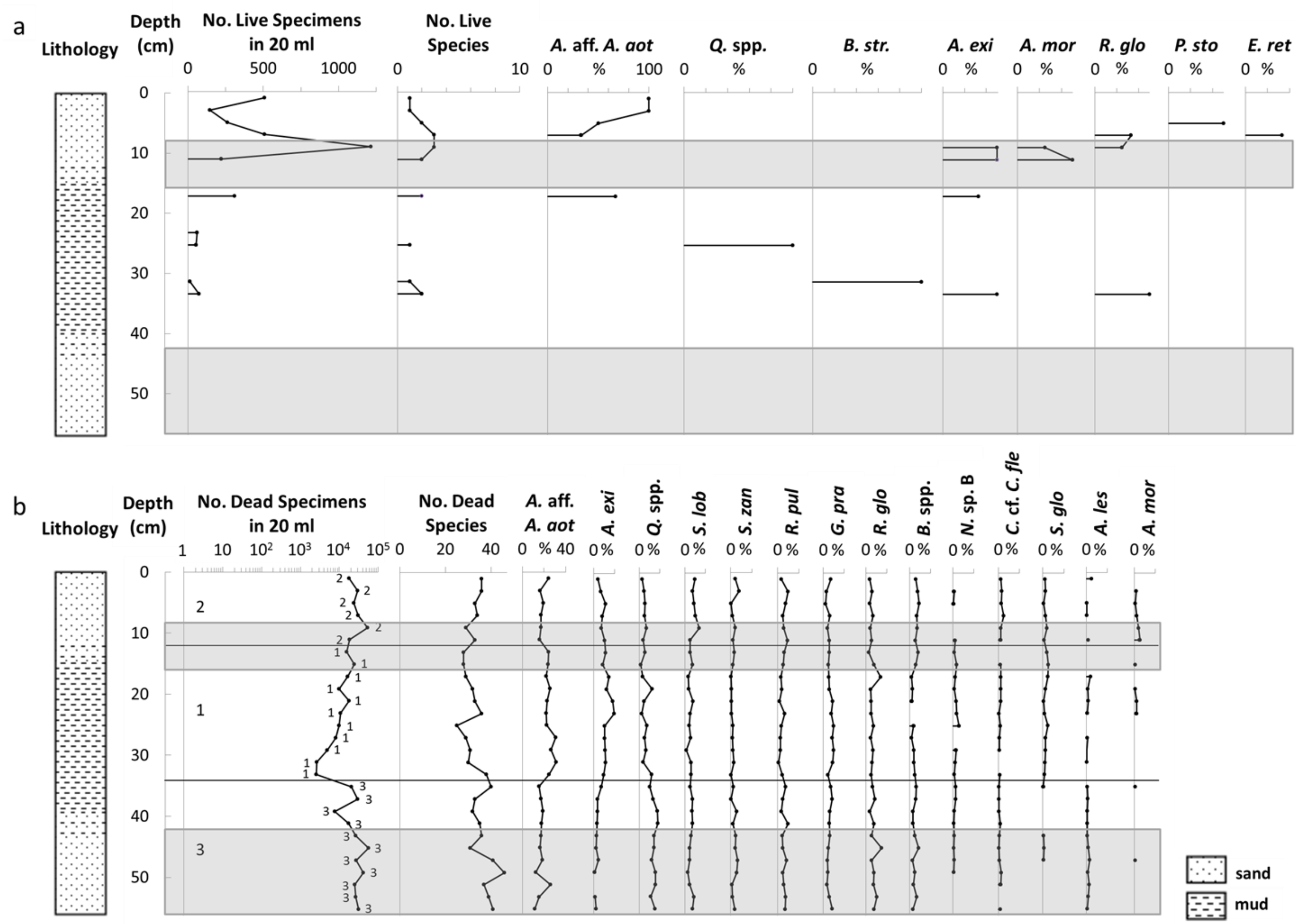

Figure 8. Relative abundance of all taxa comprising 5% or more of the live assemblage (a) and of the dead assemblage (b) in core S40. Numbers on No. Dead Specimens in 20 ml plot represent cluster groups and are separated by solid horizontal lines. Key to abbreviated taxon names given in Appendix A. Shaded regions at the bottom of the core represent the 1970s. Shaded regions between 8 and 16 cm represent the early 2000s.

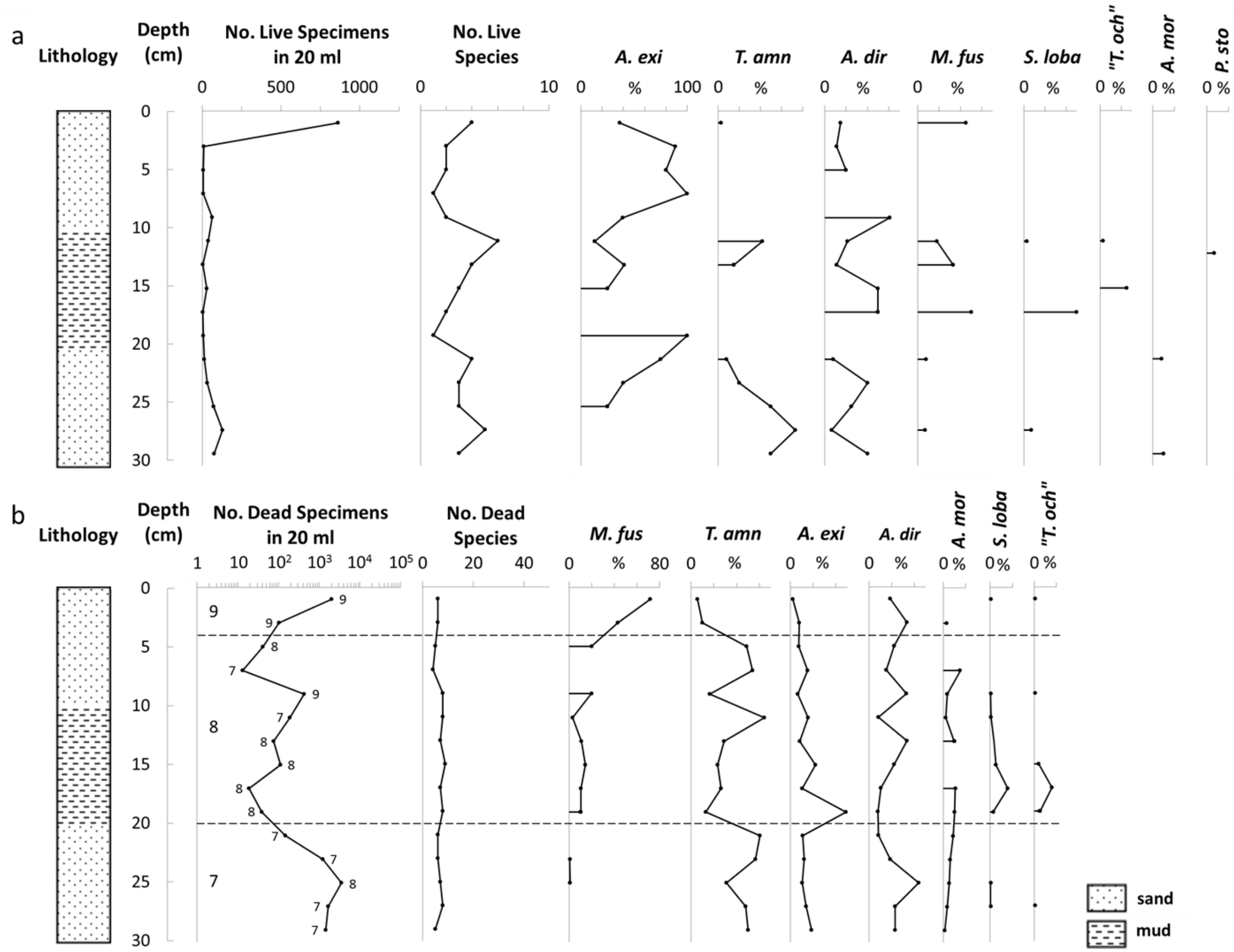

Figure 9. Relative abundance of all taxa comprising 5% or more of the live assemblage (a) and of the dead assemblage (b) in core S9A. Numbers on No. Dead Specimens in 20 ml plot represent cluster groups. Dashed lines separate cluster groups, although groups are not as distinct as those in S43 and S40. Samples that do not cluster with samples from similar depths are discussed in the text. Key to abbreviated taxon names given in Appendix A.

average alpha value for the samples in Thanatofacies 5 (middle of core) is 7.63. The average alpha value for the samples in Thanatofacies 6 (top of core) is 6.22. In core S40, Thanatofacies 3 (bottom of core) has a higher average alpha value (13.21) than Thanatofacies 1 (middle of core) (10.43) and Thanatofacies 2 (top of core) (11.45). In core S9A, alpha values are lower than those in S43 and S40. Thanatofacies 9 (bottom of core) and Thanatofacies 7 (top of core) have similar average alpha values (1.44 and 1.41 respectively). The average alpha value for Thanatofacies 8 (middle of core) is slightly higher at 2.19. The higher values in Thanatofacies 8 correspond to a low number of individuals per 20 ml of sample (Fig. 9b).

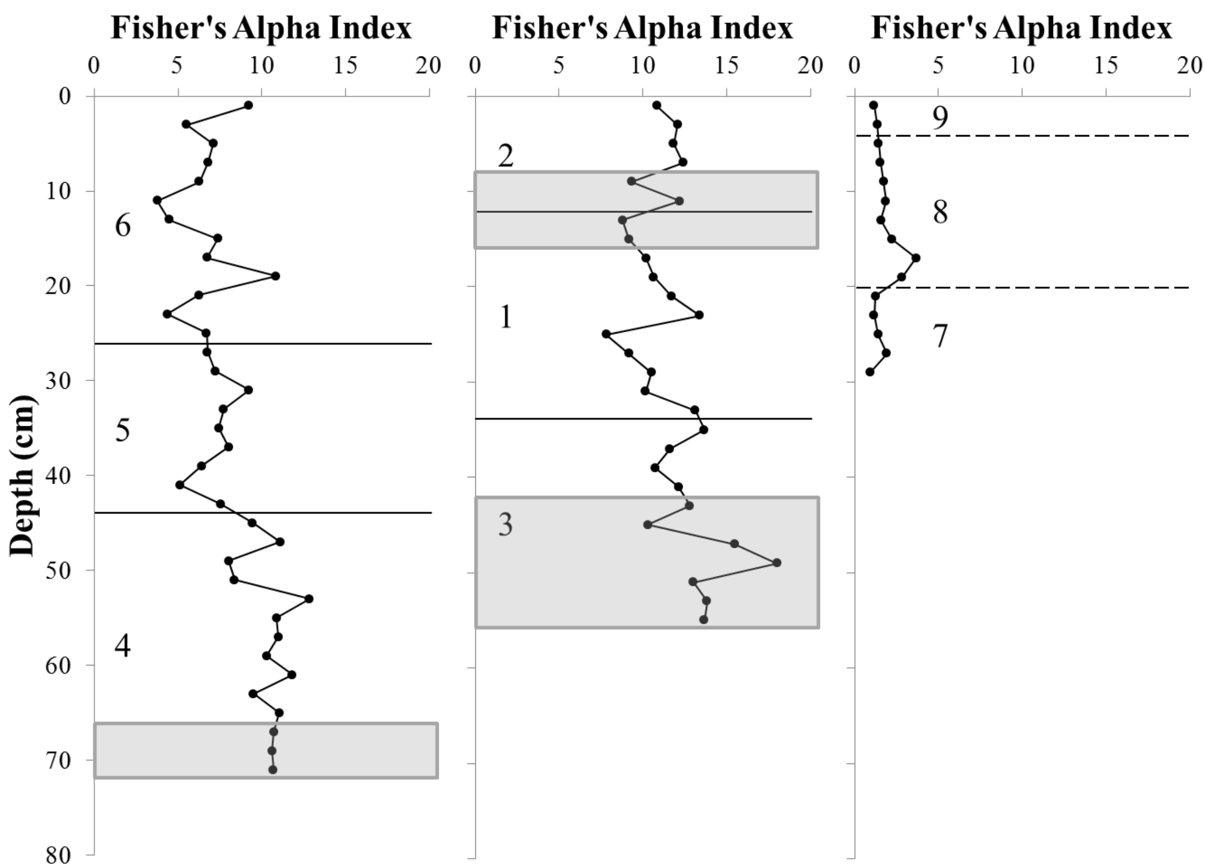

Figure 10. Down-core profiles of Fisher's alpha index. Cluster groups are separated by solid horizontal lines for S43 and S40 and dashed horizontal lines (representing less distinct grouping) for S9A. Shaded regions at the bottom of the cores represent the 1970s. The shaded region between 8 and 16 cm for S40 represents the early 2000s.

Table 3. Values for various assemblage characteristics for each sample. CG, cluster group (thanatofacies); nT, total number of foraminifera picked; nD, number of dead foraminifera picked; nL, number of live foraminifera picked; NT, total number of foraminifera/20 ml of sediment; ND, number of dead foraminifera/20 ml of sediment; NL, number of live foraminifera/20 ml of sediment; % live; ST, total number of species; SD, number of dead species; SL, number of live species; α, Fisher's alpha for total assemblage; STt, total number of textulariid species; STc, total number of calcareous species; SDt, number of dead textulariid species; SDc, number of dead calcareous species; SLt, number of live textulariid species; SLc, number of live calcareous species; T%t, percent of textulariid specimens in total assemblage; T%c, percent of calcareous specimens in total assemblage; D%t, percent of textlariid specimens in dead assemblage; D%c, percent of calcareous specimens in dead assemblage; L%t, percent of textlariid specimens in live population; L%c, percent of calcareous specimens in live population.

S43 Sample Depth (cm)	CG	nT	nD	nL	NT	ND	NL	% live	ST	SD	SL	α	STt	STc	SDt	SDc	SLt	SLc	T%t	T%c	D%t	D%c	L%t	L%c
1	6	165	105	60	929	591	338	36	27	26	9	9.2	8	19	7	19	5	4	42	58	41	59	45	55
3	6	201	125	76	402	250	152	38	20	19	9	5.5	8	12	8	11	3	6	38	62	43	57	30	70
5	6	202	180	22	333	297	36	11	24	23	4	7.1	7	17	6	17	3	1	32	68	31	69	45	55
7	6	225	198	27	450	396	54	12	25	24	4	6.8	6	19	5	19	3	1	31	69	30	70	37	63
9	6	203	164	39	246	199	47	19	22	21	4	6.3	11	11	11	10	2	2	66	34	66	34	62	38
11	6	198	187	11	324	306	18	6	16	16	3	3.8	7	9	7	9	2	1	55	45	55	45	45	55
13	6	198	176	22	396	352	44	11	18	18	5	4.5	12	6	12	6	4	1	68	32	69	31	64	36
15	6	210	203	7	630	609	21	3	25	25	3	7.4	7	18	7	18	2	1	45	55	45	55	43	57
17	6	199	190	9	703	671	32	5	24	24	2	6.7	4	20	4	20	1	1	27	73	26	74	44	56
19	5	237	229	8	948	916	32	3	34	33	3	10.9	7	27	7	26	1	2	21	79	21	79	13	88
21	6	206	198	8	5297	5091	206	4	22	22	2	6.2	7	15	7	15	1	1	40	60	41	59	13	88
23	6	211	202	9	844	808	36	4	17	17	2	4.4	6	11	6	11	1	1	35	65	34	66	56	44
25	6	201	190	11	635	600	35	6	24	22	3	6.7	7	17	7	15	1	2	26	74	27	73	9	91
27	5	197	195	2	1125	1114	11	1	23	23	2	6.8	6	17	6	17	1	1	17	83	16	84	50	50
29	5	194	190	4	1552	1520	32	2	24	24	1	7.2	5	19	5	19	1	0	14	86	13	87	100	0
31	5	256	253	3	1280	1265	15	1	31	31	1	9.2	7	24	7	24	0	1	19	81	19	81	0	100
33	5	216	212	4	1728	1696	32	2	26	26	2	7.7	6	20	6	20	1	1	15	85	15	85	25	75
35	5	208	206	2	2033	2014	19	1	25	25	2	7.4	3	22	3	22	1	1	15	85	15	85	50	50
37	5	200	197	3	1440	1418	22	2	27	27	1	8.0	4	23	4	23	0	1	14	87	14	86	0	100
39	5	191	191	0	4436	4436	0	0	22	22	0	6.4	4	18	4	18	0	0	15	85	15	85	0	0
41	5	205	204	1	12300	12240	60	0	19	19	1	5.1	3	16	3	16	0	1	16	84	16	84	0	100
43	5	200	200	0	3789	3789	0	0	25	25	0	7.5	4	21	4	21	0	0	13	87	13	87	0	0
45	4	216	216	0	22217	22217	0	0	30	30	0	9.5	6	24	6	24	0	0	11	89	11	89	0	0
47	4	249	249	0	13791	13791	0	0	35	35	0	11.1	8	27	8	27	0	0	11	89	11	89	0	0
49	4	197	197	0	12895	12895	0	0	26	26	0	8.0	1	25	1	25	0	0	5	95	5	95	0	0
51	4	202	202	0	20777	20777	0	0	27	27	0	8.4	3	24	3	24	0	0	4	96	4	96	0	0
53	4	192	192	0	23040	23040	0	0	35	35	0	12.9	5	30	5	30	0	0	10	90	10	90	0	0
55	4	214	214	0	38520	38520	0	0	33	33	0	10.9	2	31	2	31	0	0	6	94	6	94	0	0
57	4	231	231	0	33264	33264	0	0	34	34	0	11.0	3	31	3	31	0	0	4	96	4	96	0	0

59	4	199	199	0	40937	40937	0	0	31	31	0	10.3	4	27	4	27	0	0	8	92	8	92	0	0
61	4	216	216	0	31104	31104	0	0	35	35	0	11.8	5	30	5	30	0	0	3	97	3	97	0	0
63	4	191	191	0	17190	17190	0	0	29	29	0	9.5	1	28	1	28	0	0	3	97	3	97	0	0
65	4	190	190	0	22800	22800	0	0	33	33	0	11.1	3	30	3	30	0	0	4	96	4	96	0	0
67	4	202	202	0	29088	29088	0	0	33	33	0	10.7	4	29	4	29	0	0	5	95	5	95	0	0
69	4	206	206	0	42377	42377	0	0	32	32	0	10.6	2	30	2	30	0	0	5	95	5	95	0	0
71	4	201	201	0	28944	28944	0	0	31	31	0	10.7	1	30	1	30	0	0	0	100	0	100	0	0

S40 Sample Depth (cm)	**CG**	**nT**	**nD**	**nL**	**NT**	**ND**	**NL**	**% live**	**ST**	**SD**	**SL**	**α**	**STt**	**STc**	**SDt**	**SDc**	**SLt**	**SLc**	**T%t**	**T%c**	**D%t**	**D%c**	**L%t**	**L%c**
1	2	220	214	6	18635	18127	508	3	36	36	1	10.8	5	31	5	31	0	1	9	91	9	91	0	100
3	2	207	206	1	29808	29664	144	0	36	36	1	12.1	4	32	4	32	0	1	10	90	10	90	0	100
5	2	184	182	2	24087	23825	262	1	33	33	2	11.9	6	27	6	27	1	1	17	83	16	84	50	50
7	2	182	179	3	30833	30325	508	2	35	34	3	12.4	5	30	5	29	0	3	13	87	13	87	0	100
9	2	180	176	4	54569	53356	1213	2	29	29	3	9.34	2	27	2	27	2	1	13	87	11	89	75	25
11	2	170	168	2	18831	18609	222	1	33	33	2	12.2	5	28	5	28	2	0	19	81	18	82	100	0
13	1	203	203	0	15385	15385	0	0	28	28	0	8.8	4	24	4	24	0	0	13	87	13	87	0	0
15	1	185	185	0	24218	24218	0	0	28	28	0	9.17	3	25	3	25	0	0	10	90	10	90	0	0
17	1	165	162	3	16972	16663	309	2	29	29	2	10.2	3	26	3	26	1	1	19	81	19	81	33	67
19	1	191	191	0	9823	9823	0	0	32	32	0	10.7	6	26	6	26	0	0	19	81	19	81	0	0
21	1	185	185	0	17760	17760	0	0	33	33	0	11.7	4	29	4	29	0	0	22	78	22	78	0	0
23	1	183	182	1	10980	10920	60	1	36	36	0	13.4	6	30	6	30	0	0	25	75	24	76	100	0
25	1	184	183	1	9998	9944	54	1	25	25	1	7.81	2	23	2	23	0	1	11	89	11	89	0	100
27	1	207	207	0	8220	8220	0	0	29	29	0	9.18	5	24	5	24	0	0	14	86	14	86	0	0
29	1	190	190	0	4886	4886	0	0	31	31	0	10.5	7	24	7	24	0	0	14	86	14	86	0	0
31	1	184	183	1	2663	2649	14	1	30	30	1	10.2	4	26	4	26	0	1	13	87	13	87	0	100
33	1	208	206	2	2664	2592	72	3	38	38	2	13.1	6	32	6	32	1	1	13	88	12	88	50	50
35	3	193	193	0	20587	20587	0	0	40	40	0	13.7	4	36	4	36	0	0	9	91	9	91	0	0
37	3	187	187	0	29920	29920	0	0	33	33	0	11.6	3	30	3	30	0	0	5	95	5	95	0	0
39	3	183	183	0	7751	7751	0	0	32	32	0	10.7	2	30	2	30	0	0	4	96	4	96	0	0
41	3	205	205	0	17365	17365	0	0	35	35	0	12.1	3	32	3	32	0	0	4	96	4	96	0	0
43	3	200	200	0	26182	26182	0	0	36	36	0	12.8	2	34	2	34	0	0	4	96	4	96	0	0
45	3	198	198	0	57024	57024	0	0	31	31	0	10.3	1	30	1	30	0	0	3	97	3	97	0	0
47	3	190	190	0	27360	27360	0	0	41	41	0	15.5	5	36	5	36	0	0	7	93	7	93	0	0
49	3	202	202	0	41554	41554	0	0	46	46	0	18	6	40	6	40	0	0	4	96	4	96	0	0
51	3	210	210	0	25200	25200	0	0	37	37	0	13	4	33	4	33	0	0	2	98	2	98	0	0
53	3	218	218	0	26160	26160	0	0	39	39	0	13.8	3	36	3	36	0	0	3	97	3	97	0	0
55	3	261	261	0	31320	31320	0	0	41	41	0	13.7	3	38	3	38	0	0	3	97	3	97	0	0

S9A Sample Depth (cm)	CG	nT	nD	nL	NT	ND	NL	% live	ST	SD	SL	α	STt	STc	SDt	SDc	SLt	SLc	T%t	T%c	D%t	D%c	L%t	L%c
1	9	201	141	60	2894	2030	864	30	6	6	4	1.2	6	0	6	0	4	0	100	0	100	0	100	0
3	9	111	102	9	111	102	9	8	6	6	2	1.4	6	0	6	0	2	0	100	0	100	0	100	0
5	8	46	41	5	46	41	5	11	5	5	2	1.4	5	0	5	0	2	0	100	0	100	0	100	0
7	7	19	13	6	19	13	6	32	4	4	1	1.5	4	0	4	0	1	0	100	0	100	0	100	0
9	9	217	189	28	495	431	64	13	8	8	2	1.7	8	0	8	0	2	0	100	0	100	0	100	0
11	7	228	190	38	228	190	38	17	9	8	6	1.9	9	0	8	0	6	0	100	0	100	0	100	0
13	8	138	111	27	81	77	4	5	7	7	4	1.6	7	0	7	0	4	0	100	0	100	0	100	0
15	8	81	77	4	138	111	27	20	9	9	3	2.2	9	0	9	0	3	0	100	0	100	0	100	0
17	8	21	19	2	21	19	2	10	7	7	2	3.7	7	0	7	0	2	0	100	0	100	0	100	0
19	8	45	39	6	45	39	6	13	8	8	1	2.8	8	0	8	0	1	0	100	0	100	0	100	0
21	7	161	149	12	161	149	12	7	6	6	4	1.2	6	0	6	0	4	0	100	0	100	0	100	0
23	7	194	189	5	1247	1215	32	3	6	6	3	1.2	6	0	6	0	3	0	100	0	100	0	100	0
25	8	199	195	4	3582	3510	72	2	7	7	3	1.4	7	0	7	0	3	0	100	0	100	0	100	0
27	7	207	192	15	1775	1646	129	7	9	8	5	1.9	9	0	8	0	5	0	100	0	100	0	100	0
29	7	203	193	10	1523	1448	75	5	5	5	3	0.9	5	0	5	0	3	0	100	0	100	0	100	0

Table 4. Summary data for thanatofacies defined by cluster analysis of dead foraminifera. Mean ND, mean number of dead specimens/20 ml of sediment; Mean NL, mean number of live specimens/20 ml of sediment; Mean Live %; Mean SD, mean number of dead species; Mean SDt, mean number of dead textulariid species; Mean SDc, mean number of dead calcareous species; Mean α, mean value of Fisher's alpha for total assemblage; Mean D%t, mean percent of dead textulariid specimens; Mean D%c, mean percent of dead calcareous specimens.

Cluster Group	**Mean ND**	**Mean NL**	**Mean Live %**	**Mean SD**	**Mean SDt**	**Mean SDc**	**Mean α**	**Mean D%t**	**Mean D%c**
1	28984	46	1	31	4.5	26.3	10.4	15.6	84.4
2	11187	476	2	34	4.5	29.0	11.5	12.9	87.1
3	28220	0	0	37	3.3	34.1	13.2	4.5	95.5
4	27287	0	0	32	3.2	28.6	10.5	5.4	94.6
5	4784	20	1	26	5.0	20.9	7.6	15.2	84.8
6	848	85	13	21	7.3	14.2	6.2	42.5	57.6
7	777	49	13	6	6.2	0.0	1.4	100.0	0.0
8	633	19	10	7	7.2	0.0	2.2	100.0	0.0
9	854	312	17	7	6.7	0.0	1.4	100.0	0.0

SEDIMENTOLOGY

Patterns in grain size differ throughout each core (Fig. 11). Grain size at S43 ranges from mud to medium sand (Table 5) and sediments are poorly to very poorly sorted. At S43, percent sand decreases up-core from ~80% to near 0%.

At S40, grain size ranges from mud to very fine sand (Table 6) and sediments are moderately to poorly sorted. Percent sand gradually decreases from the bottom of the core to 30 cm. Between 30 cm and 16 cm, percent sand remains relatively constant. Between 16 cm and the top of the core, percent sand gradually increases to ~68%.

Grain size ranges from mud to coarse sand and sediments are very poorly sorted to moderately well sorted at S9A (Table 7). In the bottom 10 cm of S9A, percent sand remains around 80%. Between the two samples at 20–22 cm and 18–20 cm, a rapid change to near 0% sand occurs. Another abrupt change occurs above the sample at 12–14 cm, where grain size returns to near 100% sand.

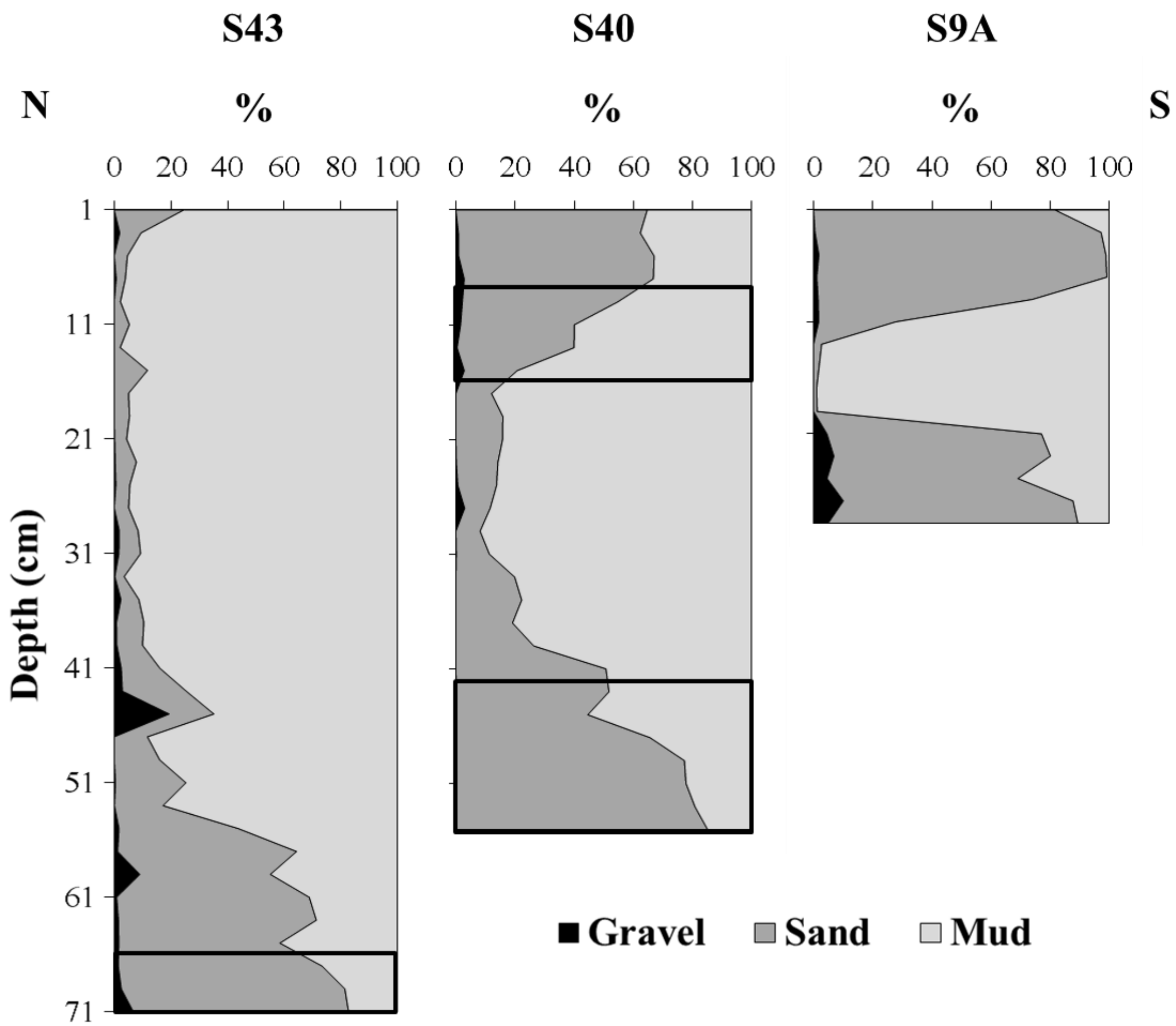

Figure 11. Down-core profiles of grain size. Black boxes at the bottom of the cores represent the 1970s, when aquaculture practices began. The black box between 8 and 16 cm for S40 represents the early 2000s.

Table 5. Sediment grain size results (S43) using Gradistat.

Sample Depth (cm)	Mean	Mean	Sorting (σ)	Sorting	Skewness (*Sk*)	Skewness	Kurtosis (*K*)	Kurtosis	Mode (f)
1	4.391	V. Coarse Silt	2.822	V. Poorly Sorted	-0.413	V. Coarse Skewed	1.180	Leptokurtic	-0.243
3	5.762	Coarse Silt	1.893	Poorly Sorted	-0.230	Coarse Skewed	1.368	Leptokurtic	0.247
5	5.884	Coarse Silt	1.305	Poorly Sorted	-0.007	Symmetrical	0.748	Platykurtic	0.247
7	5.904	Coarse Silt	1.282	Poorly Sorted	0.002	Symmetrical	0.735	Platykurtic	3.731
9	5.943	Coarse Silt	1.253	Poorly Sorted	0.007	Symmetrical	0.727	Platykurtic	3.731
11	5.868	Coarse Silt	1.354	Poorly Sorted	-0.038	Symmetrical	0.799	Platykurtic	3.731
13	5.943	Coarse Silt	1.253	Poorly Sorted	0.007	Symmetrical	0.727	Platykurtic	3.731
15	5.711	Coarse Silt	1.728	Poorly Sorted	-0.171	Coarse Skewed	1.123	Leptokurtic	1.247
17	5.878	Coarse Silt	1.318	Poorly Sorted	-0.015	Symmetrical	0.760	Platykurtic	3.731
19	5.867	Coarse Silt	1.346	Poorly Sorted	-0.032	Symmetrical	0.788	Platykurtic	3.731
21	5.887	Coarse Silt	1.299	Poorly Sorted	-0.003	Symmetrical	0.742	Platykurtic	3.731
23	5.809	Coarse Silt	1.531	Poorly Sorted	-0.120	Coarse Skewed	0.971	Mesokurtic	3.731
25	5.866	Coarse Silt	1.356	Poorly Sorted	-0.038	Symmetrical	0.799	Platykurtic	3.731
27	5.871	Coarse Silt	1.328	Poorly Sorted	-0.019	Symmetrical	0.768	Platykurtic	3.731
29	5.791	Coarse Silt	1.720	Poorly Sorted	-0.189	Coarse Skewed	1.186	Leptokurtic	3.731
31	5.772	Coarse Silt	1.687	Poorly Sorted	-0.173	Coarse Skewed	1.129	Leptokurtic	3.731
33	5.909	Coarse Silt	1.278	Poorly Sorted	0.003	Symmetrical	0.734	Platykurtic	3.237
35	5.781	Coarse Silt	1.842	Poorly Sorted	-0.222	Coarse Skewed	1.326	Leptokurtic	3.731
37	5.746	Coarse Silt	1.768	Poorly Sorted	-0.193	Coarse Skewed	1.202	Leptokurtic	3.731
39	5.744	Coarse Silt	1.750	Poorly Sorted	-0.187	Coarse Skewed	1.179	Leptokurtic	3.731
41	5.538	Coarse Silt	1.970	Poorly Sorted	-0.218	Coarse Skewed	1.246	Leptokurtic	3.731
43	4.771	V. Coarse Silt	2.553	V. Poorly Sorted	-0.347	V. Coarse Skewed	1.208	Leptokurtic	3.731
45	3.263	V. Fine Sand	3.781	V. Poorly Sorted	-0.480	V. Coarse Skewed	0.732	Platykurtic	-2.243
47	5.694	Coarse Silt	1.839	Poorly Sorted	-0.202	Coarse Skewed	1.237	Leptokurtic	0.747
49	5.553	Coarse Silt	1.863	Poorly Sorted	-0.188	Coarse Skewed	1.141	Leptokurtic	3.731
51	5.179	Coarse Silt	2.096	V. Poorly Sorted	-0.224	Coarse Skewed	1.089	Mesokurtic	3.731
53	5.537	Coarse Silt	1.542	Poorly Sorted	-0.025	Symmetrical	0.773	Platykurtic	3.731
55	3.998	V. Fine Sand	2.671	V. Poorly Sorted	-0.154	Coarse Skewed	0.712	Platykurtic	3.731
57	3.341	V. Fine Sand	2.499	V. Poorly Sorted	0.115	Fine Skewed	0.766	Platykurtic	1.247
59	3.558	V. Fine Sand	2.977	V. Poorly Sorted	-0.113	Coarse Skewed	0.867	Platykurtic	-2.243
61	2.754	Fine Sand	2.493	V. Poorly Sorted	0.423	V. Fine Skewed	0.801	Platykurtic	0.747
63	2.629	Fine Sand	2.488	V. Poorly Sorted	0.430	V. Fine Skewed	0.893	Platykurtic	0.747
65	3.555	V. Fine Sand	2.634	V. Poorly Sorted	-0.013	Symmetrical	0.718	Platykurtic	3.731
67	2.380	Fine Sand	2.474	V. Poorly Sorted	0.528	V. Fine Skewed	0.903	Mesokurtic	0.747
69	1.861	Medium Sand	2.246	V. Poorly Sorted	0.547	V. Fine Skewed	0.999	Mesokurtic	0.747
71	1.479	Medium Sand	2.283	V. Poorly Sorted	0.457	V. Fine Skewed	1.381	Leptokurtic	0.747

Table 6. Sediment grain size results (S40) using Gradistat.

S40 Mid Sample Depth (cm)	Mean	Mean	Sorting (S)	Sorting	Skewness (*Sk*)	Skewness	Kurtosis (*K*)	Kurtosis	Mode (f)
1	4.309	V. Coarse Silt	1.432	Poorly Sorted	0.581	V. Fine Skewed	1.189	Leptokurtic	3.731
3	4.353	V. Coarse Silt	1.491	Poorly Sorted	0.547	V. Fine Skewed	1.132	Leptokurtic	3.731
5	4.252	V. Coarse Silt	1.437	Poorly Sorted	0.533	V. Fine Skewed	1.399	Leptokurtic	3.731
7	4.255	V. Coarse Silt	1.770	Poorly Sorted	0.314	V. Fine Skewed	1.743	V. Leptokurtic	3.731
9	4.496	V. Coarse Silt	1.842	Poorly Sorted	0.339	V. Fine Skewed	1.182	Leptokurtic	3.731
11	4.820	V. Coarse Silt	1.875	Poorly Sorted	0.187	Fine Skewed	0.990	Mesokurtic	3.731
13	4.945	V. Coarse Silt	1.652	Poorly Sorted	0.271	Fine Skewed	0.781	Platykurtic	3.731
15	5.308	Coarse Silt	1.960	Poorly Sorted	-0.141	Coarse Skewed	1.053	Mesokurtic	3.731
17	5.666	Coarse Silt	1.484	Poorly Sorted	-0.039	Symmetrical	0.800	Platykurtic	3.731
19	5.572	Coarse Silt	1.524	Poorly Sorted	-0.028	Symmetrical	0.777	Platykurtic	3.731
21	5.587	Coarse Silt	1.515	Poorly Sorted	-0.027	Symmetrical	0.778	Platykurtic	3.731
23	5.610	Coarse Silt	1.506	Poorly Sorted	-0.030	Symmetrical	0.784	Platykurtic	3.731
25	5.631	Coarse Silt	1.505	Poorly Sorted	-0.038	Symmetrical	0.798	Platykurtic	3.731
27	5.680	Coarse Silt	1.573	Poorly Sorted	-0.097	Symmetrical	0.915	Mesokurtic	3.731
29	5.761	Coarse Silt	1.430	Poorly Sorted	-0.043	Symmetrical	0.808	Platykurtic	3.731
31	5.676	Coarse Silt	1.536	Poorly Sorted	-0.075	Symmetrical	0.868	Platykurtic	3.731
33	5.444	Coarse Silt	1.639	Poorly Sorted	-0.057	Symmetrical	0.811	Platykurtic	3.237
35	5.368	Coarse Silt	1.603	Poorly Sorted	0.010	Symmetrical	0.730	Platykurtic	3.731
37	5.343	Coarse Silt	1.632	Poorly Sorted	-0.005	Symmetrical	0.740	Platykurtic	3.237
39	5.270	Coarse Silt	1.681	Poorly Sorted	-0.008	Symmetrical	0.744	Platykurtic	3.237
41	4.556	V. Coarse Silt	1.686	Poorly Sorted	0.463	V. Fine Skewed	0.790	Platykurtic	3.237
43	4.570	V. Coarse Silt	1.612	Poorly Sorted	0.522	V. Fine Skewed	0.823	Platykurtic	3.731
45	4.790	V. Coarse Silt	1.611	Poorly Sorted	0.407	V. Fine Skewed	0.731	Platykurtic	3.731
47	4.291	V. Coarse Silt	1.472	Poorly Sorted	0.579	V. Fine Skewed	1.125	Leptokurtic	3.237
49	3.791	V. Fine Sand	1.128	Poorly Sorted	0.587	V. Fine Skewed	2.469	V. Leptokurtic	3.237
51	3.797	V. Fine Sand	1.145	Poorly Sorted	0.583	V. Fine Skewed	2.463	V. Leptokurtic	3.237
53	3.679	V. Fine Sand	1.000	Moderately Sorted	0.467	V. Fine Skewed	2.512	V. Leptokurtic	3.237
55	3.486	V. Fine Sand	0.867	Moderately Sorted	0.224	Fine Skewed	2.563	V. Leptokurtic	3.237

Table 7. Sediment grain size results (S9A) using Gradistat.

Sample Depth (cm)	**Mean**	**Mean**	**Sorting (S)**	**Sorting**	**Skewness (*Sk*)**	**Skewness**	**Kurtosis (*K*)**	**Kurtosis**	**Mode (f)**
1	1.586	Medium Sand	1.550	Poorly Sorted	0.493	V. Fine Skewed	2.588	V. Leptokurtic	1.247
3	0.952	Coarse Sand	0.756	Moderately Sorted	-0.035	Symmetrical	1.061	Mesokurtic	1.247
5	0.714	Coarse Sand	0.749	Moderately Sorted	-0.029	Symmetrical	1.036	Mesokurtic	0.747
7	0.931	Coarse Sand	0.646	Mod. Well Sorted	-0.137	Coarse Skewed	1.247	Leptokurtic	1.247
9	2.070	Fine Sand	2.539	V. Poorly Sorted	0.640	V. Fine Skewed	1.174	Leptokurtic	0.747
11	4.342	V. Coarse Silt	2.707	V. Poorly Sorted	-0.318	V. Coarse Skewed	0.676	Platykurtic	1.247
13	5.930	Coarse Silt	1.262	Poorly Sorted	0.005	Symmetrical	0.730	Platykurtic	1.747
15	5.952	Coarse Silt	1.246	Poorly Sorted	0.008	Symmetrical	0.726	Platykurtic	3.731
17	5.971	Coarse Silt	1.231	Poorly Sorted	0.011	Symmetrical	0.722	Platykurtic	3.237
19	5.961	Coarse Silt	1.239	Poorly Sorted	0.009	Symmetrical	0.724	Platykurtic	1.747
21	2.043	Fine Sand	2.499	V. Poorly Sorted	0.435	V. Fine Skewed	1.401	Leptokurtic	1.247
23	1.529	Medium Sand	2.411	V. Poorly Sorted	0.381	V. Fine Skewed	1.711	V. Leptokurtic	0.747
25	2.421	Fine Sand	2.729	V. Poorly Sorted	0.432	V. Fine Skewed	0.840	Platykurtic	1.247
27	0.843	Coarse Sand	1.877	Poorly Sorted	0.125	Fine Skewed	1.604	V. Leptokurtic	1.247
29	1.128	Medium Sand	1.550	Poorly Sorted	0.153	Fine Skewed	2.038	V. Leptokurtic	1.247

GEOCHEMISTRY: CARBON AND NITROGEN

Values for $\delta^{13}C$ do not show distinct trends throughout core S43 or S40. In core S43, values vary between -25.79‰ to -24.80‰, with the exception of the sample at 4–6 cm which has an abnormally high value (Fig. 12). The ^{210}Pb data suggests that this part of the core is well-mixed and therefore this point is an anomaly. In core S40, values vary between -26.92‰ to -24.94‰ (Fig. 12). With the exception of the sample from 52–54 cm, the top 10 cm have the lowest $\delta^{13}C$ values. $\delta^{13}C$ values in core S9A vary from -28.00‰ to -29.32‰ (Fig. 12). The values show a slight decreasing up-core trend between 24 cm and 6 cm. It should be noted that some values had low precision because they yielded less than 100 μg of carbon. These values are indicated by an open square symbol in Figure 12. $\delta^{13}C$ values for two fish heads and two fish pellets averaged -18.26‰ and -22.41‰, respectively. $\delta^{13}C$ values for the common mangrove plants (Fig. 13a) in the SEL averaged -26.7‰ for *Nypa fruiticans*, -27.6‰ for *Rhizophora apiculata*, and -25.6‰ for *Avicennia alba* (Kuramoto and Minagawa, 2001).

Values for $\delta^{15}N$ do not show distinct trends throughout any of the three cores. In core S43, $\delta^{15}N$ values vary throughout the core from -0.27‰ to 1.03‰, again with the exception of the sample at 4–6 cm that has an abnormally high value (Fig. 14). Approximately half of the samples analyzed from core S40 (all samples between 32 and 56 cm) had low precision because the samples contained less than 20 μg of nitrogen or the sample size was too small. These samples, including one from S9A as well, are indicated by an open square symbol in Figure 14. The values from the top of core S40 vary between -0.38‰ and 0.45‰. In core S9A, $\delta^{15}N$ values range from -0.47‰ to 0.76‰ with the exception of the sample from 18-20 cm with a low precision value of 1.09 (Fig. 14). $\delta^{15}N$ values for two fish heads and two fish pellets averaged 11.40‰ and 5.83‰, respectively. $\delta^{15}N$ values for the common mangrove plants (Fig. 13a) in the

SEL averaged 4.2 for *Nypa fruiticans*, 1.8 for *Rhizophora apiculata*, and 1.2 for *Avicennia alba* (Kuramoto and Minagawa, 2001).

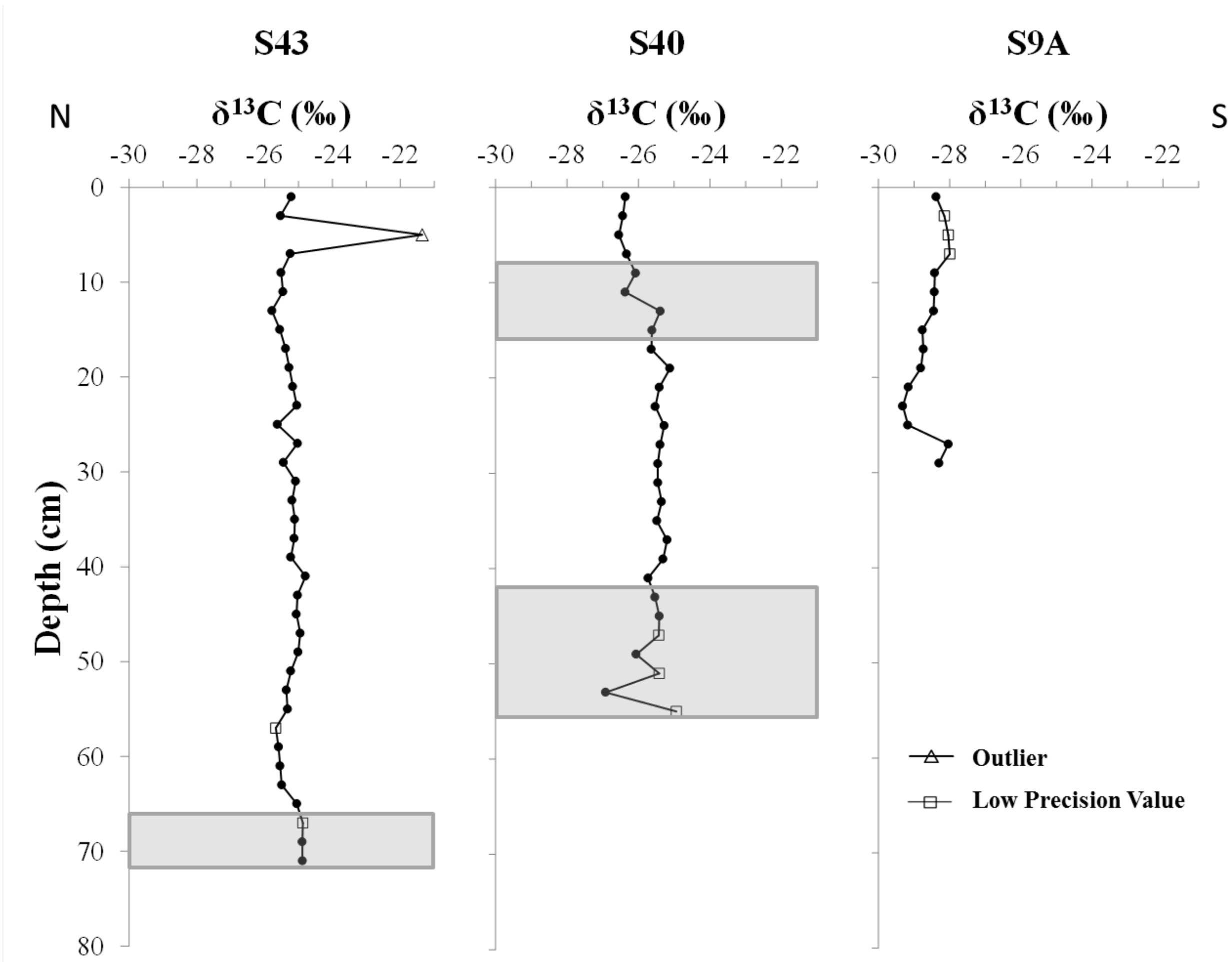

Figure 12. Down-core profiles of $\delta^{13}C$ values. Values labeled as "Low Precision Value" were returned with a message indicating that precision decreases for samples containing less than 100 µg of carbon. Shaded regionsat the bottom of the cores represent the 1970s. The shaded region between 8 and 16 cm for S40 represents the early 2000s.

The $\delta^{13}C$ values and $\delta^{15}N$ values throughout cores S43 and S40 are more similar to each other than to those of S9A (Fig. 13a). However, all three cores plot in the range of C_3 plants and near the average values of the common mangroves in the SEL.

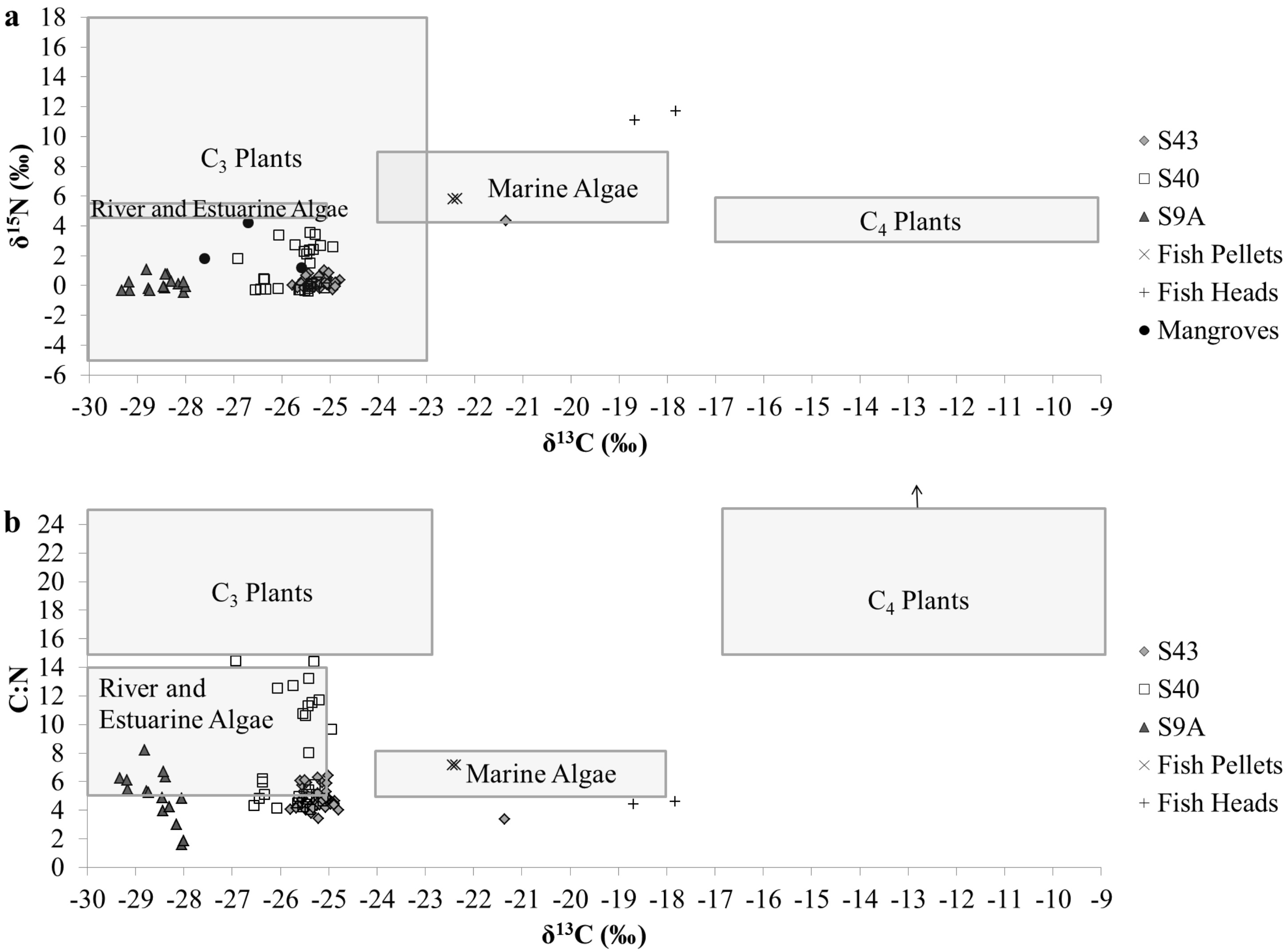

Figure 13. $\delta^{15}N$ vs. $\delta^{13}C$ (a) and C:N ratios vs. $\delta^{13}C$ (b) for all three cores and the two types of fish food with common ranges of organic matter sources outlined in gray. Mangrove plant values include those for *Nypa fruiticans*, *Rhizophora aviculata*, and *Avicennia alba* as reported by Kuramoto and Minagawa (2001). The C:N ratios for the mangrove plants range from 28-50 and therefore are not shown on this plot.

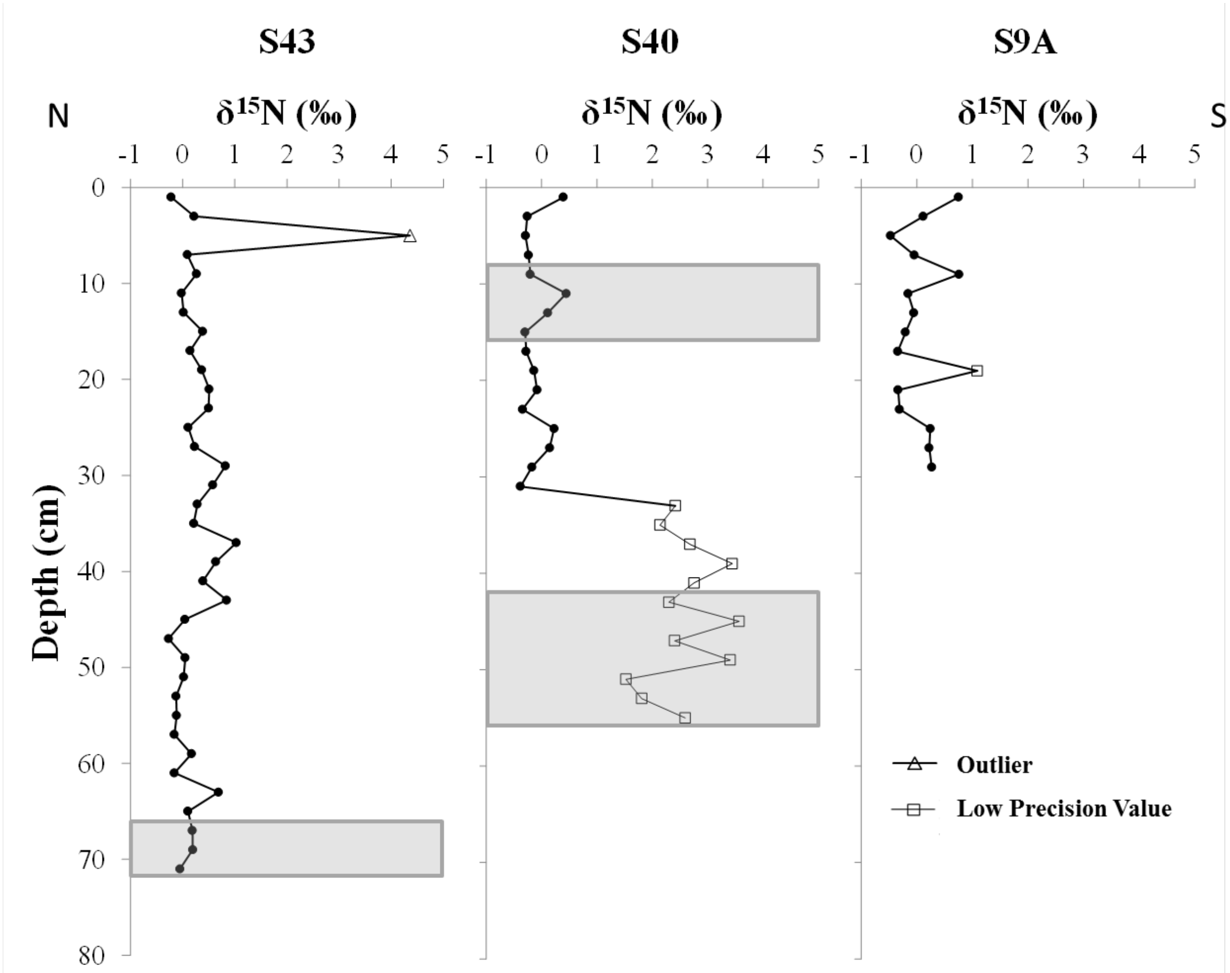

Figure 14. Down-core profiles of $\delta^{15}N$ values. Values labeled as "Low Precision Value" were returned with a message indicating that either precision decreases for samples containing less than 20 μg of nitrogen or sample sizes were too small. Shaded regions represent the 1970s, when aquaculture practices began.

The percent carbon and the percent nitrogen throughout each core demonstrate an inverse relationship with the percent of sand (Figs. 15, 16). The average percent carbon in two fish heads and two fish pellets was 26.31% and 38.17%, respectively; the average percent nitrogen was 6.80% and 6.22%, respectively.

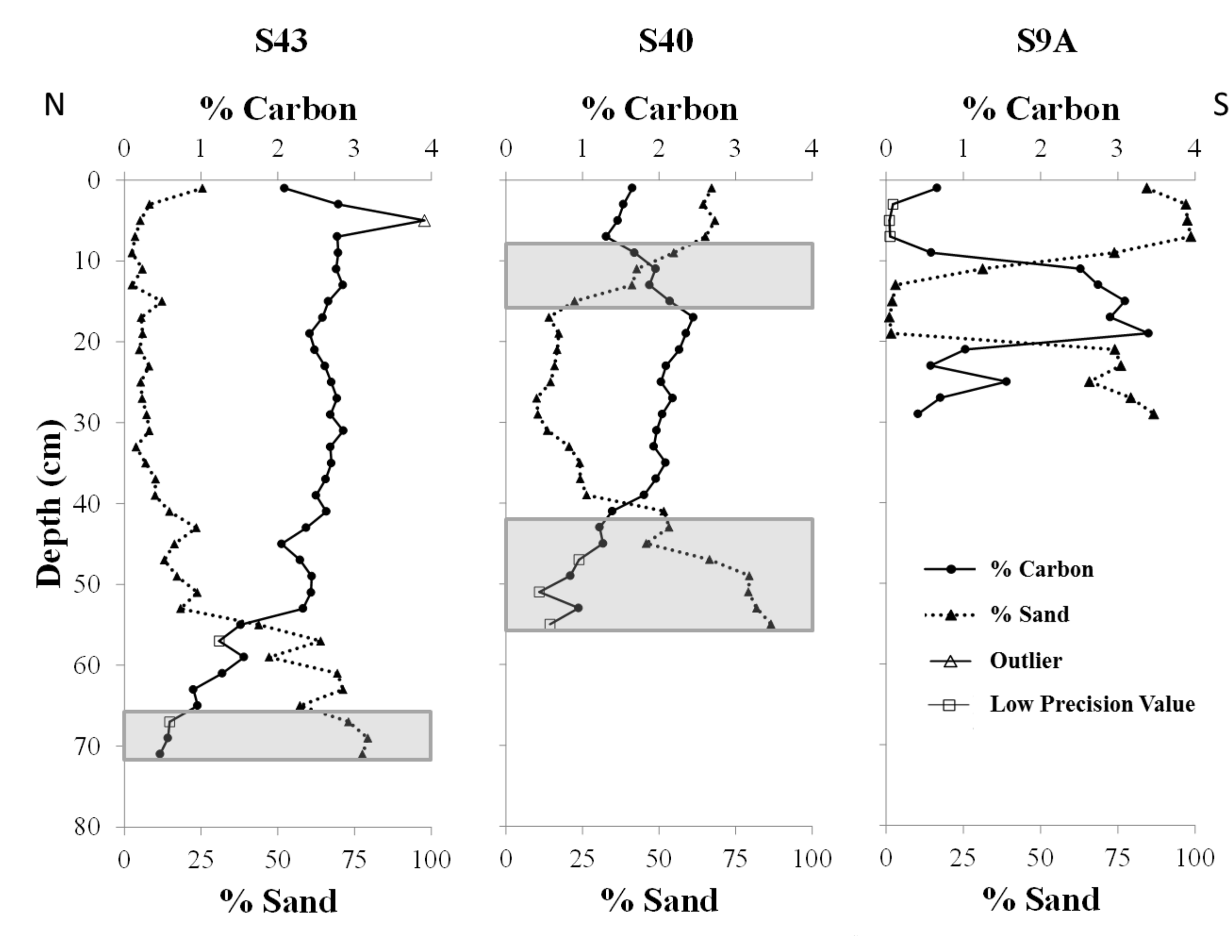

Figure 15. Percent carbon and percent sand throughout each core demonstrate an inverse relationship. Values labeled as “Low Precision Value” were returned with a message indicating that precision decreases for samples containing less than 100 µg of carbon. Shaded regions represent the 1970s, when aquaculture practices began.

In core S43, percent carbon and percent nitrogen increase up-core as percent sand decreases (Figs. 15, 16). In the top few centimeters, percent carbon and percent nitrogen decrease slightly as percent sand increases.

From the bottom of core S40 to 16 cm percent carbon and percent nitrogen generally increase and percent sand decreases (Figs. 15, 16). From 16 cm to the top of the core, percent carbon and percent nitrogen generally decrease and percent sand generally increases.

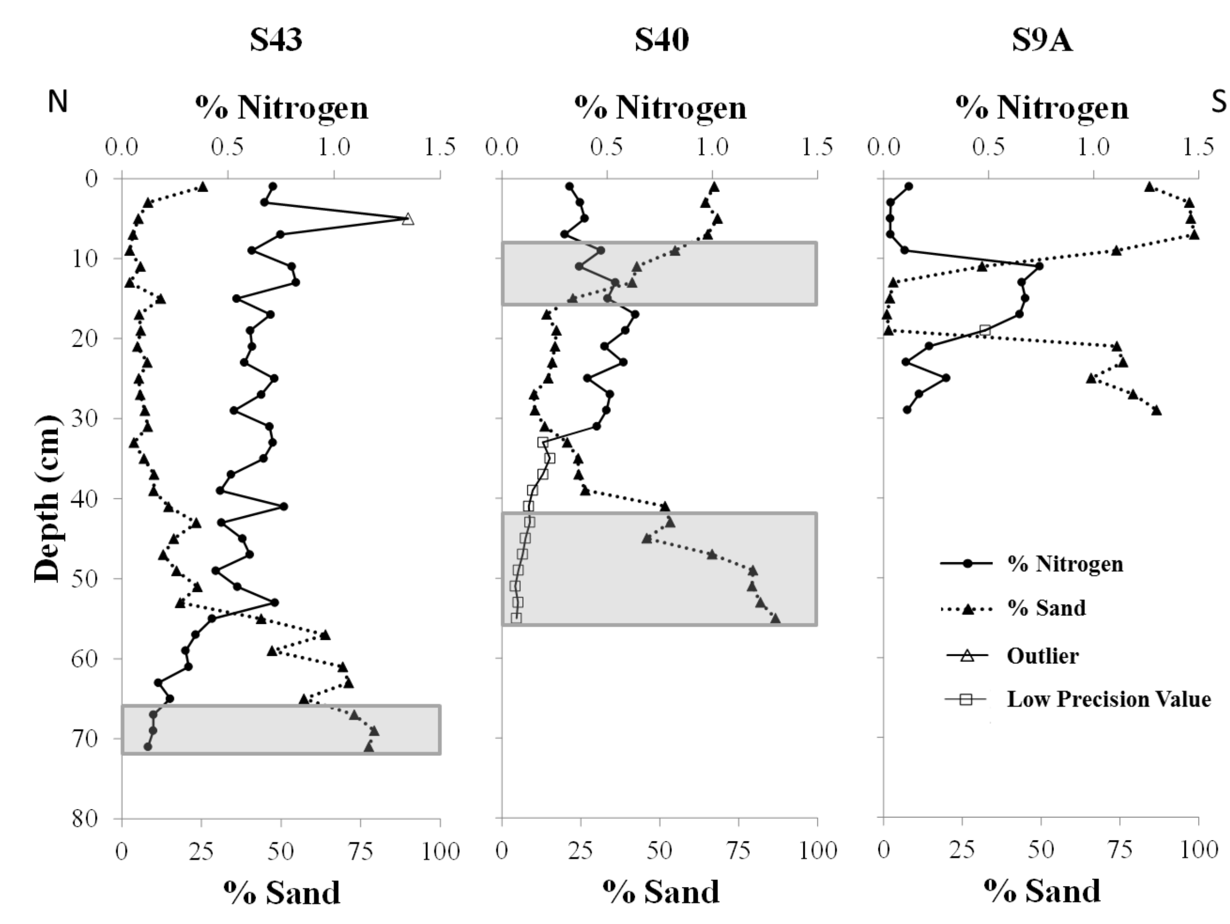

Figure 16. Percent nitrogen and percent sand throughout each core demonstrate an inverse relationship. Values labeled as "Low Precision Value" were returned with a message indicating that either precision decreases for samples containing less than 20 μg of nitrogen or sample sizes were too small. Shaded regions represent the 1970s, when aquaculture practices began.

In the bottom 10 cm (20–30 cm) of core S9A, percent carbon, percent nitrogen, and percent sand vary, but do not show distinct trends (Figs. 15, 16). Between the two samples at 20–22 cm and 18–20 cm, percent carbon and percent nitrogen rapidly increase and percent sand rapidly decreases. Between 18 cm and 12 cm, percent carbon, percent nitrogen, and percent sand remain relatively constant. Percent carbon and percent nitrogen then rapidly decrease again and percent sand increases between the samples at 10–12 cm and 8–10 cm. Near the top of the core, percent carbon and percent nitrogen approach 0% and percent sand nears 100%.

C:N plots (Fig. 17) show patterns nearly identical to those for $\delta^{15}N$. C:N values within all three cores remain relatively constant, varying between 3 and 7. C:N averages for two fish heads and two fish pellets were 4.52 and 7.16, respectively. C:N ratios for the common mangrove plants (Fig. 13b) in the SEL averaged 37.2 for *Nypa fruiticans*, 49.5 for *Rhizophora apiculata*, and 28.9 for *Avicennia alba* (Kuramoto and Minagawa, 2001).

The $\delta^{13}C$ values and C:N ratios throughout cores S43 and S40 are more similar to each other than to those of S9A (Fig. 13b). However, all three cores plot in the range of C_3 plants. C:N ratios throughout cores S43, S40, and S9A are much lower than those reported by Kuramotoa and Minagawa (2001) for the mangrove plants.

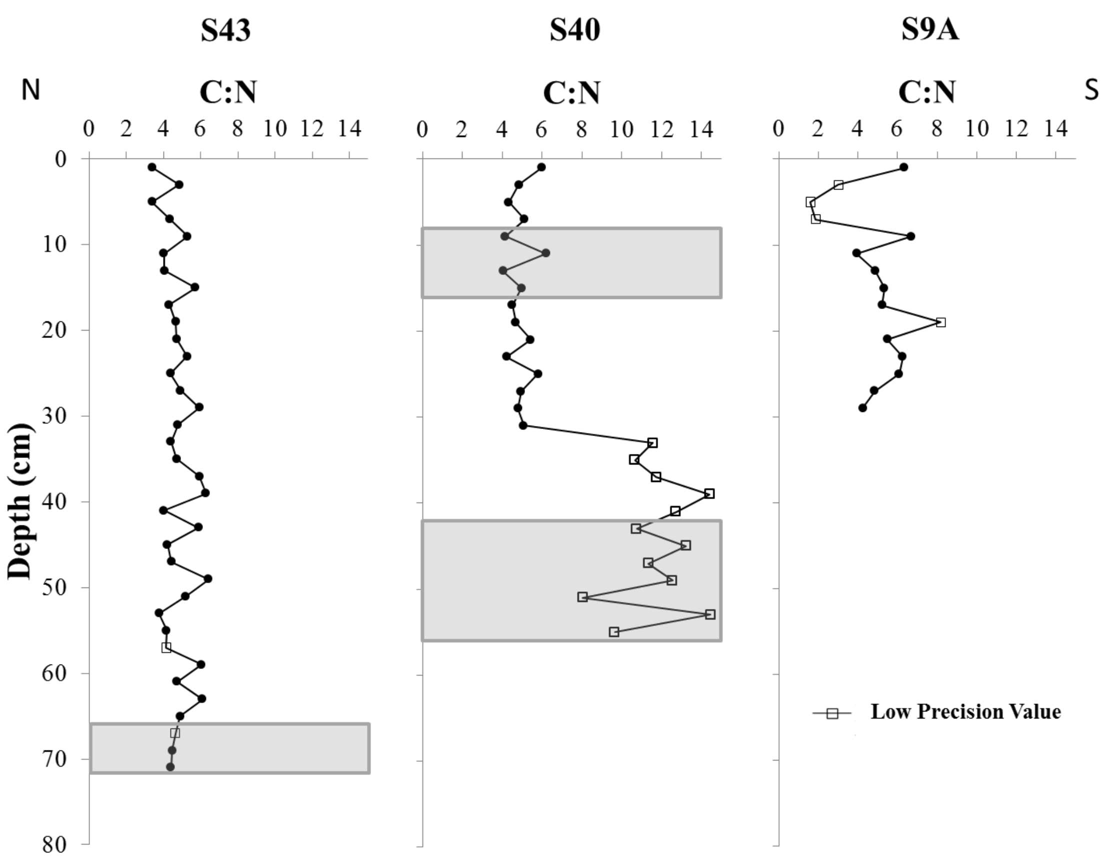

Figure 17. Down-core profiles of C:N. Values labeled as “Low Precision Value” were returned with a message indicating that either precision decreases for samples containing less than 100 µg of carbon, 20 µg of nitrogen, or sample sizes were too small. Shaded regions represent the 1970s, when aquaculture practices began.

DISCUSSION

SEDIMENTOLOGY

The greatest change in the SEL caused by the presence of aquaculture is a decrease in average sediment grain size (Fig. 11). Mojica and Nelson (1993) also found that the average amount of mud beneath a clam aquaculture site in Florida was much greater than at nearby reference sites. After the onset of aquaculture in a site in Nova Scotia, Grant and others (1995) found that sediments changed from an olive gray sandy silt to a black sandy mud.

In core S43, a steady trend towards muddier sediments up-core (Fig. 11) is attributed to the continuous usage of the fish cages. In core S9A, the onset of aquaculture is represented by a rapid change from orange quartz sand to black mud. A rapid return farther up-core to orange quartz sand likely corresponds to the abandonment of the fish cages. The fish cage complex at S9A was abandoned probably due to the closure of an inlet in 2003 that was 4 km south of the current inlet (Culver and others, 2012). The presence of an inlet in that location would have allowed salinity to be greater farther south where the S9A complex is located. Grain size in core S40 initially demonstrates a similar trend as S43, decreasing after the onset of aquaculture (Fig. 11); however, around 30 cm, there is a shift and percent sand begins to increase up-core again. This pattern is similar to that in S9A. With the closure of the second inlet in 2003, tidal current strength likely increased in the lagoon. Such an increase would have enhanced transport of marine sand towards the S40 fish cage complex. Alternatively, the grain size pattern in core S40 could reverse due to recent decreased usage of the S40 fish cages. However, there is no evidence for this as the complex was active at the time of collection.

FORAMINIFERA

Densities of dead foraminifera (Figs. 7b, 8b, 9b) demonstrate an inverse relationship with the amount of organic matter (percent carbon) (Fig. 15) and percent mud (Fig. 11) beneath the cages in all three cores. Foraminiferal density decreases up-core in S43. The consistent usage of fish cages at S43 explains this pattern. At S40, densities initially decrease up-core and then increase, following the opposite patterns of percent carbon and percent mud. At S9A, foraminiferal densities are low in the middle of the core, where percent carbon and percent mud are very high compared to the bottom of the core (pre-aquaculture) and the top of the core (post-aquaculture).

Patterns of decreasing total densities of foraminifera during consistent fish cage usage in this study are similar to those found by Angel and others (2000) in the Red Sea. The presence of aquaculture causes decreased total densities of foraminifera near the point source, as is evidenced by this study and others (Clark, 1971; Angel and others, 2000; Tarasova and Preobrazhenskaya, 2007). It is common to have a decrease in total foraminiferal density in the immediate vicinity of a source of organic matter (e.g., Bandy and others 1964; Buckley and others, 1974; Schafer and Cole, 1974; Alve, 1995; Hayek and Buzas, 2006), such as directly beneath fish cages.

The extremely high densities of dead foraminifera near the bottom and top of S40 and the bottom of S43 (Figs. 8b, 7b), where the amount of organic matter (percent carbon) is lower (Fig. 15), can be attributed to the transport of materials from the nearby inlet. The physical presence of the fish cages in the shallow lagoon creates a baffling effect, causing materials to drop out of suspension and accumulate beneath the cages. With an increase in tidal current strength near S40, as described above, dead foraminifera accumulate as the marine sands accumulate. This hypothesis is supported by the presence of very worn tests and a lack of live foraminifera.

Culver and others (2012) found that many calcareous hyaline taxa collected in the Setiu lagoon exhibited broken tests and were not present in live populations.

Percent live foraminifera in surface samples collected throughout the S43 fish cage complex and S40 fish cage complex averaged 24% and 6%, respectively (A. Ellis, personal communication, March 2013). The top samples of cores S43 and S40 had 36% and 3% live foraminifera, respectively (Table 3). The low percentage of live foraminifera at S40 may be a result of mixing within surface sediments and accumulation of sediments due to baffling as the tides from the nearby inlet enter the shallow lagoon. At S43, the percent of live foraminifera may be higher than that at S40 because of the greater percentage of organic matter (percent carbon) (Fig. 15) near the surface (Alve, 1995).

In a previous study of foraminifera in the SEL, Culver and others (2012) found high densities of dead foraminifera (average of 37,980/20 ml sample), low percentages of live foraminifera (average of 1.3%), high species richness (average of 37), and high species diversity (average of 13.5) at three locations 2–3 m from fish cages in the northern lagoon. In samples from the present study, comparable high densities of foraminifera are found near the bottom of cores S43 and S40 (Figs. 7b, 8b), at the beginning of farming practices, and near the top of core S40, where conditions of grain size, percent carbon, and percent nitrogen return to pre-aquaculture values (Figs. 11, 15, 16). These high densities at locations near the fish cages are likely the result of the accumulation of materials falling out of suspension with the incoming tides. Species richness is similar in cores S43 and S40 (average of 34 and 27, respectively) to the average found by Culver and others (2012). Species diversity (Fisher's α) in this study is closest to the average found by Culver and others (2012) only at the bottom of S43 and throughout all of S40 (Fig. 10; Table 3).

In core S43, *Ammobaculites exiguus*, an agglutinated species becomes more dominant through time over *Ammonia* aff. *A. aoteana,* a calcareous species that dominates near the bottom of the core. Similarly, agglutinated species *Paratrochammina stoeni*, "*Trochammina ochracea*," and *Trochammina* sp. E, are more abundant towards the top of the core (Fig. 7b). In core S40, *Ammobaculites exiguus* is most abundant in Thanatofacies 1 (Fig. 8b), which is the middle of the core where percent mud, percent carbon, and percent nitrogen are greatest (Figs. 11, 15, 16). Tarasova and Preobrazhenskaya (2007) found the highest percentage of agglutinated foraminifera near aquaculture sites in Minonosok Bay, Sea of Japan compared to reference sites. Eurytopic agglutinated taxa are often found to dominate assemblages near pollution point sources (Zalesny, 1959; Watkins, 1961; Bandy and others, 1964; Alve, 1995).

Culver and others (2012) found miliolids to be common near the inlet (Fig. 1), but very rare near the fish cages in the SEL. Miliolids decrease in abundance from south (at the inlet) to north; percent miliolids approaches 0 near S40 and S43 (Culver and others, 2012). Miliolids (*Quinqueloculina* spp.) in cores S43 and S40 are also rare near the surface (Figs. 7b, 8b). They are more abundant at the bottom of S40, when aquaculture practices had only just begun. This, paired with the data of Culver and others (2012), suggests that miliolids extended farther north in the lagoon prior to the installment of fish cages. Miliolids are typically found in normal marine to hypersaline environments (Murray, 1978, 2006). Increased abundance of organic matter, which results in hypoxic conditions, can cause particular species of foraminifera, such as *Quinqueloculina* spp., to decrease in abundance or disappear from the assemblage completely (Hayek and Buzas, 2006).

GEOCHEMISTRY: CARBON AND NITROGEN

In comparison with trends of grain size, there are no up-core trends in $\delta^{13}C$ and $\delta^{15}N$ values. This is likely due to the high sediment influx from mangrove plants surrounding the SEL, which would mask any signatures from fish feed or feces. $\delta^{13}C$ values for three of the common C_3 mangrove plants present in the SEL, *Nypa fruiticans, Avicennia alba*, and *Rhizophora apiculata*, range between -25.4‰ and -29.0‰ (Kuramoto and Minagawa, 2001) (Fig. 13a). C_3 plants typically have $\delta^{13}C$ values between -30.0‰ and -23.0‰ (Smith and Epstein, 1971; Cai and others, 1988; Boutton, 1991; Maksymowska and others, 2000). The depleted $\delta^{13}C$ values at S43 and S40 (-25.79‰ to -24.80‰ and -26.92‰ to -24.94‰, respectively) (Fig. 12) are, therefore, a result of terrestrial influence. The $\delta^{13}C$ values at S9A (-28.00‰ to -29.32‰) are even more depleted than those at S43 and S40 (Fig. 12), which is likely a result of the terrestrial influence of the Setiu and Caluk Rivers (Fig. 1).

Average $\delta^{13}C$ values for the two types of fish food, fish pellets and fish heads, are -22.41‰ and -18.26‰, respectively. These values compare well with $\delta^{13}C$ values that Ye and others (1991) found for fish feed (-21.53‰). Marine $\delta^{13}C$ values typically range between -24‰ and -18‰ (Fry and Sherr, 1984; Boutton, 1991; Tucker and others, 1999; Sampaio and others, 2010). The $\delta^{13}C$ values for the fish food are similar to those for marine sediments. $\delta^{13}C$ values at S43, S40, and S9A are more depleted than the fish food and marine signatures, and, therefore, are more likely the result of terrestrial influence.

$\delta^{15}N$ values for the three common mangrove plants listed above range between -0.4‰ and 6.3‰ (Kuramoto and Minagawa, 2001). C_3 plants in general have $\delta^{15}N$ values between -5.0‰ and 18.0‰ (Peters and others, 1978; Sweeney and Kaplan, 1980; Owens, 1987; Maksymowska et al., 2000). Similar conclusions to those made from the $\delta^{13}C$ data can be made from the $\delta^{15}N$ data: at all three core locations, $\delta^{15}N$ values are near zero and, therefore, have more of a terrestrial signature than a marine signature.

Average $\delta^{15}N$ values for the two types of fish food, fish pellets and fish heads, are 5.83‰ and 11.40‰, respectively. Marine $\delta^{15}N$ values typically range between 4‰ and 9‰ (Sweeney and Kaplan, 1980; Fry and Sherr, 1984; Owens, 1987; Tucker and others, 1999; Sampaio and others, 2010). $\delta^{15}N$ values for fish food and marine sediments are similar, like those for the $\delta^{13}C$ values , and are higher than those of the cores S43, S40, S9A. Thus, the sediment influx from the mangrove forest surrounding the SEL is likely responsible for the terrestrial signatures of both $\delta^{13}C$ and $\delta^{15}N$ beneath the fish cages. However, if the mangrove forest continues to be cleared for the installment of shrimp farms, the $\delta^{13}C$ and $\delta^{15}N$ signatures beneath the fish cages may shift from a mangrove signature to a signature representative of the shrimp farms.

The percent carbon, percent nitrogen, and percent mud show the same patterns in all three cores (Figs. 15, 16, 11). During periods of fish cage usage, all three increase. Carroll and others (2003) found that total organic carbon beneath salmon cages in Norway was higher than at reference sites. Similarly, Yokoyama and others (2006) found high levels of total organic carbon and total nitrogen near fish cages in Gokasho Bay, Japan compared to reference sites.

C:N ratios greater than 15 indicate terrestrial C_3 plant sources and C:N ratios ranging between 6.5 and 8.1 are typical of marine sediments (Meyers, 1997; Maksymowska and others, 2000; Kuramoto and Minagawa, 2001; Hu and others, 2006). C:N ratios for the three common mangrove plants listed above range from 27.7 to 49.7 (Kuramoto and Minagawa, 2001). The C:N ratios of the fish food averaged 7.16 for two pellets and 4.52 for two fish heads. Both of these values are very similar to the C:N values (3-7) throughout all three cores. However, the $\delta^{13}C$ and $\delta^{15}N$ values throughout the cores are more similar to those of terrestrial sources than the fish food. Cifuentes and others (1996) found high $\delta^{13}C$ values similar to mangrove plants and unusually low C:N values in an estuary in Ecuador. They attributed the low C:N values to nitrogen immobilization as mangrove plants decompose. With the amount of nitrogen being held constant and carbon being removed as CO_2, the C:N ratio decreases. Thus, the low C:N ratios in the SEL are likely a result of the decomposition of mangrove plants.

SUMMARY

The percent of organic matter (percent carbon) and percent nitrogen have a strong correlation with grain size beneath the fish cages. The presence of aquaculture causes a large flux of organic matter to the sediments in the form of fish feces and fish feed waste. However, the signature of carbon and nitrogen isotopes is a result of the influx of sediments from the surrounding mangroves. $\delta^{13}C$ and $\delta^{15}N$ values in both the lagoon and estuary are similar to those of terrestrial sources, including the nearby mangrove plants. The increased organic matter does however result in decreases in foraminiferal densities, diversity, and changes in abundances of particular taxa.

Patterns of grain size, foraminiferal density and diversity, percent carbon, and percent nitrogen all show similar patterns throughout core S43: percent sand and foraminiferal density and diversity decrease up-core as percent carbon and percent nitrogen increase. Patterns are also similar throughout core S40: percent sand and foraminiferal density and diversity initially decrease up-core as percent carbon and percent nitrogen initially increase. Near the same depth (~30 cm), all four trends reverse. This is likely in response to the closure of the southern inlet in 2003, which would have increased tidal current strength in the lagoon, especially near S40. High densities of foraminifera at the bottom of S43 and at the bottom and top of S40 are likely due to the baffling effect of the cages. In S9A, patterns of percent sand, percent carbon and percent nitrogen exhibit two abrupt trend reversals near the same depths, the lower one corresponding to the onset of aquaculture and the upper one corresponding to the abandonment of the cages. Foraminiferal density demonstrates less abrupt changes and foraminiferal diversity does not demonstrate a change at all.

CONCLUSIONS

The abrupt changes in foraminiferal distributions, grain size, and geochemistry in S9A, where the complex was abandoned, and the gradual changes to pre-aquaculture conditions in S40suggest that aquaculture in the SEL is not creating any permanent detrimental effects on the environment. Changes in sediment properties reversed quickly after abandonment at S9A. Sediment properties at S40 have reversed more gradually, but this corresponds with a likely increase in tidal current strength associated with the closure of the southern inlet in 2003.. Tidal flushing and the presence of the surrounding mangrove forest are reducing the signature of the fish cage complex in the sediments at S40. Current farming activities at the active cage complexes do not appear to be great enough to significantly compromise the environmental health of the SEL.

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APPENDIX A. Taxonomic Reference List (abbreviated names of taxa used in Figs. 7-9)

Ammobaculities exiguus Cushman and Brönnimann, 1948, p. 38, pl. 7, figs. 7, 8. (*A. exi*)

Ammonia aff. *A. aoteana* (Finlay) = *Streblus aoteanus* Finlay, 1940, p.461. (*A.* aff. *A. aoteana*)

Ammonia tepida (Cushman) = *Rotalia beccarii* (Linné) var. *tepida* Cushman, 1926, p. 79, pl. 1, figs. 8a, b, c.

Ammotium directum (Cushman and Brönnimann) = *Ammobaculites directum* Cushman and Brönnimann, 1948, p. 38, pl. 7, figs. 3a, b, 4. (*A. dir*)

Ammotium morenoi (Acosta) = *Ammobaculites morenoi* Acosta, 1940, p. 272, pl. 49, figs. 3, 8, not fig. 1. (*A. mor*)

Amphistegina lessonii d'Orbigny, 1826, p. 304, no. 3. (*A. les*)

Asterorotalia pulchella (d'Orbigny) = *Rotalia (Calcarina) pulchella* d'Orbigny, 1839a, p. 80, pl. 5, figs. 16–18.

Bolivina striatula Cushman, 1922, p. 27, pl. 3, fig. 10. (*B. str*)

Bruneica clypea Brönnimann, Keij and Zaninetti, 1983, p. 36, pls. 1, 2.

Brizalina subtenuis (Cushman) = *Bolivina subtenuis* Cushman, 1936, p. 57, pl. 8, fig. 10.

Buliminella elegantissima (d'Orbigny) = *Bulimina elegantissima* d'Orbigny, 1839b, p. 51, pl. 7, figs. 13,14.

Buliminoides williamsoni (Brady) = *Bulimina williamsoniana* Brady, 1884, p. 408, pl. 51, figs. 16, 17.

Cancris carinatus (Millett) = *Pulvinulina oblonga* (Williamson) var. *carinata* Millett, 1904, p. 498, pl. 10, fig. 3.

Caronia exilis (Cushman and Brönnimann) = *Gaudryina exilis* Cushman and Brönnimann, 1948, p. 40, pl. 7, figs. 15, 16. (*C. exi*)

Cellanthus biperforatus Whittaker and Hodgkinson, 1979, p. 84, fig. 61; pl. 7, figs. 3a, b; pl. 10, fig. 21.

Chrysalidinella dimorpha (Brady) = *Chrysalidina dimorpha* Brady, 1884, p. 388, pl. 46, figs. 20, 21.

Cibicides cf. *C. fletcheri* Galloway and Wissler, 1927, p. 64, pl. 10, figs. 8, 9. (*C.* cf. *C. fle*)

Dyocibicides primitivus Vella, 1957, p. 41, pl. 9, figs. 198–200.

Elphidium advenum s. l. (Cushman) = *Polystomella advenum* Cushman, 1922, p. 56, pl. 9, figs. 11, 12.

Elphidium crispum (Linné) = *Nautilus crispus* Linné, 1758, p. 709.

Elphidium hyalocostatum Todd, 1957, p. 300, pl. 88, fig. 19.

Elphidium indicum Cushman, 1936, p. 83, pl. 14, fig. 10.

Elphidium cf. *E. neosimplex* McCulloch, 1977, p. 223, pl. 91, fig. 1.

Elphidium poeyanum (d'Orbigny) = *Polystomella poeyana* d'Orbigny, 1839a, p. 55, pl. 6, figs, 25, 26.

Elphidium cf. *reticulosum* Cushman, 1933a, p. 51, pl. 12, figs. 5a, b. (*E. ret*)

Elphidium aff. *E. simplex* Cushman, 1933b, p. 52, pl. 12, figs. 8, 9.

Elphidium aff. *E. simulatum* McCulloch, 1977, p. 224, pl. 97, fig. 8.

Elphidium singaporense McCulloch, 1977, p. 224, pl. 97, fig. 2.

Fissurina cf. *F. paula* McCulloch, 1977, p. 120, pl. 58, fig. 5.

Gavelinopsis praegeri (Heron-Allen and Earland) = *Discorbina praegeri* Heron-Allen and Earland, 1913, p. 122, pl. 10, figs. 8-10. (*G. pra*)

"Glomospira" fijiensis Brönnimann, Whittaker and Zaninetti, 1992, p. 23, pl. 3, figs. 1–4.

"Glomospirella" fijiensis Brönnimann, Whittaker and Zaninetti, 1992, p. 23, pl. 13, figs. 1–4.

Haplophragmoides cf. *H. manilaensis* Andersen, 1953, p. 22, pl. 4, fig. 8a, b.

Haplophragmoides wilberti Andersen, 1953, p. 21, pl. 4, fig. 7.

Miliammina fusca (Brady) = *Quinqueloculina fusca* Brady *in* Brady and Robertson, 1870, p. 47, pl. 11, figs. 2, 3. (*M. fus*)

Murrayina murrayi (Heron-Allen and Earland) = *Rotalia murrayi* Heron-Allen and Earland, 1915, p. 721.

Notorotalia cf. *N. inornata* Vella, 1957, p. 54, pl. 2, fig. 29; pl. 3, figs. 36-38.

Pararotalia aff. *P. calcariformata* McCulloch, 1977, p. 428, pl. 177, figs. 10, 11.

Pararotalia nipponica (Asano) = *Rotalia nipponica* Asano, 1936, p. 614, pl. 31, figs. 2a–c.

Pararotalia venusta (Brady) = *Rotalia venusta* Brady, 1884, p. 708, pl. 108, fig. 2.

Paratrochammina stoeni Brönnimann and Zaninetti, 1979, p. 51-54, pl. 2, figs. 1–7. (*P. sto*)

Peneroplis pertusus (Forskål) = *Nautilus pertusus* Forskål, 1775, p. 125.

Planispirinella exigua Brady, 1879, p. 267.

Planorbulina acervalis Brady, 1884, p. 657, pl. 92, fig. 4.

Pseudorotalia schroeteriana (Parker and Jones) = *Planorbulina schroeteriana* Parker and Jones *in* Carpenter and others, 1862, p. 213, pl. 13, figs. 7–9.

Reussella pulchra Cushman, 1945, p. 34, pl. 34, figs. 11–12. (*R. pul*)

Reussella spinulosa (Reuss) = *Verneuilina spinulosa* Reuss, 1850, p. 374, pl. 47, fig. 12.

Rosalina globularis d'Orbigny, 1826, p. 271, pl. 13, figs. 1–4. (*R. glo*)

Sagrina zanzibarica (Cushman) = *Bolivina zanzibarica* Cushman, 1936, p. 58, pl. 8, fig. 12. (*S. zan*)

Sagrinella lobata (Brady) = *Bolivina lobata* Brady, 1881, p. 58; Brady, 1884, pl. 53, figs. 22, 23. (*S. lob*)

Schackoinella globosa (Millett) = *Discorbina imperatoria* (d'Orbigny) var. *globosa* Millett, 1903, p. 701, pl. 7, figs. 6a, b. (*S. glo*)

Siphotrochammina lobata Saunders, 1957, p. 9, 10, pl. 3, figs. 1, 2. (*S. loba*)

Sorites marginalis (Lamarck) = *Orbulites marginalis* Lamarck, 1816, p. 196.

Spirolina cylindracea (Lamarck) = *Spirolinites cylindracea* Lamarck, 1804, p. 245; 1806, pl. 62, fig. 15.

Trochammina amnicola Brönnimann and Keij, 1986, p. 22, pl. 2, figs. 1, 2; pl. 4, figs. 1–13. (*T. amn*)

Wisenerella auriculata (Egger) = *Planispirina auriculata* Egger, 1893, p. 245, pl. 3, figs. 13–15.

Asterigerinata sp. A (*A.* sp. A)

Bolivina spp. (*B.* spp.)

Nonion sp. B (*N.* sp. B)

Quinqueloculina spp. (*Q.* spp.)

Trochammina sp. E (*T.* sp. E.)

"*Trochammina ochracea*" ("*T. och*.")

APPENDIX B. Foraminiferal census data, S43. L, live; D, dead. Sample depth, cm.

Taxon ↓ Sample depth →		1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65	67	69	71
Agglutinella sp. A	L	1																																			
	D	1		1			1	2										1						1	2			1			2	1			1	1	
Ammobaculities exiguus	L	16	16	8	8	22	4	7		4	1	1	5	1	1	4		1	1																		
	D	35	41	40	44	73	72	86	42	42	33	64	55	38	19	17	36	27	27	20	24	31	18	16	17	10	7	14	12	5	11	3	6	5	8	10	
Ammonia aff. *A. aoteana*	L	30	46	12	17	14	6	8	4	5	6	7	4	9			3	3	1			1															
	D	18	50	53	73	40	62	46	52	85	110	85	111	82	87	85	99	105	93	90	73	96	100	101	109	87	90	74	85	114	70	80	82	83	97	98	92
Ammonia tepida	L																																				
	D																																	1			
Ammotium directum	L																																				
	D				2	1		1								1	1					1															
Ammotium morenoi	L	2		1																																	
	D	1	1	1		3	4	5	2		1	1	2	1			3				2						1	1			2	1			1		
Amphistegina lessonii	L																																				
	D	2		1	1				1		2							1	1	1				3		1		2		2		3			1	1	
Asterigerinata sp. A	L													1																							
	D		1	2																		1		1	1												
Asterorotalia pulchella	L																																				
	D			2																					1				1	1	1	1		1			2
Bolivina striatula	L																																				
	D										2	1			3	3	2				1	1		3	1	4	3	2	2		2	7		1	4	3	4
Bolivina sp. 8	L																																				
	D																																	1			
Brizalina subtenuis	L																																				
	D				2												1																	1			
Bruneica clypea	L																																				
	D			1		1								1								1															
Bulimina sp. 2	L																																				
	D											1															1			1							
Bulimina sp. 3	L																																				
	D																											2									1
Buliminella elegantissima	L																																				
	D																								1								1				1
Buliminoides williamsoni	L																																				
	D									1							1	1											1					1	1	1	1
Cancris carinatus	L																																				
	D																																				
Caronia exilis	L			1	1																																
	D					2			1			1	1							2					1												
Cassidulina sp. A	L																																				
	D										1												1			1		2									
Cellanthus biperforatus	L																																				
	D				1																											2		1			
Cheilochanus sp. 1	L																																				
	D															1	1	1	1				1			2				1	1	1					
Chrysalidinella dimorpha	L																																				
	D																																		1		
Cibicides cf. *C. fletcheri*	L																																				
	D	1		3								1		1			1	1	1						3			1		2		3			1	2	3
Cibicides sp. 1	L																																				
	D	1		1	5					1	1		1	1	5	3	5	6	5	1	1		1	1	6	2	6		3	4	1	2	2		1	4	
Cibicides sp. 2	L																																				
	D								1		1								2		1		1		1				1	1			1	2		1	2

Cibicides sp. 4	L																																				
	D																					1				2	2	1	1			1	1			4
Discorbis sp. A	L																																				
	D														1		1													2	1	2				
Dyocibicides primitivus	L																																				
	D								1	2								2								1		3							1	
Elphidium advenum s. l.	L																																				
	D	1							1										2				1	1	1				1						1	1
Elphidium crispum	L																																				
	D																									1										
Elphidium hyalocostatum	L																																				
	D	1			1				5		2		1		1				1		1															
Elphidium indicum	L																																				
	D									2						1		2	1							1				1	1	1					
Elphidium cf. E. *neosimplex*	L																																				
	D						2		1	1																			1					1		1	
Elphidium poeyanum	L																																				
	D					1						2								1																	
Elphidium cf. *E. reticulosum*	L																																				
	D				3		3	1			1	2			2		2			4	1	1	5	1			3	1		2				3	2		2
Elphidium aff. *E. simplex*	L																																				
	D		2		1				1	2				1	1	1				1	1		3		3	1	1	1			2	1	3		4	1	
Elphidium aff. *E. simulatum*	L																																				
	D	1		2						1	1					1	1		1					2		1						1			1		1
Elphidium singaporense	L																																				
	D																							1						1		3					1
Elphidium sp. L	L																																				
	D										1																	1	1							1	
Elphidium sp. Q	L																																				
	D										1															1			1					1			
Elphidium sp. 4	L																																				
	D				1				1		2									1					2	2	1	1	1	1		3	2		4	3	
Fissurina cf. *F. paula*	L																																				
	D																																				
Fissurina sp. 1	L																																				
	D																					1				1			1			1					
Gavelinopsis praegeri	L		3																																		
	D	11	4	15	13					2	4			8	3	2	8	4	3	8	4	2	4		2		1	1	3	2	4	2	3	5	6	2	7
"Glomospira" fijiensis	L	1																																			
	D		1				1	1																													
"Glomospirella" fijiensis	L																																				
	D							1																													
Haplophragmoides cf. *H. manilaensis*	L																																				
	D										1																							1			
Haplophragmoides wilberti	L																																				
	D																1																				
Miliammina fusca	L																																				
	D		2			1																															
Murrayinella murrayi	L																																				
	D	2							2	1	1						1	5	1	2	3		4	1		4	4	4	3		6	5	4	3	2	1	4
Neoconorbina sp. 1	L																																				
	D																											1		1	1	1	1	1		1	
Nonion sp. A	L																																				
	D																1											2		1	2						1
Nonion sp. B	L	1	1																																		
	D	1	3		2	1			4	1	4	1	1	3	3	2	2	5	4	3	5	3	2	6	11	7	6	6	3	3	6	1	5	2	1	3	10
Nonion sp. C	L																																				
	D								4		2				1	1	3	1					2	1	1	1	1		2	2	2	3	3		1		2
Nonionella sp. A	L																																				
	D																												2							3	
Pararotalia nipponica	L																																				
	D			1													2							1	1		1	1								1	1

Pararotalia venusta	L																																				
	D																												1				1		1		
Paratrochammina stoeni	L	7	1		1		1	3	1																												
	D	2	2		4	8	8	7	24	4	1	2	4	7	3	1	3	1				1	1	1	1			1				1					
Peneroplis pertusus	L																																				
	D															1				1		2		1				2	1	3	1		3		1		
Peneroplis sp. A	L																																				
	D						1																														
Planispirinella exigua	L																																				
	D																																1				
Planorbulina acervalis	L																																				
	D										1														1			2		1	2	1	1	2	1	1	1
Pseudorotalia schroeteriana	L																																				
	D						1		1			1		2			1			2				1	1	3	1				2	2	4	5	2	3	1
Quinqueloculina sp. 3	L																																				
	D											1											2	3	1	1		1	1	2	1						
Reussella pulchra	L	1																																			
	D	1	1	5	2	1		1	3	2	6		2	2	4	2	5	2	2	1	4	5	4	6	9	4	7	6	15	6	7	3	4	8	10	7	8
Reussella spinulosa	L																																				
	D																			1					1					1				1	2	1	1
Reussella sp. C	L																																				
	D										2																										
Rosalina globularis	L	1	1			1																															
	D	4	1	3	4		3		5	7	4	7	4	8	10	16	21	17	17	16	22	14	15	29	21	18	13	14	23	24	25	32	17		15	26	16
Sagrina zanzibarica	L		1																																		
	D	1							7	1	4	2	1	1	3	4	2	4	7	4	6		2	4	11	2	9	3	6	7	1	3	7	9	4	1	7
Sagrinella lobata	L																																				
	D	4	4	14	12	4	8	3	8	8	5	8	7	13	12	8	10	4	6	7	11	12	4	8	6	10	13	1	10	12	8	8	9	14	6	8	8
Schackoinella globosa	L														1																						
	D	2		2	4									1	1		3		1		2	10	3		1		4	7	3				2	3	3	3	
Siphotrochammina lobata	L																																				
	D	1		1		2						3		1							1																
Sorites marginalis	L																																				
	D																											1					1				
Spirolina cylindracea	L																																				
	D																												1	1		1		1	2		1
Trochammina amnicola	L		6																																		
	D		2			3		1	1		1			1	2						2		1	3	2					2							
"*Trochammina ochracea*"	L							1																													
	D	2	4	10	6	9	7	4	4		4	10	4	2	4	3	3	1	1	1				1	1		1	2						1			
Trochammina sp. E	L					2		3	2																												
	D		1	2	4	6	10	10	17	3	7	1	2	2	3	2	2	1	2	4			6	1	2				1	3					1		
Trochammina sp. 2	L																																				
	D							1																													
Bolivina spp.	L																																				
	D	3	1	2	5			1	5	2	3	1	1		5	9	2	3	7	1	8	5	5	4	10	8	10	6	6	8	3	8	11	8	3	2	1
Elphidium spp.	L																																				
	D	1				1	1				5							1	1	1				1				3			3		1	1			
nodosariid	L																																				
	D																														1						
Quinqueloculina spp.	L		1																																		
	D	4	3	4	1	4			3	10	8	1	1	6	12	16	12	9	11	10	13	7	9	9	6	12	10	7	13	10	16	17	8	11	10	10	9
indeterminate genus A	L																																				
	D					1																							1								
indeterminate rotaliid	L																																				
	D	1	1	13	7	1	3	3	8	10	6	2	4	7	10	9	18	7	8	12	5	10	5	4	10	12	4	7	5	4	12	12	5	10	4	4	7
indeterminate agglutinated	L																																				
	D	1				1		2		1					1			1							1						1	1					1
Number of live specimens	L	60	76	22	27	39	11	22	7	9	8	8	9	11	2	4	3	4	2	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of dead specimens	D	105	125	180	198	164	187	176	203	190	229	198	202	190	195	190	253	212	206	197	191	204	200	216	249	197	202	192	214	231	199	216	191	190	202	206	201
Total foraminifera (live + dead)		165	201	202	225	203	198	198	210	199	237	206	211	201	197	194	256	216	208	200	191	205	200	216	249	197	202	192	214	231	199	216	191	190	202	206	201

APPENDIX C. Foraminiferal census data, S40. L, live; D, dead. Sample depth, cm.

Taxon ↓ Sample depth →		1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55
Agglutinella sp. A	L																												
	D																	1		2					2	3	1	2	1
Agglutinella sp. B	L																												
	D																					1				1		1	
Ammobaculities exiguus	L					2	1			1			1					1											
	D	9	14	21	15	13	18	23	16	24	24	34	36	19	22	21	21	20	14	7	7	7	6	5	9	2	1	3	6
Ammonia aff. *A. aoteana*	L	6	1	1	1					2																			
	D	52	34	35	31	30	27	49	44	36	49	42	40	41	64	50	57	51	30	32	35	36	34	32	35	25	55	34	30
Ammonia tepida	L																												
	D												1								1					1			
Ammotium directum	L																												
	D														1														
Ammotium morenoi	L					1	1																						
	D	1	4	2	4	7	9		2		1	4	4					1	1						1		1		
Amphistegina lessonii	L																												
	D	11	1	1	1		4			6	3	3	2		3	1	1	1	2	3	2	2	2	4	6	3	6	4	3
Asterigerinata sp. A	L																												
	D	4	1		1				2	2		2	1			1	1	3		1			1	3					
Asterorotalia pulchella	L																												
	D		1		1	1			3	1										1	3		1	1	1		2	1	2
Bolivina striatula	L																1												
	D	2	2		1	1	1	4		3	1	1	1			4	2	2		2		1		1	2	2	1	1	1
Bolivina sp. 8	L																												
	D	1			1							1	1							1		1					2	4	2
Bolivina sp. 9	L																												
	D																	1											
Brizalina subtenuis	L																												
	D				1	1												2	1	1		1			2				
Bruneica clypea	L																												
	D			1	1									1															
Bulimina sp. 2	L																												
	D																		1	2									
Bulimina sp. 3	L																												
	D		1																										
Bulimina sp. 4	L																												
	D																								1				
Buliminella elegantissima	L																												
	D																									1			
Buliminoides williamsoni	L																												
	D	1				1		1													2	1				1		3	3
Cancris carinatus	L																												
	D				1																			1					
Caronia exilis	L																												
	D	5	1		1					6	3	1	1		1	1	1												1
Cassidulina sp. A	L																												
	D																					1		1		1	1		
Cellanthus biperforatus	L																												
	D										1	1	1	1	1		2												
Cheilochanus sp. 1	L																												
	D			1				2	1	1	1		1						1	1				1	1				
Chrysalidinella dimorpha	L																												
	D																		1										1

Cibicides cf. *C. fletcheri*	L																												
	D	5	7	5	9	4	4	1	4	4	4	4	1	3	2	2		3	1	1	1	4	2	1	2	6	5	1	4
Cibicides sp. 1	L																												
	D	4	1	3	5	4	2	5	5	3	1	1	3	1	1	3		3	4		1	6	6	7	3	1	3		
Cibicides sp. 2	L																												
	D		3	1			1	1	1		1		1			2	1	1		1	1	6	2	2	1	4	2	3	6
Cibicides sp. 4	L																												
	D			2			1					1									1					1		3	1
Cibicides sp. 5	L																												
	D				1																								
Discorbis sp. A	L																												
	D	1			1	2			1				1	1				2											1
Dyocibicides primitivus	L																												
	D	1				1	1	1		1	1		1				2	2	2			1	6		4	2	3		5
Elphidium advenum s. l.	L																												
	D				1							1			1	2		1					1		1	3	3	1	2
Elphidium crispum	L																												
	D	1									1												1				2	2	1
Elphidium hyalocostatum	L																												
	D									1																			
Elphidium indicum	L																												
	D																		4		1								1
Elphidium cf. E. *neosimplex*	L																												
	D		1	3			1						1		1			1		1		1		2	1		1	1	1
Elphidium poeyanum	L																												
	D							1			1	1			2											1			
Elphidium cf. *E. reticulosum*	L				1																								
	D		2				2		1	3	6	1	1	4	2		2	1	1	3	3		2	1	2	1		1	3
Elphidium aff. *E. simplex*	L																												
	D	4	2	2	1	4	5	4	1	1	1	1	3		4		1	1	2		2		2		5	2	1	2	6
Elphidium aff. *E. simulatum*	L																												
	D		1			1														1						2			1
Elphidium singaporense	L																												
	D			1			2			1				1	1			1				1	2			1	1		
Elphidium sp. L	L																												
	D		5	1	1														2			1						2	
Elphidium sp. P	L																												
	D										1																		
Elphidium sp. Q	L																												
	D	1																		1		1	1		3			2	
Elphidium sp. 4	L																												
	D		3			1							1	2		1	1	1	2				2	2		1		1	1
Fissurina cf. *F. paula*	L																												
	D	1					1																						
Fissurina sp. 1	L																												
	D																									1			
Gavelinopsis praegeri	L																												
	D	16	7	4	11	7	10	12	9	9	11	17	14	18	18	19	17	9	14	16	12	12	13	10	8	9	8	13	22
Haplophragmoides cf. *H. manilaensis*	L																												
	D																	1	1		1								
Haplophragmoides wilberti	L																												
	D													1		1		1								1			
Miliammina fusca	L																												
	D	1		1																									
Murrayinella murrayi	L																												
	D	2	3				1	5		1		1				4	2	1		9	1		2	2	1		2		1
Nonion sp. A	L																												
	D	2											1	1		3		1		6	4	1	1			1			
Nonion sp. B	L																												
	D		3	1			4	3	7	4	3	6	7	11	1	6	4	3	5	5	3	2	3	2	3	2			
Nonion sp. C	L																												
	D	1	1		1			1				1		2					3				1		1			1	2

Nonionella sp. A	L																												
	D																				1			1					
Notorotalia cf. *N. inornata*	L																												
	D																			1									
Pararotalia aff. *P. calcariformata*	L																												
	D					1																							
Pararotalia nipponica	L																												
	D		1	1		2	1	2	1										1		1	1	3		2	1	2	1	1
Pararotalia venusta	L																												
	D			1																									
Pararotalia sp. 1	L																												
	D	1																								1			
Paratrochammina stoeni	L			1																									
	D			2			1	1	1	1	4	1				1				1									
Peneroplis pertusus	L																												
	D			1								1	1			1	1		4		4	1		1	2	6	5	7	7
Planispirinella exigua	L																												
	D																				1								
Planorbulina acervalis	L																												
	D		1		2			1				1	1					2	1	2	3	3	3	4		5	3	2	3
Pseudorotalia schroeteriana	L																												
	D																		1	1						1		2	
Quinqueloculina sp. 1	L																												
	D	1																											
Quinqueloculina sp. 2	L																												
	D		1																						1				
Quinqueloculina sp. 3	L																												
	D			1		1					1	1				1	1	1		1		1	3	1	4	3	4	4	1
Reussella pulchra	L																												
	D	8	20	14	9	10	16	13	10	5	8	3	12	7	6	5	2	9	15	9	7	20	9	10	16	10	12	17	19
Reussella spinulosa	L																												
	D				3	5	1		1	1	1						1							3			1	2	4
Reussella sp. C	L																												
	D				1	2					1								1										
Rosalina globularis	L				1	1												1											
	D	8	12	7	12	7	9	6	14	23	9	9	9	13	9	13	11	10	12	16	7	16	11	30	10	16	15	23	20
Rosalina sp. 1	L																												
	D		1																										
Rosalina sp. 2	L																												
	D																		1										
Rosalina sp. 3	L																												
	D																									1			
Sagrina zanzibarica	L																												
	D	10	17	1	3	8	4	7	4	1	2	2	2	4	4	4	6	1	5	1	11	5	10	9	13	12	3	4	10
Sagrinella lobata	L																												
	D	21	15	16	18	25	9	10	14	5	7	15	9	8	12	3	11	13	10	14	13	15	12	9	9	6	10	19	20
Schackoinella globosa	L																												
	D	5	6	2	5	7	2	8	10	8	5	2	3	9	6	5	4	4	1				2	3	2	1	1	1	
Siphotrochammina lobata	L																												
	D			1			1				1					1	1									1			
Sorites marginalis	L																												
	D																								1		1		
Spirolina cylindracea	L																												
	D						2		3	2				2	4		1	1	2	1	7	1	7	3	2	2	2	1	1
Trochammina amnicola	L																												
	D	3					1	1					1			1	1	1	1										
"Trochammina ochracea"	L																												
	D												1		1	1											1		
Trochammina sp. E	L																												
	D		1	3	1			1			4				3														

Trochammina sp. 1	L																												
	D																				1								
Trochammina sp. 2	L																												
	D																							1					
Wisenerella auriculata	L																												
	D																	1											
Bolivina spp.	L																												
	D	13	16	17	12	13	9	17	11	3	5	4		7	4	8	8	10	12	11	6	7	10	17	5	10	8	15	8
Cibicides spp.	L																												
	D												2										1					1	2
Elphidium spp.	L																												
	D	1	2				1		1	1		2		1	1	1	1		1		1	2	3		1	1	1	1	4
nodosariid	L																												
	D			2					1																				
Quinqueloculina spp.	L													1															
	D	6	10	10	9	12	6	11	3	5	24	9	4	14	11	12	7	25	20	25	32	37	29	28	23	32	33	24	40
indeterminate genus A	L																												
	D					1									1				1										
indeterminate rotaliid	L																												
	D	9	5	13	12	4	11	12	14			11	12	11	20	12	12	14	11	8	8	7	4	2	1	13	7	8	13
indeterminate agglutinated	L																												
	D				2								1										2		1	1			
Number of live specimens	L	6	1	2	3	4	2	0	0	3	0	0	1	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0
Number of dead specimens	D	214	206	182	179	176	168	203	185	162	191	185	182	183	207	190	183	206	193	187	183	205	200	198	190	202	210	218	261
Total foraminifera (live + dead)		220	207	184	182	180	170	203	185	165	191	185	183	184	207	190	184	208	193	187	183	205	200	198	190	202	210	218	261

APPENDIX D. Foraminiferal census data, S9A. L, live; D, dead. Sample depth, cm.

Taxon ↓ Sample depth →		1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
Ammobaculities exiguus	L	22	8	4	6	11	5	11	1		6	9	2	1		
	D	3	8	3	2	12	30	9	17	2	19	16	23	20	27	36
Ammotium directum	L	9	1	1		17	8	3	2	1		1	2	1	1	4
	D	26	34	9	2	62	16	37	17	2	3	12	35	85	44	44
Ammotium morenoi	L											1				1
	D		3		2	7	4	11		2	4	13	12	10	7	3
Haplophragmoides wilberti	L															
	D					1			3			1				
?*Jadammina* sp.	L															
	D								1							
Miliammina fusca	L	27					7	9							1	
	D	101	44	8		37	6	12	11	2	4		1	2		
Paratrochammina stoeni	L														1	
	D														1	
Siphotrochammina lobata	L						1			1					1	
	D	2				1	2	4	4	3	1			1	1	
Trochammina amnicola	L	2					16	4				1	1	2	11	5
	D	8	10	20	7	31	122	32	18	5	5	90	107	61	92	97
"Trochammina ochracea"	L						1		1							
	D	1				1			3	3	2				1	
Trochammina sp. 1	L															
	D						1									
indeterminate agglutinated	L															
	D		3	1			9	6	3		1	17	11	16	19	13
Number of live specimens	L	60	9	5	6	28	38	27	4	2	6	12	5	4	15	10
Number of dead specimens	D	141	102	41	13	189	190	111	77	19	39	149	189	195	192	193
Total foraminifera (live + dead)		201	111	46	19	217	228	138	81	21	45	161	194	199	207	203

APPENDIX E. Percent of species (S43) for the dead cluster analysis including all taxa ≥ 2% of the dead assemblage. Sample depth, cm.

Taxon↓ Sample depth →	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65	67	69	71
Agglutinella sp. A	0.97	0.00	0.56	0.00	0.00	0.54	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.46	0.80	0.00	0.00	0.55	0.00	0.00	1.01	0.46	0.00	0.00	0.50	0.49	0.00
Ammobaculites exiguus	33.98	32.80	22.35	22.22	44.51	38.71	49.14	20.69	22.22	14.35	32.32	27.23	20.11	9.74	8.95	14.23	12.74	13.11	10.15	12.57	15.20	9.00	7.41	6.83	5.08	3.47	7.65	5.61	2.16	5.53	1.39	3.14	2.65	3.96	4.85	0.00
Ammonia aff. *A. aoteana*	17.48	40.00	29.61	36.87	24.39	33.33	26.29	25.62	44.97	47.83	42.93	54.95	43.39	44.62	44.74	39.13	49.53	45.15	45.69	38.22	47.06	50.00	46.76	43.78	44.16	44.55	40.44	39.72	49.35	35.18	37.04	42.93	43.92	48.02	47.57	45.77
Ammotium directum	0.00	0.00	0.00	1.01	0.61	0.00	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.40	0.00	0.00	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammotium morenoi	0.97	0.80	0.56	0.00	1.83	2.15	2.86	0.99	0.00	0.43	0.51	0.99	0.53	0.00	0.00	1.19	0.00	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.50	0.55	0.00	0.00	1.01	0.46	0.00	0.00	0.50	0.00	0.00
Amphistegina lessonii	1.94	0.00	0.56	0.51	0.00	0.00	0.00	0.49	0.00	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.49	0.51	0.00	0.00	0.00	1.39	0.00	0.51	0.00	1.09	0.00	0.87	0.00	1.39	0.00	0.00	0.50	0.49	0.00
Asterigerinata sp. A	0.00	0.80	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.46	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asterorotalia pulchella	0.00	0.00	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.47	0.43	0.50	0.46	0.00	0.53	0.00	0.00	1.00
Bolivina striatula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.87	0.51	0.00	0.00	1.54	1.58	0.79	0.00	0.00	0.00	0.52	0.49	0.00	1.39	0.40	2.03	1.49	1.09	0.93	0.00	1.01	3.24	0.00	0.53	1.98	1.46	1.99
Bolivina spp.	2.91	0.80	1.12	2.53	0.00	0.00	0.57	2.46	1.06	1.30	0.51	0.50	0.00	2.56	4.74	0.79	1.42	3.40	0.51	4.19	2.45	2.50	1.85	4.02	4.06	4.95	3.28	2.80	3.46	1.51	3.70	5.76	4.23	1.49	0.97	0.50
Bolivina sp. 8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00
Caronia exilis	0.00	0.00	0.00	0.00	1.22	0.00	0.00	0.49	0.00	0.00	0.51	0.50	0.00	0.00	0.00	0.00	0.00	0.00	1.02	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides cf. *C. fletcheri*	0.97	0.00	1.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.53	0.00	0.00	0.40	0.47	0.49	0.00	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.55	0.00	0.87	0.00	1.39	0.00	0.00	0.50	0.97	1.49
Cibicides sp. 1	0.97	0.00	0.56	2.53	0.00	0.00	0.00	0.00	0.53	0.43	0.00	0.50	0.53	2.56	1.58	1.98	2.83	2.43	0.51	0.52	0.00	0.50	0.46	2.41	1.02	2.97	0.00	1.40	1.73	0.50	0.93	1.05	0.00	0.50	1.94	0.00
Cibicides sp. 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.00	0.52	0.00	0.50	0.00	0.40	0.00	0.00	0.00	0.47	0.43	0.00	0.00	0.52	1.06	0.00	0.49	1.00
Cibicides sp. 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.99	1.09	0.47	0.43	0.00	0.00	0.52	0.53	0.00	0.00	1.99
Dyocibicides primitivus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00
Elphidium advenum s.l.	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.02	0.00	0.00	0.00	0.46	0.40	0.51	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.49	0.50
Elphidium hyalocostatum	0.97	0.00	0.00	0.51	0.00	0.00	0.00	2.46	0.00	0.87	0.00	0.50	0.00	0.51	0.00	0.00	0.00	0.49	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium indicum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.06	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.94	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.43	0.50	0.46	0.00	0.00	0.00	0.00	0.00
Elphidium cf. *E. neosimplex*	0.00	0.00	0.00	0.00	0.00	1.08	0.00	0.49	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.53	0.00	0.49	0.00
Elphidium cf. *E. reticulosum*	0.00	0.00	0.00	1.52	0.00	1.61	0.57	0.00	0.00	0.43	1.01	0.00	0.00	1.03	0.00	0.79	0.00	0.00	2.03	0.52	0.49	2.50	0.46	0.00	0.00	1.49	0.55	0.00	0.87	0.00	0.00	0.00	1.59	0.99	0.00	1.00
Elphidium cf. *E. simplex*	0.00	1.60	0.00	0.51	0.00	0.00	0.00	0.49	1.06	0.00	0.00	0.00	0.53	0.51	0.53	0.00	0.00	0.00	0.51	0.52	0.00	1.50	0.00	1.20	0.51	0.50	0.55	0.00	0.00	1.01	0.46	1.57	0.00	1.98	0.49	0.00
Elphidium sp. 4	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.49	0.00	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.80	1.02	0.50	0.55	0.47	0.43	0.00	1.39	1.05	0.00	1.98	1.46	0.00
Elphidium sp. L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00
Elphidium sp. Q	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00
Elphidium spp.	0.97	0.00	0.00	0.00	0.61	0.54	0.00	0.00	0.00	2.17	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.49	0.51	0.00	0.00	0.00	0.46	0.00	0.00	0.00	1.64	0.00	0.00	1.51	0.00	0.52	0.53	0.00	0.00	0.00
Gavelinopsis praegeri	10.68	3.20	8.38	6.57	0.00	0.00	0.00	0.00	1.06	1.74	0.00	0.00	4.23	1.54	1.05	3.16	1.89	1.46	4.06	2.09	0.98	2.00	0.00	0.80	0.00	0.50	0.55	1.40	0.87	2.01	0.93	1.57	2.65	2.97	0.97	3.48
Haplophragmoides wilberti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miliammina fusca	0.00	1.60	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Murrayinella murrayi	1.94	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.53	0.43	0.00	0.00	0.00	0.00	0.00	0.40	2.36	0.49	1.02	1.57	0.00	2.00	0.46	0.00	2.03	1.98	2.19	1.40	0.00	3.02	2.31	2.09	1.59	0.99	0.49	1.99
Nonion sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.09	0.00	0.43	1.01	0.00	0.00	0.00	0.00	0.00	0.50
Nonion sp. B	0.97	2.40	0.00	1.01	0.61	0.00	0.00	1.97	0.53	1.74	0.51	0.50	1.59	1.54	1.05	0.79	2.36	1.94	1.52	2.62	1.47	1.00	2.78	4.42	3.55	2.97	3.28	1.40	1.30	3.02	0.46	2.62	1.06	0.50	1.46	4.98
Nonion sp. C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.97	0.00	0.87	0.00	0.00	0.00	0.51	0.53	1.19	0.47	0.00	0.00	0.00	0.00	1.00	0.46	0.40	0.51	0.50	0.00	0.93	0.87	1.01	1.39	1.57	0.00	0.50	0.00	1.00
Nonionella sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93	0.00	0.00	0.00	0.00	0.00	0.00	1.46	0.00
Pararotalia nipponica	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.40	0.00	0.50	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.50
Paratrochammina stoeni	1.94	1.60	0.00	2.02	4.88	4.30	4.00	11.82	2.12	0.43	1.01	1.98	3.70	1.54	0.53	1.19	0.47	0.00	0.00	0.00	0.49	0.50	0.46	0.40	0.00	0.00	0.55	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00
Peneroplis pertusus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.51	0.00	0.98	0.00	0.46	0.00	0.00	0.00	1.09	0.47	1.30	0.50	0.00	1.57	0.00	0.50	0.00	0.00
Planorbulina acervalis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	1.09	0.00	0.43	1.01	0.46	0.52	1.06	0.50	0.49	0.50
Pseudorotalia schroeteriana	0.00	0.00	0.00	0.00	0.00	0.54	0.00	0.49	0.00	0.00	0.51	0.00	1.06	0.00	0.00	0.40	0.00	0.00	1.02	0.00	0.00	0.00	0.46	0.40	1.52	0.50	0.00	0.00	0.00	1.01	0.93	2.09	2.65	0.99	1.46	0.50
Quinqueloculina sp. 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.39	0.40	0.51	0.00	0.55	0.47	0.87	0.50	0.00	0.00	0.00	0.00	0.00	0.00
Quinqueloculina spp.	3.88	2.40	2.23	0.51	2.44	0.00	0.00	1.48	5.29	3.48	0.51	0.50	3.17	6.15	8.42	4.74	4.25	5.34	5.08	6.81	3.43	4.50	4.17	2.41	6.09	4.95	3.83	6.07	4.33	8.04	7.87	4.19	5.82	4.95	4.85	4.48
Reussella pulchra	0.97	0.80	2.79	1.01	0.61	0.00	0.57	1.48	1.06	2.61	0.00	0.99	1.06	2.05	1.05	1.98	0.94	0.97	0.51	2.09	2.45	2.00	2.78	3.61	2.03	3.47	3.28	7.01	2.60	3.52	1.39	2.09	4.23	4.95	3.40	3.98
Reussella spinulosa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.53	0.99	0.49	0.50
Rosalina globularis	3.88	0.80	1.68	2.02	0.00	1.61	0.00	2.46	3.70	1.74	3.54	1.98	4.23	5.13	8.42	8.30	8.02	8.25	8.12	11.52	6.86	7.50	13.43	8.43	9.14	6.44	7.65	10.75	10.39	12.56	14.81	8.90	0.00	7.43	12.62	7.96
Sagrina zanzibarica	0.97	0.00	0.00	0.00	0.00	0.00	0.00	3.45	0.53	1.74	1.01	0.50	0.53	1.54	2.11	0.79	1.89	3.40	2.03	3.14	0.00	1.00	1.85	4.42	1.02	4.46	1.64	2.80	3.03	0.50	1.39	3.66	4.76	1.98	0.49	3.48
Sagrinella lobata	3.88	3.20	7.82	6.06	2.44	4.30	1.71	3.94	4.23	2.17	4.04	3.47	6.88	6.15	4.21	3.95	1.89	2.91	3.55	5.76	5.88	2.00	3.70	2.41	5.08	6.44	0.55	4.67	5.19	4.02	3.70	4.71	7.41	2.97	3.88	3.98

Schackoinella globosa	1.94	0.00	1.12	2.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.51	0.00	1.19	0.00	0.49	0.00	1.05	4.90	1.50	0.00	0.40	0.00	1.98	3.83	1.40	0.00	0.00	0.00	1.05	1.59	1.49	1.46	0.00
Siphotrochammina lobata	0.97	0.00	0.56	0.00	1.22	0.00	0.00	0.00	0.00	0.00	1.52	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Spirolina cylindracea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.43	0.00	0.46	0.00	0.53	0.99	0.00	0.50
Trochammina amnicola	0.00	1.60	0.00	0.00	1.83	0.00	0.57	0.49	0.00	0.43	0.00	0.00	0.53	1.03	0.00	0.00	0.00	0.00	0.00	1.05	0.00	0.50	1.39	0.80	0.00	0.00	0.00	0.00	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00
"Trochammina ochracea"	1.94	3.20	5.59	3.03	5.49	3.76	2.29	1.97	0.00	1.74	5.05	1.98	1.06	2.05	1.58	1.19	0.47	0.49	0.51	0.00	0.00	0.00	0.46	0.40	0.00	0.50	1.09	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00
Trochammina sp. E	0.00	0.80	1.12	2.02	3.66	5.38	5.71	8.37	1.59	3.04	0.51	0.99	1.06	1.54	1.05	0.79	0.47	0.97	2.03	0.00	0.00	3.00	0.46	0.80	0.00	0.00	0.00	0.47	1.30	0.00	0.00	0.00	0.00	0.50	0.00	0.00
indeterminate rotaliids	0.97	0.80	7.26	3.54	0.61	1.61	1.71	3.94	5.29	2.61	1.01	1.98	3.70	5.13	4.74	7.11	3.30	3.88	6.09	2.62	4.90	2.50	1.85	4.02	6.09	1.98	3.83	2.34	1.73	6.03	5.56	2.62	5.29	1.98	1.94	3.48
indeterminate textulariids	0.97	0.00	0.00	0.00	0.61	0.00	1.14	0.00	0.53	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.50	0.46	0.00	0.00	0.00	0.00	0.50

Percent of species (S40) for the dead cluster analysis including all taxa ≥ 2% of the dead assemblage. Sample depth, cm.

Taxon ↓ Sample depth →	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55
Agglutinella sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	1.07	0.00	0.00	0.00	0.00	1.06	1.49	0.48	0.92	0.38
Ammobaculites exiguus	4.27	6.83	11.86	8.43	7.43	10.71	11.33	8.65	14.81	12.97	18.38	19.78	10.38	10.63	11.05	11.48	9.76	7.33	3.74	3.85	3.41	3.00	2.53	4.76	1.00	0.48	1.38	2.30
Ammonia aff. *A. aoteana*	24.64	16.59	19.77	17.42	17.14	16.07	24.14	23.78	22.22	26.49	22.70	21.98	22.40	30.92	26.32	31.15	24.88	15.71	17.11	19.23	17.56	17.00	16.16	18.52	12.44	26.19	15.60	11.49
Ammotium directum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammotium morenoi	0.47	1.95	1.13	2.25	4.00	5.36	0.00	1.08	0.00	0.54	2.16	2.20	0.00	0.00	0.00	0.00	0.49	0.52	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.48	0.00	0.00
Amphistegina lessonii	5.21	0.49	0.56	0.56	0.00	2.38	0.00	0.00	3.70	1.62	1.62	1.10	0.00	1.45	0.53	0.55	0.49	1.05	1.60	1.10	0.98	1.00	2.02	3.17	1.49	2.86	1.83	1.15
Asterigerinata sp. A	1.90	0.49	0.00	0.56	0.00	0.00	0.00	1.08	1.23	0.00	1.08	0.55	0.00	0.00	0.53	0.55	1.46	0.00	0.53	0.00	0.00	0.50	1.52	0.00	0.00	0.00	0.00	0.00
Asterorotalia pulchella	0.00	0.49	0.00	0.56	0.57	0.00	0.00	1.62	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	1.65	0.00	0.50	0.51	0.53	0.00	0.95	0.46	0.77
Bolivina striatula	0.95	0.98	0.00	0.56	0.57	0.60	1.97	0.00	1.85	0.54	0.54	0.55	0.00	0.00	2.11	1.09	0.98	0.00	1.07	0.00	0.49	0.00	0.51	1.06	1.00	0.48	0.46	0.38
Bolivina spp.	6.16	7.80	9.60	6.74	7.43	5.36	8.37	5.95	1.85	2.70	2.16	0.00	3.83	1.93	4.21	4.37	4.88	6.28	5.88	3.30	3.41	5.00	8.59	2.65	4.98	3.81	6.88	3.07
Bolivina sp. 8	0.47	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.49	0.00	0.00	0.00	0.00	0.95	1.83	0.77
Caronia exilis	2.37	0.49	0.00	0.56	0.00	0.00	0.00	0.00	3.70	1.62	0.54	0.55	0.00	0.48	0.53	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38
Cibicides cf. *C. fletcheri*	2.37	3.41	2.82	5.06	2.29	2.38	0.49	2.16	2.47	2.16	2.16	0.55	1.64	0.97	1.05	0.00	1.46	0.52	0.53	0.55	1.95	1.00	0.51	1.06	2.99	2.38	0.46	1.53
Cibicides sp. 1	1.90	0.49	1.69	2.81	2.29	1.19	2.46	2.70	1.85	0.54	0.54	1.65	0.55	0.48	1.58	0.00	1.46	2.09	0.00	0.55	2.93	3.00	3.54	1.59	0.50	1.43	0.00	0.00
Cibicides sp. 2	0.00	1.46	0.56	0.00	0.00	0.60	0.49	0.54	0.00	0.54	0.00	0.55	0.00	0.00	1.05	0.55	0.49	0.00	0.53	0.55	2.93	1.00	1.01	0.53	1.99	0.95	1.38	2.30
Cibicides sp. 4	0.00	0.00	1.13	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.50	0.00	1.38	0.38
Dyocibicides primitivus	0.47	0.00	0.00	0.00	0.57	0.60	0.49	0.00	0.62	0.54	0.00	0.55	0.00	0.00	0.00	1.09	0.98	1.05	0.00	0.00	0.49	3.00	0.00	2.12	1.00	1.43	0.00	1.92
Elphidium advenum s.l.	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.00	0.00	0.48	1.05	0.00	0.49	0.00	0.00	0.00	0.00	0.50	0.00	0.53	1.49	1.43	0.46	0.77
Elphidium hyalocostatum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium indicum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.09	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38
Elphidium cf. *E. neosimplex*	0.00	0.49	1.69	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.48	0.00	0.00	0.49	0.00	0.53	0.00	0.49	0.00	1.01	0.53	0.00	0.48	0.46	0.38
Elphidium cf. *E. reticulosum*	0.00	0.98	0.00	0.00	0.00	1.19	0.00	0.54	1.85	3.24	0.54	0.55	2.19	0.97	0.00	1.09	0.49	0.52	1.60	1.65	0.00	1.00	0.51	1.06	0.50	0.00	0.46	1.15
Elphidium cf. *E. simplex*	1.90	0.98	1.13	0.56	2.29	2.98	1.97	0.54	0.62	0.54	0.54	1.65	0.00	1.93	0.00	0.55	0.49	1.05	0.00	1.10	0.00	1.00	0.00	2.65	1.00	0.48	0.92	2.30
Elphidium sp. 4	0.00	1.46	0.00	0.00	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.55	1.09	0.00	0.53	0.55	0.49	1.05	0.00	0.00	0.00	1.00	1.01	0.00	0.50	0.00	0.46	0.38
Elphidium sp. L	0.00	2.44	0.56	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.92	0.00
Elphidium sp. Q	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.49	0.50	0.00	1.59	0.00	0.00	0.92	0.00
Elphidium spp.	0.47	0.98	0.00	0.00	0.00	0.60	0.00	0.54	0.62	0.00	1.08	0.00	0.55	0.48	0.53	0.55	0.00	0.52	0.00	0.55	0.98	1.50	0.00	0.53	0.50	0.48	0.46	1.53
Gavelinopsis praegeri	7.58	3.41	2.26	6.18	4.00	5.95	5.91	4.86	5.56	5.95	9.19	7.69	9.84	8.70	10.00	9.29	4.39	7.33	8.56	6.59	5.85	6.50	5.05	4.23	4.48	3.81	5.96	8.43
Haplophragmoides wilberti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.53	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00
Miliammina fusca	0.47	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Murrayinella murrayi	0.95	1.46	0.00	0.00	0.00	0.60	2.46	0.00	0.62	0.00	0.54	0.00	0.00	0.00	2.11	1.09	0.49	0.00	4.81	0.55	0.00	1.00	1.01	0.53	0.00	0.95	0.00	0.38
Nonion sp. A	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.55	0.00	1.58	0.00	0.49	0.00	3.21	2.20	0.49	0.50	0.00	0.00	0.50	0.00	0.00	0.00
Nonion sp. B	0.00	1.46	0.56	0.00	0.00	2.38	1.48	3.78	2.47	1.62	3.24	3.85	6.01	0.48	3.16	2.19	1.46	2.62	2.67	1.65	0.98	1.50	1.01	1.59	1.00	0.00	0.00	0.00
Nonion sp. C	0.47	0.49	0.00	0.56	0.00	0.00	0.49	0.00	0.00	0.00	0.54	0.00	1.09	0.00	0.00	0.00	0.00	1.57	0.00	0.00	0.00	0.50	0.00	0.53	0.00	0.00	0.46	0.77
Nonionella sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.00	0.53	0.00	0.00	0.00	0.00
Pararotalia nipponica	0.00	0.49	0.56	0.00	1.14	0.60	0.99	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.55	0.49	1.50	0.00	1.06	0.50	0.95	0.46	0.38

Paratrochammina stoeni	0.00	0.00	1.13	0.00	0.00	0.60	0.49	0.54	0.62	2.16	0.54	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peneroplis pertusus	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.55	0.00	0.00	0.53	0.55	0.00	2.09	0.00	2.20	0.49	0.00	0.51	1.06	2.99	2.38	3.21	2.68
Planorbulina acervalis	0.00	0.49	0.00	1.12	0.00	0.00	0.49	0.00	0.00	0.00	0.54	0.55	0.00	0.00	0.00	0.00	0.98	0.52	1.07	1.65	1.46	1.50	2.02	0.00	2.49	1.43	0.92	1.15
Pseudorotalia schroeteriana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.53	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.92	0.00
Quinqueloculina sp. 3	0.00	0.00	0.56	0.00	0.57	0.00	0.00	0.00	0.00	0.54	0.54	0.00	0.00	0.00	0.53	0.55	0.49	0.00	0.53	0.00	0.49	1.50	0.51	2.12	1.49	1.90	1.83	0.38
Quinqueloculina spp.	2.84	4.88	5.65	5.06	6.86	3.57	5.42	1.62	3.09	12.97	4.86	2.20	7.65	5.31	6.32	3.83	12.20	10.47	13.37	17.58	18.05	14.50	14.14	12.17	15.92	15.71	11.01	15.33
Reussella pulchra	3.79	9.76	7.91	5.06	5.71	9.52	6.40	5.41	3.09	4.32	1.62	6.59	3.83	2.90	2.63	1.09	4.39	7.85	4.81	3.85	9.76	4.50	5.05	8.47	4.98	5.71	7.80	7.28
Reussella spinulosa	0.00	0.00	0.00	1.69	2.86	0.60	0.00	0.54	0.62	0.54	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	1.52	0.00	0.00	0.48	0.92	1.53
Rosalina globularis	3.79	5.85	3.95	6.74	4.00	5.36	2.96	7.57	14.20	4.86	4.86	4.95	7.10	4.35	6.84	6.01	4.88	6.28	8.56	3.85	7.80	5.50	15.15	5.29	7.96	7.14	10.55	7.66
Sagrina zanzibarica	4.74	8.29	0.56	1.69	4.57	2.38	3.45	2.16	0.62	1.08	1.08	1.10	2.19	1.93	2.11	3.28	0.49	2.62	0.53	6.04	2.44	5.00	4.55	6.88	5.97	1.43	1.83	3.83
Sagrinella lobata	9.95	7.32	9.04	10.11	14.29	5.36	4.93	7.57	3.09	3.78	8.11	4.95	4.37	5.80	1.58	6.01	6.34	5.24	7.49	7.14	7.32	6.00	4.55	4.76	2.99	4.76	8.72	7.66
Schackoinella globosa	2.37	2.93	1.13	2.81	4.00	1.19	3.94	5.41	4.94	2.70	1.08	1.65	4.92	2.90	2.63	2.19	1.95	0.52	0.00	0.00	0.00	1.00	1.52	1.06	0.50	0.48	0.46	0.00
Siphotrochammina lobata	0.00	0.00	0.56	0.00	0.00	0.60	0.00	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.53	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00
Spirolina cylindracea	0.00	0.00	0.00	0.00	0.00	1.19	0.00	1.62	1.23	0.00	0.00	0.00	1.09	1.93	0.00	0.55	0.49	1.05	0.53	3.85	0.49	3.50	1.52	1.06	1.00	0.95	0.46	0.38
Trochammina amnicola	1.42	0.00	0.00	0.00	0.00	0.60	0.49	0.00	0.00	0.00	0.00	0.55	0.00	0.00	0.53	0.55	0.49	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
"Trochammina ochracea"	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.48	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00
Trochammina sp. E	0.00	0.49	1.69	0.56	0.00	0.00	0.49	0.00	0.00	2.16	0.00	0.00	0.00	1.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
indeterminate rotaliids	4.27	2.44	7.34	6.74	2.29	6.55	5.91	7.57	0.00	0.00	5.95	6.59	6.01	9.66	6.32	6.56	6.83	5.76	4.28	4.40	3.41	2.00	1.01	0.53	6.47	3.33	3.67	4.98
indeterminate textulariids	0.00	0.00	0.00	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.53	0.50	0.00	0.00	0.00

Percent of species (S9A) for the dead cluster analysis including all taxa ≥ 2% of the dead assemblage. Sample depth, cm.

Taxon ↓ Sample depth →	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
Agglutinella sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammobaculites exiguus	2.13	7.84	7.32	15.38	7.89	15.79	8.11	22.37	10.53	48.72	10.74	12.17	10.26	14.06	18.65
Ammonia aff. *A. aoteana*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammotium directum	18.44	33.33	21.95	15.38	40.79	8.42	33.33	22.37	10.53	7.69	8.05	18.52	43.59	22.92	22.80
Ammotium morenoi	0.00	2.94	0.00	15.38	4.61	2.11	9.91	0.00	10.53	10.26	8.72	6.35	5.13	3.65	1.55
Amphistegina lessonii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asterigerinata sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asterorotalia pulchella	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bolivina striatula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bolivina spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bolivina sp. 8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Caronia exilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides cf. *C. fletcheri*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides sp. 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides sp. 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides sp. 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dyocibicides primitivus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium advenum s.l.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium hyalocostatum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium indicum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium cf. *E. neosimplex*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium cf. *E. reticulosum*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium cf. *E. simplex*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium sp. 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium sp. L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Elphidium sp. Q	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gavelinopsis praegeri	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Haplophragmoides wilberti	0.00	0.00	0.00	0.00	0.66	0.00	0.00	3.95	0.00	0.00	0.67	0.00	0.00	0.00	0.00
Miliammina fusca	71.63	43.14	19.51	0.00	24.34	3.16	10.81	14.47	10.53	10.26	0.00	0.53	1.03	0.00	0.00
Murrayinella murrayi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nonion sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nonion sp. B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nonion sp. C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nonionella sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pararotalia nipponica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paratrochammina stoeni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00
Peneroplis pertusus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Planorbulina acervalis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudorotalia schroeteriana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quinqueloculina sp. 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quinqueloculina spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reussella pulchra	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reussella spinulosa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rosalina globularis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sagrina zanzibarica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sagrinella lobata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Schackoinella globosa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Siphotrochammina lobata	1.42	0.00	0.00	0.00	0.66	1.05	3.60	5.26	15.79	2.56	0.00	0.00	0.51	0.52	0.00
Spirolina cylindracea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trochammina amnicola	5.67	9.80	48.78	53.85	20.39	64.21	28.83	23.68	26.32	12.82	60.40	56.61	31.28	47.92	50.26
"Trochammina ochracea"	0.71	0.00	0.00	0.00	0.66	0.00	0.00	3.95	15.79	5.13	0.00	0.00	0.00	0.52	0.00
Trochammina sp. E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
indeterminate rotaliids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
indeterminate textulariids	0.00	2.94	2.44	0.00	0.00	4.74	5.41	3.95	0.00	2.56	11.41	5.82	8.21	9.90	6.74

APPENDIX F. Transformed data (S43) for the dead cluster analysis including all taxa ≥ 2% of the dead assemblage. Sample depth, cm.

Taxon ↓ Sample depth →	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65	67	69	71
Agglutinella sp. A	0.20	0.00	0.15	0.00	0.00	0.15	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.14	0.18	0.00	0.00	0.15	0.00	0.00	0.20	0.14	0.00	0.00	0.14	0.14	0.00
Ammobaculites exiguus	1.24	1.22	0.98	0.98	1.46	1.34	1.55	0.94	0.98	0.78	1.21	1.10	0.93	0.63	0.61	0.77	0.73	0.74	0.65	0.72	0.80	0.61	0.55	0.53	0.45	0.37	0.56	0.48	0.30	0.47	0.24	0.36	0.33	0.40	0.44	0.00
Ammonia aff. *A. aoteana*	0.86	1.37	1.15	1.31	1.03	1.23	1.08	1.06	1.47	1.53	1.43	1.67	1.44	1.46	1.47	1.35	1.56	1.47	1.48	1.33	1.51	1.57	1.51	1.45	1.45	1.46	1.38	1.36	1.56	1.27	1.31	1.43	1.45	1.53	1.52	1.49
Ammotium directum	0.00	0.00	0.00	0.20	0.16	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.13	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammotium morenoi	0.20	0.18	0.15	0.00	0.27	0.29	0.34	0.20	0.00	0.13	0.14	0.20	0.15	0.00	0.00	0.22	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.14	0.15	0.00	0.00	0.20	0.14	0.00	0.00	0.14	0.00	0.00
Amphistegina lessonii	0.28	0.00	0.15	0.14	0.00	0.00	0.00	0.14	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.14	0.00	0.00	0.00	0.24	0.00	0.14	0.00	0.21	0.00	0.19	0.00	0.24	0.00	0.00	0.14	0.14	0.00
Asterigerinata sp. A	0.00	0.18	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.14	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asterorotalia pulchella	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.14	0.13	0.14	0.14	0.00	0.15	0.00	0.00	0.20
Bolivina striatula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.14	0.00	0.00	0.25	0.25	0.18	0.00	0.00	0.00	0.14	0.14	0.00	0.24	0.13	0.29	0.24	0.21	0.19	0.00	0.20	0.36	0.00	0.15	0.28	0.24	0.28
Bolivina spp.	0.34	0.18	0.21	0.32	0.00	0.00	0.15	0.32	0.21	0.23	0.14	0.14	0.00	0.32	0.44	0.18	0.24	0.37	0.14	0.41	0.31	0.32	0.27	0.40	0.41	0.45	0.36	0.34	0.37	0.25	0.39	0.48	0.41	0.24	0.20	0.14
Bolivina sp. 8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00
Caronia exilis	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.14	0.00	0.00	0.14	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides cf. *C. fletcheri*	0.20	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.15	0.00	0.00	0.13	0.14	0.14	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.15	0.00	0.19	0.00	0.24	0.00	0.00	0.14	0.20	0.24
Cibicides sp. 1	0.20	0.00	0.15	0.32	0.00	0.00	0.00	0.00	0.15	0.13	0.00	0.14	0.15	0.32	0.25	0.28	0.34	0.31	0.14	0.14	0.00	0.14	0.14	0.31	0.20	0.35	0.00	0.24	0.26	0.14	0.19	0.21	0.00	0.14	0.28	0.00
Cibicides sp. 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.14	0.00	0.14	0.00	0.13	0.00	0.00	0.00	0.14	0.13	0.00	0.00	0.14	0.21	0.00	0.14	0.20
Cibicides sp. 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.20	0.21	0.14	0.13	0.00	0.00	0.14	0.15	0.00	0.00	0.28
Dyocibicides primitivus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00
Elphidium advenum s.l.	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.14	0.13	0.14	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.14	0.14
Elphidium hyalocostatum	0.20	0.00	0.00	0.14	0.00	0.00	0.00	0.32	0.00	0.19	0.00	0.14	0.00	0.14	0.00	0.00	0.00	0.14	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium indicum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.19	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.13	0.14	0.14	0.00	0.00	0.00	0.00	0.00
Elphidium cf. *E. neosimplex*	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.14	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.15	0.00	0.14	0.00
Elphidium cf. *E. reticulosum*	0.00	0.00	0.00	0.25	0.00	0.25	0.15	0.00	0.00	0.13	0.20	0.00	0.00	0.20	0.00	0.18	0.00	0.00	0.29	0.14	0.14	0.32	0.14	0.00	0.00	0.24	0.15	0.00	0.19	0.00	0.00	0.00	0.25	0.20	0.00	0.20
Elphidium cf. *E. simplex*	0.00	0.25	0.00	0.14	0.00	0.00	0.00	0.14	0.21	0.00	0.00	0.00	0.15	0.14	0.15	0.00	0.00	0.00	0.14	0.14	0.00	0.25	0.00	0.22	0.14	0.14	0.15	0.00	0.00	0.20	0.14	0.25	0.00	0.28	0.14	0.00
Elphidium sp. 4	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.14	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.18	0.20	0.14	0.15	0.14	0.13	0.00	0.24	0.21	0.00	0.28	0.24	0.00
Elphidium sp. L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00
Elphidium sp. Q	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00
Elphidium spp.	0.20	0.00	0.00	0.00	0.16	0.15	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.14	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.26	0.00	0.00	0.25	0.00	0.14	0.15	0.00	0.00	0.00
Gavelinopsis praegeri	0.67	0.36	0.59	0.52	0.00	0.00	0.00	0.00	0.21	0.26	0.00	0.00	0.41	0.25	0.21	0.36	0.28	0.24	0.41	0.29	0.20	0.28	0.00	0.18	0.00	0.14	0.15	0.24	0.19	0.28	0.19	0.25	0.33	0.35	0.20	0.38
Haplophragmoides wilberti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miliammina fusca	0.00	0.25	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Murrayinella murrayi	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.15	0.13	0.00	0.00	0.00	0.00	0.00	0.13	0.31	0.14	0.20	0.25	0.00	0.28	0.14	0.00	0.29	0.28	0.30	0.24	0.00	0.35	0.31	0.29	0.25	0.20	0.14	0.28
Nonion sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.13	0.20	0.00	0.00	0.00	0.00	0.00	0.14
Nonion sp. B	0.20	0.31	0.00	0.20	0.16	0.00	0.00	0.28	0.15	0.26	0.14	0.14	0.25	0.25	0.21	0.18	0.31	0.28	0.25	0.33	0.24	0.20	0.33	0.42	0.38	0.35	0.36	0.24	0.23	0.35	0.14	0.33	0.21	0.14	0.24	0.45
Nonion sp. C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.19	0.00	0.00	0.00	0.14	0.15	0.22	0.14	0.00	0.00	0.00	0.00	0.20	0.14	0.13	0.14	0.14	0.00	0.19	0.19	0.20	0.24	0.25	0.00	0.14	0.00	0.20
Nonionella sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00
Pararotalia nipponica	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.13	0.00	0.14	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14
Paratrochammina stoeni	0.28	0.25	0.00	0.29	0.45	0.42	0.40	0.70	0.29	0.13	0.20	0.28	0.39	0.25	0.15	0.22	0.14	0.00	0.00	0.00	0.14	0.14	0.14	0.13	0.00	0.00	0.15	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00
Peneroplis pertusus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.14	0.00	0.20	0.00	0.14	0.00	0.00	0.00	0.21	0.14	0.23	0.14	0.00	0.25	0.00	0.14	0.00	0.00
Planorbulina acervalis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.21	0.00	0.13	0.20	0.14	0.14	0.21	0.14	0.14	0.14
Pseudorotalia schroeteriana	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.14	0.00	0.00	0.14	0.00	0.21	0.00	0.00	0.13	0.00	0.00	0.20	0.00	0.00	0.00	0.14	0.13	0.25	0.14	0.00	0.00	0.00	0.20	0.19	0.29	0.33	0.20	0.24	0.14
Quinqueloculina sp. 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.24	0.13	0.14	0.00	0.15	0.14	0.19	0.14	0.00	0.00	0.00	0.00	0.00	0.00
Quinqueloculina spp.	0.40	0.31	0.30	0.14	0.31	0.00	0.00	0.24	0.46	0.38	0.14	0.14	0.36	0.50	0.59	0.44	0.42	0.47	0.45	0.53	0.37	0.43	0.41	0.31	0.50	0.45	0.39	0.50	0.42	0.57	0.57	0.41	0.49	0.45	0.44	0.43
Reussella pulchra	0.20	0.18	0.34	0.20	0.16	0.00	0.15	0.24	0.21	0.32	0.00	0.20	0.21	0.29	0.21	0.28	0.19	0.20	0.14	0.29	0.31	0.28	0.33	0.38	0.29	0.37	0.36	0.54	0.32	0.38	0.24	0.29	0.41	0.45	0.37	0.40
Reussella spinulosa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.15	0.20	0.14	0.14
Rosalina globularis	0.40	0.18	0.26	0.29	0.00	0.25	0.00	0.32	0.39	0.26	0.38	0.28	0.41	0.46	0.59	0.58	0.57	0.58	0.58	0.69	0.53	0.55	0.75	0.59	0.61	0.51	0.56	0.67	0.66	0.72	0.79	0.61	0.00	0.55	0.73	0.57
Sagrina zanzibarica	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.15	0.26	0.20	0.14	0.15	0.25	0.29	0.18	0.28	0.37	0.29	0.36	0.00	0.20	0.27	0.42	0.20	0.43	0.26	0.34	0.35	0.14	0.24	0.39	0.44	0.28	0.14	0.38
Sagrinella lobata	0.40	0.36	0.57	0.50	0.31	0.42	0.26	0.40	0.41	0.30	0.40	0.37	0.53	0.50	0.41	0.40	0.28	0.34	0.38	0.48	0.49	0.28	0.39	0.31	0.45	0.51	0.15	0.44	0.46	0.40	0.39	0.44	0.55	0.35	0.40	0.40
Schackoinella globosa	0.28	0.00	0.21	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.14	0.00	0.22	0.00	0.14	0.00	0.21	0.45	0.25	0.00	0.13	0.00	0.28	0.39	0.24	0.00	0.00	0.00	0.21	0.25	0.24	0.24	0.00

Siphotrochammina lobata	0.20	0.00	0.15	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Spirolina cylindracea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.13	0.00	0.14	0.00	0.15	0.20	0.00	0.14
Trochammina amnicola	0.00	0.25	0.00	0.00	0.27	0.00	0.15	0.14	0.00	0.13	0.00	0.00	0.15	0.20	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.14	0.24	0.18	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
"Trochammina ochracea"	0.28	0.36	0.48	0.35	0.47	0.39	0.30	0.28	0.00	0.26	0.45	0.28	0.21	0.29	0.25	0.22	0.14	0.14	0.14	0.00	0.00	0.00	0.14	0.13	0.00	0.14	0.21	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00
Trochammina sp. E	0.00	0.18	0.21	0.29	0.38	0.47	0.48	0.59	0.25	0.35	0.14	0.20	0.21	0.25	0.21	0.18	0.14	0.20	0.29	0.00	0.00	0.35	0.14	0.18	0.00	0.00	0.00	0.14	0.23	0.00	0.00	0.00	0.00	0.14	0.00	0.00
indeterminate rotaliids	0.20	0.18	0.55	0.38	0.16	0.25	0.26	0.40	0.46	0.32	0.20	0.28	0.39	0.46	0.44	0.54	0.37	0.40	0.50	0.33	0.45	0.32	0.27	0.40	0.50	0.28	0.39	0.31	0.26	0.50	0.48	0.33	0.46	0.28	0.28	0.38
indeterminate textulariids	0.20	0.00	0.00	0.00	0.16	0.00	0.21	0.00	0.15	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.00	0.00	0.00	0.00	0.14

Transformed data (S40) for the dead cluster analysis including all taxa ≥ 2% of the dead assemblage. Sample depth, cm.

Taxon ↓ Sample depth →	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55
Agglutinella sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.21	0.00	0.00	0.00	0.00	0.21	0.24	0.14	0.19	0.12
Ammobaculites exiguus	0.42	0.53	0.70	0.59	0.55	0.67	0.69	0.60	0.79	0.74	0.89	0.92	0.66	0.66	0.68	0.69	0.64	0.55	0.39	0.39	0.37	0.35	0.32	0.44	0.20	0.14	0.24	0.30
Ammonia aff. *A. aoteana*	1.04	0.84	0.92	0.86	0.85	0.82	1.03	1.02	0.98	1.08	0.99	0.98	0.99	1.18	1.08	1.18	1.04	0.82	0.85	0.91	0.86	0.85	0.83	0.89	0.72	1.07	0.81	0.69
Ammotium directum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammotium morenoi	0.14	0.28	0.21	0.30	0.40	0.47	0.00	0.21	0.00	0.15	0.30	0.30	0.00	0.00	0.00	0.00	0.14	0.14	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.14	0.00	0.00
Amphistegina lessonii	0.46	0.14	0.15	0.15	0.00	0.31	0.00	0.00	0.39	0.26	0.26	0.21	0.00	0.24	0.15	0.15	0.14	0.21	0.25	0.21	0.20	0.20	0.29	0.36	0.24	0.34	0.27	0.21
Asterigerinata sp. A	0.28	0.14	0.00	0.15	0.00	0.00	0.00	0.21	0.22	0.00	0.21	0.15	0.00	0.00	0.15	0.15	0.24	0.00	0.15	0.00	0.00	0.14	0.25	0.00	0.00	0.00	0.00	0.00
Asterorotalia pulchella	0.00	0.14	0.00	0.15	0.15	0.00	0.00	0.26	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.26	0.00	0.14	0.14	0.15	0.00	0.20	0.14	0.18
Bolivina striatula	0.20	0.20	0.00	0.15	0.15	0.15	0.28	0.00	0.27	0.15	0.15	0.15	0.00	0.00	0.29	0.21	0.20	0.00	0.21	0.00	0.14	0.00	0.14	0.21	0.20	0.14	0.14	0.12
Bolivina spp.	0.50	0.57	0.63	0.53	0.55	0.47	0.59	0.49	0.27	0.33	0.30	0.00	0.39	0.28	0.41	0.42	0.45	0.51	0.49	0.37	0.37	0.45	0.59	0.33	0.45	0.39	0.53	0.35
Bolivina sp. 8	0.14	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.14	0.00	0.00	0.00	0.00	0.20	0.27	0.18
Caronia exilis	0.31	0.14	0.00	0.15	0.00	0.00	0.00	0.00	0.39	0.26	0.15	0.15	0.00	0.14	0.15	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
Cibicides cf. *C. fletcheri*	0.31	0.37	0.34	0.45	0.30	0.31	0.14	0.30	0.32	0.30	0.30	0.15	0.26	0.20	0.21	0.00	0.24	0.14	0.15	0.15	0.28	0.20	0.14	0.21	0.35	0.31	0.14	0.25
Cibicides sp. 1	0.28	0.14	0.26	0.34	0.30	0.22	0.32	0.33	0.27	0.15	0.15	0.26	0.15	0.14	0.25	0.00	0.24	0.29	0.00	0.15	0.34	0.35	0.38	0.25	0.14	0.24	0.00	0.00
Cibicides sp. 2	0.00	0.24	0.15	0.00	0.00	0.15	0.14	0.15	0.00	0.15	0.00	0.15	0.00	0.00	0.21	0.15	0.14	0.00	0.15	0.15	0.34	0.20	0.20	0.15	0.28	0.20	0.24	0.30
Cibicides sp. 4	0.00	0.00	0.21	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.14	0.00	0.24	0.12
Dyocibicides primitivus	0.14	0.00	0.00	0.00	0.15	0.15	0.14	0.00	0.16	0.15	0.00	0.15	0.00	0.00	0.00	0.21	0.20	0.21	0.00	0.00	0.14	0.35	0.00	0.29	0.20	0.24	0.00	0.28
Elphidium advenum s.l.	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.14	0.21	0.00	0.14	0.00	0.00	0.00	0.00	0.14	0.00	0.15	0.24	0.24	0.14	0.18
Elphidium hyalocostatum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium indicum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
Elphidium cf. *E. neosimplex*	0.00	0.14	0.26	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.14	0.00	0.00	0.14	0.00	0.15	0.00	0.14	0.00	0.20	0.15	0.00	0.14	0.14	0.12
Elphidium cf. *E. reticulosum*	0.00	0.20	0.00	0.00	0.00	0.22	0.00	0.15	0.27	0.36	0.15	0.15	0.30	0.20	0.00	0.21	0.14	0.14	0.25	0.26	0.00	0.20	0.14	0.21	0.14	0.00	0.14	0.21
Elphidium cf. *E. simplex*	0.28	0.20	0.21	0.15	0.30	0.35	0.28	0.15	0.16	0.15	0.15	0.26	0.00	0.28	0.00	0.15	0.14	0.21	0.00	0.21	0.00	0.20	0.00	0.33	0.20	0.14	0.19	0.30
Elphidium sp. 4	0.00	0.24	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.21	0.00	0.15	0.15	0.14	0.21	0.00	0.00	0.00	0.20	0.20	0.00	0.14	0.00	0.14	0.12
Elphidium sp. L	0.00	0.31	0.15	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.19	0.00
Elphidium sp. Q	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.14	0.14	0.00	0.25	0.00	0.00	0.19	0.00
Elphidium spp.	0.14	0.20	0.00	0.00	0.00	0.15	0.00	0.15	0.16	0.00	0.21	0.00	0.15	0.14	0.15	0.15	0.00	0.14	0.00	0.15	0.20	0.25	0.00	0.15	0.14	0.14	0.14	0.25
Gavelinopsis praegeri	0.56	0.37	0.30	0.50	0.40	0.49	0.49	0.44	0.48	0.49	0.62	0.56	0.64	0.60	0.64	0.62	0.42	0.55	0.59	0.52	0.49	0.52	0.45	0.41	0.43	0.39	0.49	0.59
Haplophragmoides wilberti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.15	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00
Miliammina fusca	0.14	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Murrayinella murrayi	0.20	0.24	0.00	0.00	0.00	0.15	0.32	0.00	0.16	0.00	0.15	0.00	0.00	0.00	0.29	0.21	0.14	0.00	0.44	0.15	0.00	0.20	0.20	0.15	0.00	0.20	0.00	0.12
Nonion sp. A	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.00	0.25	0.00	0.14	0.00	0.36	0.30	0.14	0.14	0.00	0.00	0.14	0.00	0.00	0.00
Nonion sp. B	0.00	0.24	0.15	0.00	0.00	0.31	0.24	0.39	0.32	0.26	0.36	0.39	0.50	0.14	0.36	0.30	0.24	0.33	0.33	0.26	0.20	0.25	0.20	0.25	0.20	0.00	0.00	0.00
Nonion sp. C	0.14	0.14	0.00	0.15	0.00	0.00	0.14	0.00	0.00	0.00	0.15	0.00	0.21	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.14	0.00	0.15	0.00	0.00	0.14	0.18
Nonionella sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.15	0.00	0.00	0.00	0.00
Pararotalia nipponica	0.00	0.14	0.15	0.00	0.21	0.15	0.20	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.15	0.14	0.25	0.00	0.21	0.14	0.20	0.14	0.12
Paratrochammina stoeni	0.00	0.00	0.21	0.00	0.00	0.15	0.14	0.15	0.16	0.30	0.15	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peneroplis pertusus	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.00	0.00	0.15	0.15	0.00	0.29	0.00	0.30	0.14	0.00	0.14	0.21	0.35	0.31	0.36	0.33

Planorbulina acervalis	0.00	0.14	0.00	0.21	0.00	0.00	0.14	0.00	0.00	0.00	0.15	0.15	0.00	0.00	0.00	0.00	0.20	0.14	0.21	0.26	0.24	0.25	0.29	0.00	0.32	0.24	0.19	0.21
Pseudorotalia schroeteriana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.15	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.19	0.00
Quinqueloculina sp. 3	0.00	0.00	0.15	0.00	0.15	0.00	0.00	0.00	0.00	0.15	0.15	0.00	0.00	0.00	0.15	0.15	0.14	0.00	0.15	0.00	0.14	0.25	0.14	0.29	0.24	0.28	0.27	0.12
Quinqueloculina spp.	0.34	0.45	0.48	0.45	0.53	0.38	0.47	0.26	0.35	0.74	0.44	0.30	0.56	0.47	0.51	0.39	0.71	0.66	0.75	0.87	0.88	0.78	0.77	0.71	0.82	0.82	0.68	0.80
Reussella pulchra	0.39	0.64	0.57	0.45	0.48	0.63	0.51	0.47	0.35	0.42	0.26	0.52	0.39	0.34	0.33	0.21	0.42	0.57	0.44	0.39	0.64	0.43	0.45	0.59	0.45	0.48	0.57	0.55
Reussella spinulosa	0.00	0.00	0.00	0.26	0.34	0.15	0.00	0.15	0.16	0.15	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.14	0.19	0.25
Rosalina globularis	0.39	0.49	0.40	0.53	0.40	0.47	0.35	0.56	0.77	0.44	0.44	0.45	0.54	0.42	0.53	0.50	0.45	0.51	0.59	0.39	0.57	0.47	0.80	0.46	0.57	0.54	0.66	0.56
Sagrina zanzibarica	0.44	0.58	0.15	0.26	0.43	0.31	0.37	0.30	0.16	0.21	0.21	0.21	0.30	0.28	0.29	0.36	0.14	0.33	0.15	0.50	0.31	0.45	0.43	0.53	0.49	0.24	0.27	0.39
Sagrinella lobata	0.64	0.55	0.61	0.65	0.78	0.47	0.45	0.56	0.35	0.39	0.58	0.45	0.42	0.49	0.25	0.50	0.51	0.46	0.55	0.54	0.55	0.49	0.43	0.44	0.35	0.44	0.60	0.56
Schackoinella globosa	0.31	0.34	0.21	0.34	0.40	0.22	0.40	0.47	0.45	0.33	0.21	0.26	0.45	0.34	0.33	0.30	0.28	0.14	0.00	0.00	0.00	0.20	0.25	0.21	0.14	0.14	0.14	0.00
Siphotrochammina lobata	0.00	0.00	0.15	0.00	0.00	0.15	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.15	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00
Spirolina cylindracea	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.26	0.22	0.00	0.00	0.00	0.21	0.28	0.00	0.15	0.14	0.21	0.15	0.39	0.14	0.38	0.25	0.21	0.20	0.20	0.14	0.12
Trochammina amnicola	0.24	0.00	0.00	0.00	0.00	0.15	0.14	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.15	0.15	0.14	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
"Trochammina ochracea"	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.14	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00
Trochammina sp. E	0.00	0.14	0.26	0.15	0.00	0.00	0.14	0.00	0.00	0.30	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
indeterminate rotaliids	0.42	0.31	0.55	0.53	0.30	0.52	0.49	0.56	0.00	0.00	0.49	0.52	0.50	0.63	0.51	0.52	0.53	0.48	0.42	0.42	0.37	0.28	0.20	0.15	0.51	0.37	0.39	0.45
indeterminate textulariids	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.15	0.14	0.00	0.00	0.00

Transformed data (S9A) for the dead cluster analysis including all taxa ≥ 2% of the dead assemblage. Sample depth, cm.

Taxon ↓ Sample depth →	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
Agglutinella sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammobaculites exiguus	0.29	0.57	0.55	0.81	0.57	0.82	0.58	0.99	0.66	1.55	0.67	0.71	0.65	0.77	0.89
Ammonia aff. *A. aoteana*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammotium directum	0.89	1.23	0.98	0.81	1.39	0.59	1.23	0.99	0.66	0.56	0.58	0.89	1.44	1.00	1.00
Ammotium morenoi	0.00	0.34	0.00	0.81	0.43	0.29	0.64	0.00	0.66	0.65	0.60	0.51	0.46	0.38	0.25
Amphistegina lessonii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asterigerinata sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asterorotalia pulchella	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bolivina striatula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bolivina spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bolivina sp. 8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Caronia exilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides cf. *C. fletcheri*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides sp. 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides sp. 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides sp. 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dyocibicides primitivus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium advenum s.l.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium hyalocostatum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium indicum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium cf. *E. neosimplex*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium cf. *E. reticulosum*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium cf. *E. simplex*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium sp. 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium sp. L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium sp. Q	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gavelinopsis praegeri	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Haplophragmoides wilberti	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.40	0.00	0.00	0.16	0.00	0.00	0.00	0.00
Miliammina fusca	2.02	1.43	0.92	0.00	1.03	0.36	0.67	0.78	0.66	0.65	0.00	0.15	0.20	0.00	0.00
Murrayinella murrayi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nonion sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nonion sp. B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nonion sp. C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nonionella sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pararotalia nipponica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paratrochammina stoeni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00
Peneroplis pertusus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Planorbulina acervalis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudorotalia schroeteriana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quinqueloculina sp. 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quinqueloculina spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reussella pulchra	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reussella spinulosa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rosalina globularis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sagrina zanzibarica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sagrinella lobata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Schackoinella globosa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Siphotrochammina lobata	0.24	0.00	0.00	0.00	0.16	0.21	0.38	0.46	0.82	0.32	0.00	0.00	0.14	0.14	0.00
Spirolina cylindracea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trochammina amnicola	0.48	0.64	1.55	1.65	0.94	1.86	1.13	1.02	1.08	0.73	1.78	1.70	1.19	1.53	1.58
"Trochammina ochracea"	0.17	0.00	0.00	0.00	0.16	0.00	0.00	0.40	0.82	0.46	0.00	0.00	0.00	0.14	0.00
Trochammina sp. E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
indeterminate rotaliids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
indeterminate textulariids	0.00	0.34	0.31	0.00	0.00	0.44	0.47	0.40	0.00	0.32	0.69	0.49	0.58	0.64	0.53

APPENDIX G. Percent of species (S43) for the total (live + dead) cluster analysis including all taxa ≥ 2% of the total assemblage. Sample depth, cm.

Taxon ↓ Sample depth →	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65	67	69	71
Ammobaculities exiguus	31.29	28.36	23.88	23.11	46.80	38.58	47.21	20.00	23.23	14.35	31.55	28.44	19.50	10.15	10.82	14.06	12.96	13.46	10.15	12.57	15.12	9.00	7.41	6.83	5.08	3.47	7.65	5.61	2.16	5.53	1.39	3.14	2.65	3.98	4.85	0.00
Ammonia aff. *A. aoteana*	29.45	47.76	32.34	40.00	26.60	34.52	27.41	26.67	45.45	48.95	44.66	54.50	45.50	44.16	43.81	39.84	50.00	45.19	45.69	38.22	47.32	50.00	46.76	43.78	44.16	44.55	40.44	39.72	49.35	35.18	37.04	42.93	43.92	48.26	47.57	45.54
Ammotium directum	0.00	0.00	0.00	0.89	0.49	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.39	0.00	0.00	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammotium morenoi	1.84	0.50	1.00	0.00	1.48	2.03	2.54	0.95	0.00	0.42	0.49	0.95	0.50	0.00	0.00	1.17	0.00	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.50	0.55	0.00	0.00	1.01	0.46	0.00	0.00	0.50	0.00	0.00
Amphistegina lessonii	1.23	0.00	0.50	0.44	0.00	0.00	0.00	0.48	0.00	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.48	0.51	0.00	0.00	0.00	1.39	0.00	0.51	0.00	1.09	0.00	0.87	0.00	1.39	0.00	0.00	0.50	0.49	0.00
Bolivina striatula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.49	0.00	0.00	1.52	1.55	0.78	0.00	0.00	0.00	0.52	0.49	0.00	1.39	0.40	2.03	1.49	1.09	0.93	0.00	1.01	3.24	0.00	0.53	1.99	1.46	1.98
Bolivina spp.	1.84	0.50	1.00	2.22	0.00	0.00	0.51	2.38	1.01	1.27	0.49	0.47	0.00	2.54	4.64	0.78	1.39	3.37	0.51	4.19	2.44	2.50	1.85	4.02	4.06	4.95	3.28	2.80	3.46	1.51	3.70	5.76	4.23	1.49	0.97	0.50
Cibicides cf. *C. fletcheri*	0.61	0.00	1.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.50	0.00	0.00	0.39	0.46	0.48	0.00	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.55	0.00	0.87	0.00	1.39	0.00	0.00	0.50	0.97	1.49
Cibicides sp. 1	0.61	0.00	0.50	2.22	0.00	0.00	0.00	0.00	0.51	0.42	0.00	0.47	0.50	2.54	1.55	1.95	2.78	2.40	0.51	0.52	0.00	0.50	0.46	2.41	1.02	2.97	0.00	1.40	1.73	0.50	0.93	1.05	0.00	0.50	1.94	0.00
Cibicides sp. 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.52	0.00	0.50	0.00	0.40	0.00	0.00	0.00	0.47	0.43	0.00	0.00	0.52	1.06	0.00	0.49	0.99
Dyocibicides primitivus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00
Elphidium hyalocostatum	0.61	0.00	0.00	0.44	0.00	0.00	0.00	2.38	0.00	0.84	0.00	0.47	0.00	0.51	0.00	0.00	0.00	0.48	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium indicum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.93	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.43	0.50	0.46	0.00	0.00	0.00	0.00	0.00
Elphidium cf. *reticulosum*	0.00	0.00	0.00	1.33	0.00	1.52	0.51	0.00	0.00	0.42	0.97	0.00	0.00	1.02	0.00	0.78	0.00	0.00	2.03	0.52	0.49	2.50	0.46	0.00	0.00	1.49	0.55	0.00	0.87	0.00	0.00	0.00	1.59	1.00	0.00	0.99
Elphidium cf. *E. simplex*	0.00	1.00	0.00	0.44	0.00	0.00	0.00	0.48	1.01	0.00	0.00	0.00	0.50	0.51	0.52	0.00	0.00	0.00	0.51	0.52	0.00	1.50	0.00	1.20	0.51	0.50	0.55	0.00	0.00	1.01	0.46	1.57	0.00	1.99	0.49	0.00
Elphidium sp. L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00
Elphidium spp.	0.61	0.00	0.00	0.00	0.49	0.51	0.00	0.00	0.00	2.11	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.48	0.51	0.00	0.00	0.00	0.46	0.00	0.00	0.00	1.64	0.00	0.00	1.51	0.00	0.52	0.53	0.00	0.00	0.00
Gavelinopsis praegeri	6.75	3.48	7.46	5.78	0.00	0.00	0.00	0.00	1.01	1.69	0.00	0.00	4.00	1.52	1.03	3.13	1.85	1.44	4.06	2.09	0.98	2.00	0.00	0.80	0.00	0.50	0.55	1.40	0.87	2.01	0.93	1.57	2.65	2.99	0.97	3.47
Miliammina fusca	0.00	1.00	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Murrayina murrayi	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.95	0.51	0.42	0.00	0.00	0.00	0.00	0.00	0.39	2.31	0.48	1.02	1.57	0.00	2.00	0.46	0.00	2.03	1.98	2.19	1.40	0.00	3.02	2.31	2.09	1.59	1.00	0.49	1.98
Nonion sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.09	0.00	0.43	1.01	0.00	0.00	0.00	0.00	0.00	0.50
Nonion sp. B	1.23	1.99	0.00	0.89	0.49	0.00	0.00	1.90	0.51	1.69	0.49	0.47	1.50	1.52	1.03	0.78	2.31	1.92	1.52	2.62	1.46	1.00	2.78	4.42	3.55	2.97	3.28	1.40	1.30	3.02	0.46	2.62	1.06	0.50	1.46	4.95
Paratrochammina stoeni	5.52	1.49	0.00	2.22	3.94	4.57	5.08	11.90	2.02	0.42	0.97	1.90	3.50	1.52	0.52	1.17	0.46	0.00	0.00	0.00	0.49	0.50	0.46	0.40	0.00	0.00	0.55	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00
Peneroplis pertusus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.51	0.00	0.98	0.00	0.46	0.00	0.00	0.00	1.09	0.47	1.30	0.50	0.00	1.57	0.00	0.50	0.00	0.00
Planorbulina acervalis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	1.09	0.00	0.43	1.01	0.46	0.52	1.06	0.50	0.49	0.50
Pseudorotalia schroeteriana	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.48	0.00	0.00	0.49	0.00	1.00	0.00	0.00	0.39	0.00	0.00	1.02	0.00	0.00	0.00	0.46	0.40	1.52	0.50	0.00	0.00	0.00	1.01	0.93	2.09	2.65	1.00	1.46	0.50
Quinqueloculina sp. 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.39	0.40	0.51	0.00	0.55	0.47	0.87	0.50	0.00	0.00	0.00	0.00	0.00	0.00
Quinqueloculina spp.	2.45	1.99	1.99	0.44	1.97	0.00	0.00	1.43	5.05	3.38	0.49	0.47	3.00	6.09	8.25	4.69	4.17	5.29	5.08	6.81	3.41	4.50	4.17	2.41	6.09	4.95	3.83	6.07	4.33	8.04	7.87	4.19	5.82	4.98	4.85	4.46
Reusella pulchra	1.23	0.50	2.49	0.89	0.49	0.00	0.51	1.43	1.01	2.53	0.00	0.95	1.00	2.03	1.03	1.95	0.93	0.96	0.51	2.09	2.44	2.00	2.78	3.61	2.03	3.47	3.28	7.01	2.60	3.52	1.39	2.09	4.23	4.98	3.40	3.96
Reusella spinulosa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.53	1.00	0.49	0.50
Rosalina globularis	3.07	1.00	1.49	1.78	0.49	1.52	0.00	2.38	3.54	1.69	3.40	1.90	4.00	5.08	8.25	8.20	7.87	8.17	8.12	11.52	6.83	7.50	13.43	8.43	9.14	6.44	7.65	10.75	10.39	12.56	14.81	8.90	0.00	7.46	12.62	7.92
Sagrina zanzibarica	0.61	0.50	0.00	0.00	0.00	0.00	0.00	3.33	0.51	1.69	0.97	0.47	0.50	1.52	2.06	0.78	1.85	3.37	2.03	3.14	0.00	1.00	1.85	4.42	1.02	4.46	1.64	2.80	3.03	0.50	1.39	3.66	4.76	1.99	0.49	3.47
Sagrinella lobata	2.45	1.99	6.97	5.33	1.97	4.06	1.52	3.81	4.04	2.11	3.88	3.32	6.50	6.09	4.12	3.91	1.85	2.88	3.55	5.76	5.85	2.00	3.70	2.41	5.08	6.44	0.55	4.67	5.19	4.02	3.70	4.71	7.41	2.99	3.88	3.96
Schackoinella globosa	1.23	0.00	1.00	1.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.02	0.00	1.17	0.00	0.48	0.00	1.05	4.88	1.50	0.00	0.40	0.00	1.98	3.83	1.40	0.00	0.00	0.00	1.05	1.59	1.49	1.46	0.00
Siphotrochammina lobata	0.61	0.00	0.50	0.00	0.99	0.00	0.00	0.00	0.00	0.00	1.46	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Spirolina cylindracea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.43	0.00	0.46	0.00	0.53	1.00	0.00	0.50
Trochammina amnicola	0.00	3.98	0.00	0.00	1.48	0.00	0.51	0.48	0.00	0.42	0.00	0.00	0.50	1.02	0.00	0.00	0.00	0.00	0.00	1.05	0.00	0.50	1.39	0.80	0.00	0.00	0.00	0.00	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00
"Trochammina ochracea"	1.23	1.99	4.98	2.67	4.43	3.55	2.54	1.90	0.00	1.69	4.85	1.90	1.00	2.03	1.55	1.17	0.46	0.48	0.51	0.00	0.00	0.00	0.46	0.40	0.00	0.50	1.09	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00
Trochammina sp. E	0.00	0.50	1.00	1.78	3.94	5.08	6.60	9.05	1.52	2.95	0.49	0.95	1.00	1.52	1.03	0.78	0.46	0.96	2.03	0.00	0.00	3.00	0.46	0.80	0.00	0.00	0.00	0.47	1.30	0.00	0.00	0.00	0.00	0.50	0.00	0.00
indeterminate rotaliids	0.61	0.50	6.47	3.11	0.49	1.52	1.52	3.81	5.05	2.53	0.97	1.90	3.50	5.08	4.64	7.03	3.24	3.85	6.09	2.62	4.88	2.50	1.85	4.02	6.09	1.98	3.83	2.34	1.73	6.03	5.56	2.62	5.29	1.99	1.94	3.47
indeterminate textulariids	0.61	0.00	0.00	0.00	0.49	0.00	1.02	0.00	0.51	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.50	0.46	0.00	0.00	0.00	0.00	0.50

Percent of species (S40) for the total (live + dead) cluster analysis including all taxa ≥ 2% of the total assemblage. Sample depth, cm.

Taxon ↓ Sample depth →	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55
Ammobaculities exiguus	4.15	6.76	11.67	8.33	8.43	11.18	11.33	8.65	15.15	12.97	18.38	20.22	10.33	10.63	11.05	11.41	10.14	7.33	3.74	3.85	3.41	3.00	2.53	4.76	1.00	0.48	1.38	2.30
Ammonia aff. *A. aoteana*	26.73	16.91	20.00	17.78	16.85	15.88	24.14	23.78	23.03	26.49	22.70	21.86	22.28	30.92	26.32	30.98	24.64	15.71	17.11	19.23	17.56	17.00	16.16	18.52	12.44	26.19	15.60	11.49
Ammotium directum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammotium morenoi	0.46	1.93	1.11	2.22	4.49	5.88	0.00	1.08	0.00	0.54	2.16	2.19	0.00	0.00	0.00	0.00	0.48	0.52	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.48	0.00	0.00
Amphistegina lessonii	5.07	0.48	0.56	0.56	0.00	2.35	0.00	0.00	3.64	1.62	1.62	1.09	0.00	1.45	0.53	0.54	0.48	1.05	1.60	1.10	0.98	1.00	2.02	3.17	1.49	2.86	1.83	1.15
Bolivina striatula	0.92	0.97	0.00	0.56	0.56	0.59	1.97	0.00	1.82	0.54	0.54	0.55	0.00	0.00	2.11	1.63	0.97	0.00	1.07	0.00	0.49	0.00	0.51	1.06	1.00	0.48	0.46	0.38
Bolivina spp.	5.99	7.73	9.44	6.67	7.30	5.29	8.37	5.95	1.82	2.70	2.16	0.00	3.80	1.93	4.21	4.35	4.83	6.28	5.88	3.30	3.41	5.00	8.59	2.65	4.98	3.81	6.88	3.07
Cibicides cf. *C. fletcheri*	2.30	3.38	2.78	5.00	2.25	2.35	0.49	2.16	2.42	2.16	2.16	0.55	1.63	0.97	1.05	0.00	1.45	0.52	0.53	0.55	1.95	1.00	0.51	1.06	2.99	2.38	0.46	1.53
Cibicides sp. 1	1.84	0.48	1.67	2.78	2.25	1.18	2.46	2.70	1.82	0.54	0.54	1.64	0.54	0.48	1.58	0.00	1.45	2.09	0.00	0.55	2.93	3.00	3.54	1.59	0.50	1.43	0.00	0.00
Cibicides sp. 2	0.00	1.45	0.56	0.00	0.00	0.59	0.49	0.54	0.00	0.54	0.00	0.55	0.00	0.00	1.05	0.54	0.48	0.00	0.53	0.55	2.93	1.00	1.01	0.53	1.99	0.95	1.38	2.30
Dyocibicides primitivus	0.46	0.00	0.00	0.00	0.56	0.59	0.49	0.00	0.61	0.54	0.00	0.55	0.00	0.00	0.00	1.09	0.97	1.05	0.00	0.00	0.49	3.00	0.00	2.12	1.00	1.43	0.00	1.92
Elphidium hyalocostatum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium indicum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.09	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38
Elphidium cf. *reticulosum*	0.00	0.97	0.00	0.56	0.00	1.18	0.00	0.54	1.82	3.24	0.54	0.55	2.17	0.97	0.00	1.09	0.48	0.52	1.60	1.65	0.00	1.00	0.51	1.06	0.50	0.00	0.46	1.15
Elphidium cf. *E. simplex*	1.84	0.97	1.11	0.56	2.25	2.94	1.97	0.54	0.61	0.54	0.54	1.64	0.00	1.93	0.00	0.54	0.48	1.05	0.00	1.10	0.00	1.00	0.00	2.65	1.00	0.48	0.92	2.30
Elphidium sp. L	0.00	2.42	0.56	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.92	0.00
Elphidium spp.	0.46	0.97	0.00	0.00	0.00	0.59	0.00	0.54	0.61	0.00	1.08	0.00	0.54	0.48	0.53	0.54	0.00	0.52	0.00	0.55	0.98	1.50	0.00	0.53	0.50	0.48	0.46	1.53
Gavelinopsis praegeri	7.37	3.38	2.22	6.11	3.93	5.88	5.91	4.86	5.45	5.95	9.19	7.65	9.78	8.70	10.00	9.24	4.35	7.33	8.56	6.59	5.85	6.50	5.05	4.23	4.48	3.81	5.96	8.43
Miliammina fusca	0.46	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Murrayina murrayi	0.92	1.45	0.00	0.00	0.00	0.59	2.46	0.00	0.61	0.00	0.54	0.00	0.00	0.00	2.11	1.09	0.48	0.00	4.81	0.55	0.00	1.00	1.01	0.53	0.00	0.95	0.00	0.38
Nonion sp. A	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.54	0.00	1.58	0.00	0.48	0.00	3.21	2.20	0.49	0.50	0.00	0.00	0.50	0.00	0.00	0.00
Nonion sp. B	0.00	1.45	0.56	0.00	0.00	2.35	1.48	3.78	2.42	1.62	3.24	3.83	5.98	0.48	3.16	2.17	1.45	2.62	2.67	1.65	0.98	1.50	1.01	1.59	1.00	0.00	0.00	0.00
Paratrochammina stoeni	0.00	0.00	1.67	0.00	0.00	0.59	0.49	0.54	0.61	2.16	0.54	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peneroplis pertusus	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.55	0.00	0.00	0.53	0.54	0.00	2.09	0.00	2.20	0.49	0.00	0.51	1.06	2.99	2.38	3.21	2.68
Planorbulina acervalis	0.00	0.48	0.00	1.11	0.00	0.00	0.49	0.00	0.00	0.00	0.54	0.55	0.00	0.00	0.00	0.00	0.97	0.52	1.07	1.65	1.46	1.50	2.02	0.00	2.49	1.43	0.92	1.15
Pseudorotalia schroeteriana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.53	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.92	0.00
Quinqueloculina sp. 3	0.00	0.00	0.56	0.00	0.56	0.00	0.00	0.00	0.00	0.54	0.54	0.00	0.00	0.00	0.53	0.54	0.48	0.00	0.53	0.00	0.49	1.50	0.51	2.12	1.49	1.90	1.83	0.38
Quinqueloculina spp.	2.76	4.83	5.56	5.00	6.74	3.53	5.42	1.62	3.03	12.97	4.86	2.19	8.15	5.31	6.32	3.80	12.08	10.47	13.37	17.58	18.05	14.50	14.14	12.17	15.92	15.71	11.01	15.33
Reusella pulchra	3.69	9.66	7.78	5.00	5.62	9.41	6.40	5.41	3.03	4.32	1.62	6.56	3.80	2.90	2.63	1.09	4.35	7.85	4.81	3.85	9.76	4.50	5.05	8.47	4.98	5.71	7.80	7.28
Reusella spinulosa	0.00	0.00	0.00	1.67	2.81	0.59	0.00	0.54	0.61	0.54	0.00	0.00	0.00	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00	1.52	0.00	0.00	0.48	0.92	1.53
Rosalina globularis	3.69	6.28	4.44	6.67	3.93	5.29	2.96	7.57	13.94	4.86	4.86	4.92	7.07	4.35	6.84	5.98	5.31	6.28	8.56	3.85	7.80	5.50	15.15	5.29	7.96	7.14	10.55	7.66
Sagrina zanzibarica	4.61	8.21	0.56	1.67	4.49	2.35	3.45	2.16	0.61	1.08	1.08	1.09	2.17	1.93	2.11	3.26	0.48	2.62	0.53	6.04	2.44	5.00	4.55	6.88	5.97	1.43	1.83	3.83
Sagrinella lobata	9.68	7.25	8.89	10.00	14.04	5.29	4.93	7.57	3.03	3.78	8.11	4.92	4.35	5.80	1.58	5.98	6.28	5.24	7.49	7.14	7.32	6.00	4.55	4.76	2.99	4.76	8.72	7.66
Schackoinella globosa	2.30	2.90	1.11	2.78	3.93	1.18	3.94	5.41	4.85	2.70	1.08	1.64	4.89	2.90	2.63	2.17	1.93	0.52	0.00	0.00	0.00	1.00	1.52	1.06	0.50	0.48	0.46	0.00
Siphotrochammina lobata	0.00	0.00	0.56	0.00	0.00	0.59	0.00	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.53	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00
Spirolina cylindracea	0.00	0.00	0.00	0.00	0.00	1.18	0.00	1.62	1.21	0.00	0.00	0.00	1.09	1.93	0.00	0.54	0.48	1.05	0.53	3.85	0.49	3.50	1.52	1.06	1.00	0.95	0.46	0.38
Trochammina amnicola	1.38	0.00	0.00	0.00	0.00	0.59	0.49	0.00	0.00	0.00	0.00	0.55	0.00	0.00	0.53	0.54	0.48	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
"Trochammina ochracea"	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.48	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00
Trochammina sp. E	0.00	0.48	1.67	0.56	0.00	0.00	0.49	0.00	0.00	2.16	0.00	0.00	0.00	1.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
indeterminate rotaliids	4.15	2.42	7.22	6.67	2.25	6.47	5.91	7.57	0.00	0.00	5.95	6.56	5.98	9.66	6.32	6.52	6.76	5.76	4.28	4.40	3.41	2.00	1.01	0.53	6.47	3.33	3.67	4.98
indeterminate textulariids	0.00	0.00	0.00	1.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.53	0.50	0.00	0.00	0.00

Percent of species (S9A) for the total (live + dead) cluster analysis including all taxa ≥ 2% of the total assemblage. Sample depth, cm.

Taxon ↓ Sample depth →	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
Ammobaculities exiguus	12.44	14.41	15.22	42.11	12.78	15.35	14.49	22.50	9.52	55.56	15.53	12.89	10.55	13.04	17.73
Ammonia aff. *A. aoteana*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammotium directum	17.41	31.53	21.74	10.53	43.89	10.53	28.99	23.75	14.29	6.67	8.07	19.07	43.22	21.74	23.65
Ammotium morenoi	0.00	2.70	0.00	10.53	3.89	1.75	7.97	0.00	9.52	8.89	8.70	6.19	5.03	3.38	1.97
Amphistegina lessonii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bolivina striatula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bolivina spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides cf. *C. fletcheri*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides sp. 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides sp. 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dyocibicides primitivus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium hyalocostatum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium indicum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium cf. *reticulosum*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium cf. *E. simplex*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium sp. L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gavelinopsis praegeri	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miliammina fusca	63.68	39.64	17.39	0.00	20.56	5.70	15.22	13.75	9.52	8.89	0.00	0.52	1.01	0.48	0.00
Murrayina murrayi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nonion sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nonion sp. B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paratrochammina stoeni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.00
Peneroplis pertusus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Planorbulina acervalis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudorotalia schroeteriana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quinqueloculina sp. 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quinqueloculina spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reusella pulchra	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reusella spinulosa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rosalina globularis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sagrina zanzibarica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sagrinella lobata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Schackoinella globosa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Siphotrochammina lobata	1.00	0.00	0.00	0.00	0.56	1.32	2.90	5.00	19.05	2.22	0.00	0.00	0.50	0.97	0.00
Spirolina cylindracea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trochammina amnicola	4.98	9.01	43.48	36.84	17.22	60.53	26.09	22.50	23.81	11.11	56.52	55.67	31.66	49.76	50.25
"Trochammina ochracea"	0.50	0.00	0.00	0.00	0.56	0.44	0.00	5.00	14.29	4.44	0.00	0.00	0.00	0.48	0.00
Trochammina sp. E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
indeterminate rotaliids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
indeterminate textulariids	0.00	2.70	2.17	0.00	0.00	3.95	4.35	3.75	0.00	2.22	10.56	5.67	8.04	9.18	6.40

APPENDIX H. Transformed data (S43) for the total (live + dead) cluster analysis including all taxa ≥ 2% of the total assemblage. Sample depth, cm.

Taxon ↓ Sample depth →	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65	67	69	71
Ammobaculities exiguus	1.19	1.12	1.02	1.00	1.51	1.34	1.51	0.93	1.01	0.78	1.19	1.12	0.91	0.65	0.67	0.77	0.74	0.75	0.65	0.72	0.80	0.61	0.55	0.53	0.45	0.37	0.56	0.48	0.30	0.47	0.24	0.36	0.33	0.40	0.44	0.00
Ammonia aff. *A. aoteana*	1.15	1.53	1.21	1.37	1.08	1.26	1.10	1.09	1.48	1.55	1.46	1.66	1.48	1.45	1.45	1.37	1.57	1.47	1.48	1.33	1.52	1.57	1.51	1.45	1.45	1.46	1.38	1.36	1.56	1.27	1.31	1.43	1.45	1.54	1.52	1.48
Ammotium directum	0.00	0.00	0.00	0.19	0.14	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.13	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammotium morenoi	0.27	0.14	0.20	0.00	0.24	0.29	0.32	0.20	0.00	0.13	0.14	0.20	0.14	0.00	0.00	0.22	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.14	0.15	0.00	0.00	0.20	0.14	0.00	0.00	0.14	0.00	0.00
Amphistegina lessonii	0.22	0.00	0.14	0.13	0.00	0.00	0.00	0.14	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.14	0.00	0.00	0.00	0.24	0.00	0.14	0.00	0.21	0.00	0.19	0.00	0.24	0.00	0.00	0.14	0.14	0.00
Bolivina striatula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.14	0.00	0.00	0.25	0.25	0.18	0.00	0.00	0.00	0.14	0.14	0.00	0.24	0.13	0.29	0.24	0.21	0.19	0.00	0.20	0.36	0.00	0.15	0.28	0.24	0.28
Bolivina spp.	0.27	0.14	0.20	0.30	0.00	0.00	0.14	0.31	0.20	0.23	0.14	0.14	0.00	0.32	0.43	0.18	0.24	0.37	0.14	0.41	0.31	0.32	0.27	0.40	0.41	0.45	0.36	0.34	0.37	0.25	0.39	0.48	0.41	0.24	0.20	0.14
Cibicides cf. *C. fletcheri*	0.16	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.14	0.00	0.00	0.13	0.14	0.14	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.15	0.00	0.19	0.00	0.24	0.00	0.00	0.14	0.20	0.24
Cibicides sp. 1	0.16	0.00	0.14	0.30	0.00	0.00	0.00	0.00	0.14	0.13	0.00	0.14	0.14	0.32	0.25	0.28	0.33	0.31	0.14	0.14	0.00	0.14	0.14	0.31	0.20	0.35	0.00	0.24	0.26	0.14	0.19	0.21	0.00	0.14	0.28	0.00
Cibicides sp. 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.14	0.00	0.14	0.00	0.13	0.00	0.00	0.00	0.14	0.13	0.00	0.00	0.14	0.21	0.00	0.14	0.20
Dyocibicides primitivus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00
Elphidium hyalocostatum	0.16	0.00	0.00	0.13	0.00	0.00	0.00	0.31	0.00	0.18	0.00	0.14	0.00	0.14	0.00	0.00	0.00	0.14	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium indicum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.19	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.13	0.14	0.14	0.00	0.00	0.00	0.00	0.00
Elphidium cf. *reticulosum*	0.00	0.00	0.00	0.23	0.00	0.25	0.14	0.00	0.00	0.13	0.20	0.00	0.00	0.20	0.00	0.18	0.00	0.00	0.29	0.14	0.14	0.32	0.14	0.00	0.00	0.24	0.15	0.00	0.19	0.00	0.00	0.00	0.25	0.20	0.00	0.20
Elphidium cf. *E. simplex*	0.00	0.20	0.00	0.13	0.00	0.00	0.00	0.14	0.20	0.00	0.00	0.00	0.14	0.14	0.14	0.00	0.00	0.00	0.14	0.14	0.00	0.25	0.00	0.22	0.14	0.14	0.15	0.00	0.00	0.20	0.14	0.25	0.00	0.28	0.14	0.00
Elphidium sp. L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00
Elphidium spp.	0.16	0.00	0.00	0.00	0.14	0.14	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.14	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.26	0.00	0.00	0.25	0.00	0.14	0.15	0.00	0.00	0.00
Gavelinopsis praegeri	0.53	0.38	0.55	0.49	0.00	0.00	0.00	0.00	0.20	0.26	0.00	0.00	0.40	0.25	0.20	0.36	0.27	0.24	0.41	0.29	0.20	0.28	0.00	0.18	0.00	0.14	0.15	0.24	0.19	0.28	0.19	0.25	0.33	0.35	0.20	0.37
Miliammina fusca	0.00	0.20	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Murrayina murrayi	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.14	0.13	0.00	0.00	0.00	0.00	0.00	0.13	0.31	0.14	0.20	0.25	0.00	0.28	0.14	0.00	0.29	0.28	0.30	0.24	0.00	0.35	0.31	0.29	0.25	0.20	0.14	0.28
Nonion sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.13	0.20	0.00	0.00	0.00	0.00	0.00	0.14
Nonion sp. B	0.22	0.28	0.00	0.19	0.14	0.00	0.00	0.28	0.14	0.26	0.14	0.14	0.25	0.25	0.20	0.18	0.31	0.28	0.25	0.33	0.24	0.20	0.33	0.42	0.38	0.35	0.36	0.24	0.23	0.35	0.14	0.33	0.21	0.14	0.24	0.45
Paratrochammina stoeni	0.47	0.24	0.00	0.30	0.40	0.43	0.45	0.70	0.29	0.13	0.20	0.28	0.38	0.25	0.14	0.22	0.14	0.00	0.00	0.00	0.14	0.14	0.14	0.13	0.00	0.00	0.15	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00
Peneroplis pertusus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.14	0.00	0.20	0.00	0.14	0.00	0.00	0.00	0.21	0.14	0.23	0.14	0.00	0.25	0.00	0.14	0.00	0.00
Planorbulina acervalis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.21	0.00	0.13	0.20	0.14	0.14	0.21	0.14	0.14	0.14
Pseudorotalia schroeteriana	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.14	0.00	0.00	0.14	0.00	0.20	0.00	0.00	0.13	0.00	0.00	0.20	0.00	0.00	0.00	0.14	0.13	0.25	0.14	0.00	0.00	0.00	0.20	0.19	0.29	0.33	0.20	0.24	0.14
Quinqueloculina sp. 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.24	0.13	0.14	0.00	0.15	0.14	0.19	0.14	0.00	0.00	0.00	0.00	0.00	0.00
Quinqueloculina spp.	0.31	0.28	0.28	0.13	0.28	0.00	0.00	0.24	0.45	0.37	0.14	0.14	0.35	0.50	0.58	0.44	0.41	0.46	0.45	0.53	0.37	0.43	0.41	0.31	0.50	0.45	0.39	0.50	0.42	0.57	0.57	0.41	0.49	0.45	0.44	0.43
Reusella pulchra	0.22	0.14	0.32	0.19	0.14	0.00	0.14	0.24	0.20	0.32	0.00	0.20	0.20	0.29	0.20	0.28	0.19	0.20	0.14	0.29	0.31	0.28	0.33	0.38	0.29	0.37	0.36	0.54	0.32	0.38	0.24	0.29	0.41	0.45	0.37	0.40
Reusella spinulosa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.15	0.20	0.14	0.14
Rosalina globularis	0.35	0.20	0.24	0.27	0.14	0.25	0.00	0.31	0.38	0.26	0.37	0.28	0.40	0.45	0.58	0.58	0.57	0.58	0.58	0.69	0.53	0.55	0.75	0.59	0.61	0.51	0.56	0.67	0.66	0.72	0.79	0.61	0.00	0.55	0.73	0.57
Sagrina zanzibarica	0.16	0.14	0.00	0.00	0.00	0.00	0.00	0.37	0.14	0.26	0.20	0.14	0.14	0.25	0.29	0.18	0.27	0.37	0.29	0.36	0.00	0.20	0.27	0.42	0.20	0.43	0.26	0.34	0.35	0.14	0.24	0.39	0.44	0.28	0.14	0.37
Sagrinella lobata	0.31	0.28	0.53	0.47	0.28	0.41	0.25	0.39	0.40	0.29	0.40	0.37	0.52	0.50	0.41	0.40	0.27	0.34	0.38	0.48	0.49	0.28	0.39	0.31	0.45	0.51	0.15	0.44	0.46	0.40	0.39	0.44	0.55	0.35	0.40	0.40
Schackoinella globosa	0.22	0.00	0.20	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.20	0.00	0.22	0.00	0.14	0.00	0.21	0.45	0.25	0.00	0.13	0.00	0.28	0.39	0.24	0.00	0.00	0.00	0.21	0.25	0.24	0.24	0.00
Siphotrochammina lobata	0.16	0.00	0.14	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Spirolina cylindracea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.13	0.00	0.14	0.00	0.15	0.20	0.00	0.14
Trochammina amnicola	0.00	0.40	0.00	0.00	0.24	0.00	0.14	0.14	0.00	0.13	0.00	0.00	0.14	0.20	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.14	0.24	0.18	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
"Trochammina ochracea"	0.22	0.28	0.45	0.33	0.42	0.38	0.32	0.28	0.00	0.26	0.44	0.28	0.20	0.29	0.25	0.22	0.14	0.14	0.14	0.00	0.00	0.00	0.14	0.13	0.00	0.14	0.21	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00
Trochammina sp. E	0.00	0.14	0.20	0.27	0.40	0.45	0.52	0.61	0.25	0.35	0.14	0.20	0.20	0.25	0.20	0.18	0.14	0.20	0.29	0.00	0.00	0.35	0.14	0.18	0.00	0.00	0.00	0.14	0.23	0.00	0.00	0.00	0.00	0.14	0.00	0.00
indeterminate rotaliids	0.16	0.14	0.51	0.35	0.14	0.25	0.25	0.39	0.45	0.32	0.20	0.28	0.38	0.45	0.43	0.54	0.36	0.39	0.50	0.33	0.45	0.32	0.27	0.40	0.50	0.28	0.39	0.31	0.26	0.50	0.48	0.33	0.46	0.28	0.28	0.37
indeterminate textulariids	0.16	0.00	0.00	0.00	0.14	0.00	0.20	0.00	0.14	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.00	0.00	0.00	0.00	0.14

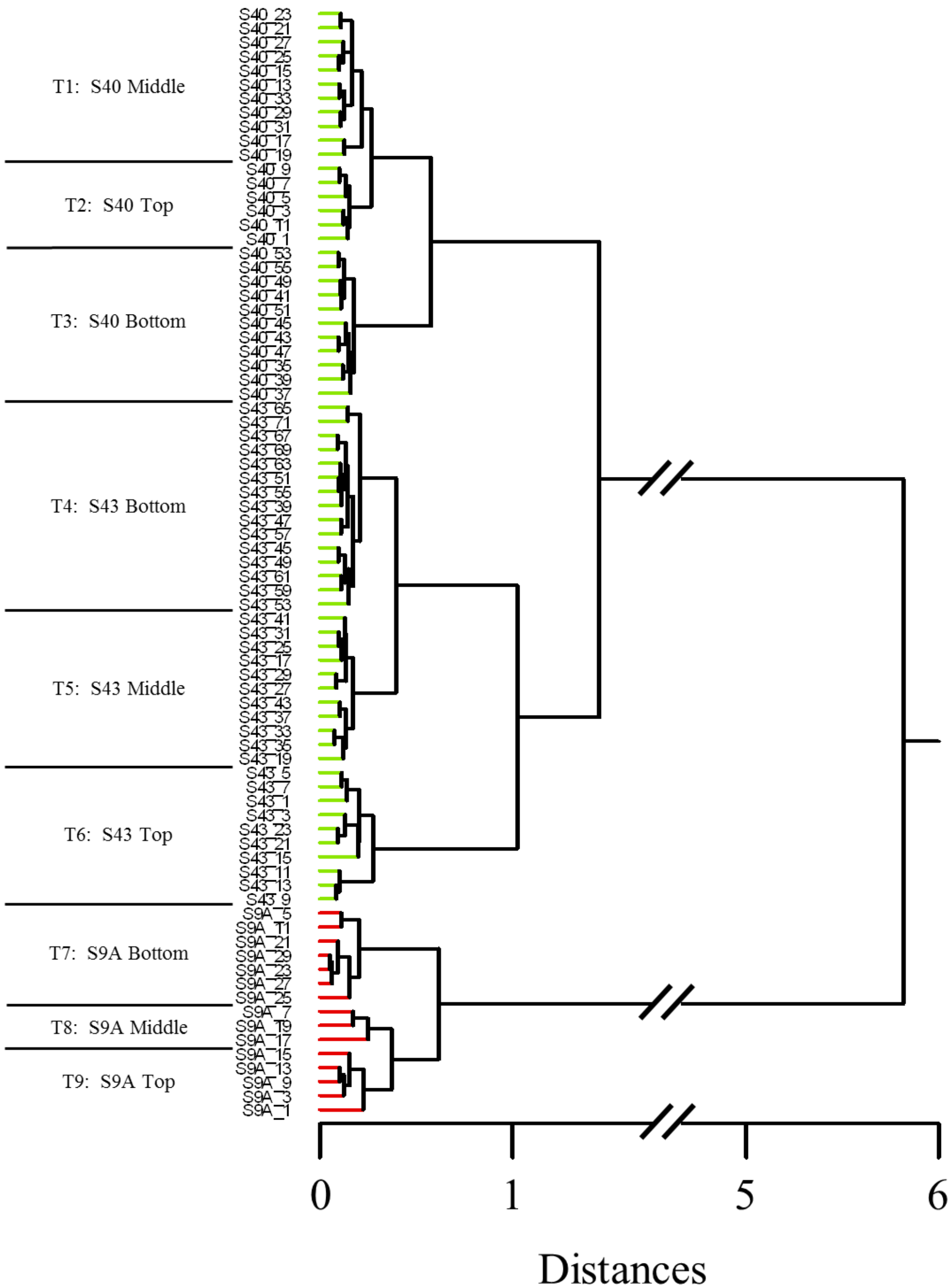
Transformed data (S40) for the total (live + dead) cluster analysis including all taxa ≥ 2% of the total assemblage. Sample depth, cm.

Taxon ↓ Sample depth →	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55
Ammobaculities exiguus	0.41	0.53	0.70	0.59	0.59	0.68	0.69	0.60	0.80	0.74	0.89	0.93	0.65	0.66	0.68	0.69	0.65	0.55	0.39	0.39	0.37	0.35	0.32	0.44	0.20	0.14	0.24	0.30
Ammonia aff. *A. aoteana*	1.09	0.85	0.93	0.87	0.85	0.82	1.03	1.02	1.00	1.08	0.99	0.97	0.98	1.18	1.08	1.18	1.04	0.82	0.85	0.91	0.86	0.85	0.83	0.89	0.72	1.07	0.81	0.69
Ammotium directum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammotium morenoi	0.14	0.28	0.21	0.30	0.43	0.49	0.00	0.21	0.00	0.15	0.30	0.30	0.00	0.00	0.00	0.00	0.14	0.14	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.14	0.00	0.00
Amphistegina lessonii	0.45	0.14	0.15	0.15	0.00	0.31	0.00	0.00	0.38	0.26	0.26	0.21	0.00	0.24	0.15	0.15	0.14	0.21	0.25	0.21	0.20	0.20	0.29	0.36	0.24	0.34	0.27	0.21
Bolivina striatula	0.19	0.20	0.00	0.15	0.15	0.15	0.28	0.00	0.27	0.15	0.15	0.15	0.00	0.00	0.29	0.26	0.20	0.00	0.21	0.00	0.14	0.00	0.14	0.21	0.20	0.14	0.14	0.12
Bolivina spp.	0.49	0.56	0.62	0.52	0.55	0.46	0.59	0.49	0.27	0.33	0.30	0.00	0.39	0.28	0.41	0.42	0.44	0.51	0.49	0.37	0.37	0.45	0.59	0.33	0.45	0.39	0.53	0.35
Cibicides cf. *C. fletcheri*	0.30	0.37	0.33	0.45	0.30	0.31	0.14	0.30	0.31	0.30	0.30	0.15	0.26	0.20	0.21	0.00	0.24	0.14	0.15	0.15	0.28	0.20	0.14	0.21	0.35	0.31	0.14	0.25
Cibicides sp. 1	0.27	0.14	0.26	0.33	0.30	0.22	0.32	0.33	0.27	0.15	0.15	0.26	0.15	0.14	0.25	0.00	0.24	0.29	0.00	0.15	0.34	0.35	0.38	0.25	0.14	0.24	0.00	0.00
Cibicides sp. 2	0.00	0.24	0.15	0.00	0.00	0.15	0.14	0.15	0.00	0.15	0.00	0.15	0.00	0.00	0.21	0.15	0.14	0.00	0.15	0.15	0.34	0.20	0.20	0.15	0.28	0.20	0.24	0.30
Dyocibicides primitivus	0.14	0.00	0.00	0.00	0.15	0.15	0.14	0.00	0.16	0.15	0.00	0.15	0.00	0.00	0.00	0.21	0.20	0.21	0.00	0.00	0.14	0.35	0.00	0.29	0.20	0.24	0.00	0.28
Elphidium hyalocostatum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium indicum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
Elphidium cf. *reticulosum*	0.00	0.20	0.00	0.15	0.00	0.22	0.00	0.15	0.27	0.36	0.15	0.15	0.30	0.20	0.00	0.21	0.14	0.14	0.25	0.26	0.00	0.20	0.14	0.21	0.14	0.00	0.14	0.21
Elphidium cf. *E. simplex*	0.27	0.20	0.21	0.15	0.30	0.34	0.28	0.15	0.16	0.15	0.15	0.26	0.00	0.28	0.00	0.15	0.14	0.21	0.00	0.21	0.00	0.20	0.00	0.33	0.20	0.14	0.19	0.30
Elphidium sp. L	0.00	0.31	0.15	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.19	0.00
Elphidium spp.	0.14	0.20	0.00	0.00	0.00	0.15	0.00	0.15	0.16	0.00	0.21	0.00	0.15	0.14	0.15	0.15	0.00	0.14	0.00	0.15	0.20	0.25	0.00	0.15	0.14	0.14	0.14	0.25
Gavelinopsis praegeri	0.55	0.37	0.30	0.50	0.40	0.49	0.49	0.44	0.47	0.49	0.62	0.56	0.64	0.60	0.64	0.62	0.42	0.55	0.59	0.52	0.49	0.52	0.45	0.41	0.43	0.39	0.49	0.59
Miliammina fusca	0.14	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Murrayina murrayi	0.19	0.24	0.00	0.00	0.00	0.15	0.32	0.00	0.16	0.00	0.15	0.00	0.00	0.00	0.29	0.21	0.14	0.00	0.44	0.15	0.00	0.20	0.20	0.15	0.00	0.20	0.00	0.12
Nonion sp. A	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.00	0.25	0.00	0.14	0.00	0.36	0.30	0.14	0.14	0.00	0.00	0.14	0.00	0.00	0.00
Nonion sp. B	0.00	0.24	0.15	0.00	0.00	0.31	0.24	0.39	0.31	0.26	0.36	0.39	0.49	0.14	0.36	0.30	0.24	0.33	0.33	0.26	0.20	0.25	0.20	0.25	0.20	0.00	0.00	0.00
Paratrochammina stoeni	0.00	0.00	0.26	0.00	0.00	0.15	0.14	0.15	0.16	0.30	0.15	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peneroplis pertusus	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.00	0.00	0.15	0.15	0.00	0.29	0.00	0.30	0.14	0.00	0.14	0.21	0.35	0.31	0.36	0.33
Planorbulina acervalis	0.00	0.14	0.00	0.21	0.00	0.00	0.14	0.00	0.00	0.00	0.15	0.15	0.00	0.00	0.00	0.00	0.20	0.14	0.21	0.26	0.24	0.25	0.29	0.00	0.32	0.24	0.19	0.21
Pseudorotalia schroeteriana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.15	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.19	0.00
Quinqueloculina sp. 3	0.00	0.00	0.15	0.00	0.15	0.00	0.00	0.00	0.00	0.15	0.15	0.00	0.00	0.00	0.15	0.15	0.14	0.00	0.15	0.00	0.14	0.25	0.14	0.29	0.24	0.28	0.27	0.12
Quinqueloculina spp.	0.33	0.44	0.48	0.45	0.53	0.38	0.47	0.26	0.35	0.74	0.44	0.30	0.58	0.47	0.51	0.39	0.71	0.66	0.75	0.87	0.88	0.78	0.77	0.71	0.82	0.82	0.68	0.80
Reusella pulchra	0.39	0.63	0.57	0.45	0.48	0.62	0.51	0.47	0.35	0.42	0.26	0.52	0.39	0.34	0.33	0.21	0.42	0.57	0.44	0.39	0.64	0.43	0.45	0.59	0.45	0.48	0.57	0.55
Reusella spinulosa	0.00	0.00	0.00	0.26	0.34	0.15	0.00	0.15	0.16	0.15	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.14	0.19	0.25
Rosalina globularis	0.39	0.51	0.42	0.52	0.40	0.46	0.35	0.56	0.77	0.44	0.44	0.45	0.54	0.42	0.53	0.49	0.47	0.51	0.59	0.39	0.57	0.47	0.80	0.46	0.57	0.54	0.66	0.56
Sagrina zanzibarica	0.43	0.58	0.15	0.26	0.43	0.31	0.37	0.30	0.16	0.21	0.21	0.21	0.30	0.28	0.29	0.36	0.14	0.33	0.15	0.50	0.31	0.45	0.43	0.53	0.49	0.24	0.27	0.39
Sagrinella lobata	0.63	0.55	0.61	0.64	0.77	0.46	0.45	0.56	0.35	0.39	0.58	0.45	0.42	0.49	0.25	0.49	0.51	0.46	0.55	0.54	0.55	0.49	0.43	0.44	0.35	0.44	0.60	0.56
Schackoinella globosa	0.30	0.34	0.21	0.33	0.40	0.22	0.40	0.47	0.44	0.33	0.21	0.26	0.45	0.34	0.33	0.30	0.28	0.14	0.00	0.00	0.00	0.20	0.25	0.21	0.14	0.14	0.14	0.00
Siphotrochammina lobata	0.00	0.00	0.15	0.00	0.00	0.15	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.15	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00
Spirolina cylindracea	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.26	0.22	0.00	0.00	0.00	0.21	0.28	0.00	0.15	0.14	0.21	0.15	0.39	0.14	0.38	0.25	0.21	0.20	0.20	0.14	0.12
Trochammina amnicola	0.24	0.00	0.00	0.00	0.00	0.15	0.14	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.15	0.15	0.14	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
"Trochammina ochracea"	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.14	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00
Trochammina sp. E	0.00	0.14	0.26	0.15	0.00	0.00	0.14	0.00	0.00	0.30	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
indeterminate rotaliids	0.41	0.31	0.54	0.52	0.30	0.51	0.49	0.56	0.00	0.00	0.49	0.52	0.49	0.63	0.51	0.52	0.53	0.48	0.42	0.42	0.37	0.28	0.20	0.15	0.51	0.37	0.39	0.45
indeterminate textulariids	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.15	0.14	0.00	0.00	0.00

Transformed data (S9A) for the total (live + dead) cluster analysis including all taxa ≥ 2% of the total assemblage. Sample depth, cm.

Taxon ↓ Sample depth →	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
Ammobaculities exiguus	0.72	0.78	0.80	1.41	0.73	0.81	0.78	0.99	0.63	1.68	0.81	0.73	0.66	0.74	0.87
Ammonia aff. *A. aoteana*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammotium directum	0.86	1.19	0.97	0.66	1.45	0.66	1.14	1.02	0.78	0.52	0.58	0.90	1.43	0.97	1.02
Ammotium morenoi	0.00	0.33	0.00	0.66	0.40	0.27	0.57	0.00	0.63	0.61	0.60	0.50	0.45	0.37	0.28
Amphistegina lessonii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bolivina striatula	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bolivina spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides cf. *C. fletcheri*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides sp. 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides sp. 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dyocibicides primitivus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium hyalocostatum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium indicum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium cf. *reticulosum*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium cf. *E. simplex*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium sp. L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gavelinopsis praegeri	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miliammina fusca	1.85	1.36	0.86	0.00	0.94	0.48	0.80	0.76	0.63	0.61	0.00	0.14	0.20	0.14	0.00
Murrayina murrayi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nonion sp. A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nonion sp. B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paratrochammina stoeni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00
Peneroplis pertusus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Planorbulina acervalis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudorotalia schroeteriana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quinqueloculina sp. 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quinqueloculina spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reusella pulchra	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reusella spinulosa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rosalina globularis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sagrina zanzibarica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sagrinella lobata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Schackoinella globosa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Siphotrochammina lobata	0.20	0.00	0.00	0.00	0.15	0.23	0.34	0.45	0.90	0.30	0.00	0.00	0.14	0.20	0.00
Spirolina cylindracea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trochammina amnicola	0.45	0.61	1.44	1.30	0.86	1.78	1.07	0.99	1.02	0.68	1.70	1.68	1.20	1.57	1.58
"Trochammina ochracea"	0.14	0.00	0.00	0.00	0.15	0.13	0.00	0.45	0.78	0.42	0.00	0.00	0.00	0.14	0.00
Trochammina sp. E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
indeterminate rotaliids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
indeterminate textulariids	0.00	0.33	0.30	0.00	0.00	0.40	0.42	0.39	0.00	0.30	0.66	0.48	0.57	0.62	0.51

APPENDIX I. Cluster analysis for total (live + dead) assemblage including taxa that make up ≥ 2% of the total assemblage. Groups T1-T9 are similar to thanatofacies 1-9 (Fig. 6), though some samples vary.



APPENDIX J. ^{210}Pb activities within each core. γ, measured by gamma spectroscopy; α, measured by alpha spectroscopy. Shaded values indicate those used to calculate sediment accumulation rates.

S43 Depth (cm)	% Mud	$^{226}Ra_{\gamma}$ (dpm/g)	Excess $^{210}Pb_{\gamma}$ (dpm/g)		Excess $^{210}Pb_{\alpha}$ (dpm/g)		Excess $^{210}Pb_{\alpha}$/Mud Fraction	LN (Excess $^{210}Pb_{\alpha}$/Mud Fraction)	Year
		Activity	Activity	Error (+/-)	Activity	Error (+/-)			
1	74.50				7.69	0.81	10.33	2.33	2011
3	89.61	1.98	9.35	1.41	8.71	0.93	9.72	2.27	2011
5	94.78				9.16	0.96	9.66	2.27	2011
7	95.68				9.20	0.96	9.62	2.26	2011
9	97.51	2.52	10.49	1.33	9.54	0.99	9.79	2.28	2011
11	94.08				9.70	1.01	10.31	2.33	2011
13	97.50				9.12	0.95	9.36	2.24	2011
15	87.62				10.15	1.05	11.58	2.45	2011
17	94.52	2.85	9.58	1.30	8.98	0.93	9.50	2.25	2011
19	94.05				8.55	0.89	9.09	2.21	2011
21	94.91				8.52	0.88	8.98	2.20	2011
23	91.56				8.36	0.87	9.13	2.21	2011
25	93.97	2.48	9.51	1.35	9.03	0.93	9.61	2.26	2011
27	94.19				9.03	0.93	9.58	2.26	2011
29	90.78				8.36	0.87	9.21	2.22	2011
31	90.04				8.94	0.92	9.93	2.30	2010
33	95.93	2.69	8.82	1.13	8.19	0.85	8.54	2.14	2008
35	90.41				8.74	0.91	9.67	2.27	2007
37	88.97				7.86	0.82	8.84	2.18	2005
39	88.91				5.29	0.57	5.95	1.78	2003
41	82.54	2.26	7.64	0.87	7.15	0.75	8.66	2.16	2002
43	73.55				5.83	0.62	7.93	2.07	2000
45	63.65				5.68	0.60	8.92	2.19	1998
47	86.97				6.36	0.67	7.32	1.99	1996
49	82.81	2.06	6.22	1.07	5.40	0.58	6.53	1.88	1995
51	75.75				6.21	0.66	8.19	2.10	1993
53	81.59				4.76	0.52	5.83	1.76	1991
55	54.44				2.78	0.32	5.10	1.63	1990
57	34.80	1.56	3.02	0.59	2.21	0.27	6.36	1.85	1988

59	43.54				2.47	0.29	5.66	1.73	1986
61	29.70				1.49	0.20	5.00	1.61	1984
63	27.20				1.38	0.19	5.07	1.62	1983
65	41.09	1.52	1.18	0.31	1.46	0.20	3.56	1.27	1981
67	25.47				0.97	0.16	3.79	1.33	1979
69	18.14				0.39	0.10	2.15	0.76	1978
71	15.50	1.06	0.39	0.32	0.70	0.13	4.52	1.51	1976

Sediment Accumulation Rate = 1.17 ± 0.16 cm/y

S40 Depth (cm)	% Mud	$^{226}Ra_{\gamma}$ (dpm/g)	Excess $^{210}Pb_{\gamma}$ (dpm/g)		Excess $^{210}Pb_{\alpha}$ (dpm/g)		Excess $^{210}Pb_{\alpha}$/Mud Fraction	LN (Excess $^{210}Pb_{\alpha}$/Mud Fraction)	Year
		Activity	Activity	Error (+/-)	Activity	Error (+/-)			
1	32.78	2.22	3.93	0.97	2.28	1.09	6.96	1.94	2010
3	34.72				2.13	1.00	6.13	1.81	2009
5	30.77				1.93	1.06	6.28	1.84	2007
7	32.01	2.48	3.37	0.79	1.78	0.97	5.55	1.71	2006
9	42.89				2.39	0.86	5.57	1.72	2005
11	55.51				2.54	0.69	4.58	1.52	2003
13	58.36	2.74	3.76	0.76	3.45	0.81	5.91	1.78	2002
15	74.00				4.54	0.79	6.14	1.81	2000
17	85.93				4.10	0.63	4.77	1.56	1999
19	82.75	2.01	6.12	0.90	4.14	0.66	5.00	1.61	1997
21	83.23				4.12	0.66	4.95	1.60	1996
23	83.93				3.58	0.59	4.27	1.45	1994
25	84.66	1.97	4.42	0.88	3.33	0.55	3.93	1.37	1993
27	86.46				3.47	0.56	4.01	1.39	1992
29	89.60				4.19	0.62	4.67	1.54	1990
31	86.29	2.27	5.04	1.24	4.00	0.61	4.64	1.54	1989
33	79.32				2.74	0.50	3.45	1.24	1987
35	75.86				2.68	0.55	3.54	1.26	1986
37	75.73	2.31	3.43	0.80	2.51	0.50	3.32	1.20	1984
39	73.62				2.06	0.45	2.80	1.03	1983
41	48.41				1.65	0.61	3.41	1.23	1981
43	46.57	1.99	1.40	0.60	1.53	0.61	3.29	1.19	1980
45	54.20				1.21	0.46	2.24	0.81	1979

47	33.47				0.61	0.58	1.82	0.60	1977
49	20.49	1.88	1.73	0.44	0.42	0.87	2.05	0.72	1976
51	20.69				0.00	0.68	0.00	-	
53	18.13				0.01	0.87	0.06	-2.84	
55	13.05	2.01	0.27	0.29	0.02	1.11	0.17	-1.75	

Sediment Accumulation Rate = 1.39 ± 0.12 cm/y

S9A Depth (cm)	% Mud	$^{226}Ra_{\gamma}$ (dpm/g)	Excess $^{210}Pb_{\gamma}$ (dpm/g)		Excess $^{210}Pb_{\alpha}$ (dpm/g)	
		Activity	**Activity**	**Error (+/-)**	**Activity**	**Error (+/-)**
1	15.57	0.84	0.69	0.29	0.80	0.14
3	2.38				0.08	0.09
5	0.64	0.54	0.22	0.24	0.13	0.09
7	0.19	0.46	0.01	0.12		
9	24.42	1.23	1.65	0.42	2.65	0.31
11	66.58				5.48	0.60
13	96.89	3.09	7.36	1.41	7.03	0.75
15	97.94	3.03	6.86	1.20	7.14	0.77
17	98.86				8.01	0.86
19	98.37	2.31	7.13	1.45	7.52	0.79
21	21.26	1.21	2.64	0.37	2.40	0.29
23	16.80				1.41	0.20
25	29.44	1.04	1.69	0.41	2.80	0.33
27	10.43				1.04	0.16
29	8.23	0.57	0.91	0.38	1.00	0.16

APPENDIX K. Grain size weights throughout each core by phi size from Ro-Tap method and mud weight from wet sieving method.

				Weight (g) by phi size														
				Mud		Sand										Gravel		
S43 Depth (cm)	Total Mud (g)	Total Sand (g)	Total Gravel (g)	Wet Sieving Mud (g)	>4	4 to 3.5	3.5 to 3	3 to 2.5	2.5 to 2	2 to 1.5	1.5 to 1	1 to 0.5	0.5 to 0	0 to -0.5	-0.5 to -1	-1 to -1.5	-1.5 to -2	> -2
1	1.87	0.64	0	1.87	0	0.05	0.02	0.01	0.02	0.04	0.05	0.09	0.13	0.16	0.07	0	0	0
3	5.35	0.49	0.13	5.3	0.05	0.06	0.02	0.01	0.03	0.04	0.05	0.07	0.11	0.04	0.06	0.02	0.11	0
5	1.09	0.06	0	1.09	0	0.02	0	0	0	0	0	0	0.02	0.01	0.01	0	0	0
7	4.87	0.18	0.04	4.84	0.03	0.07	0.01	0	0	0.01	0	0	0.03	0.02	0.04	0	0.04	0
9	7.83	0.2	0	7.83	0	0.08	0	0	0.02	0.03	0.02	0.03	0.01	0.01	0	0	0	0
11	7.79	0.49	0	7.77	0.02	0.11	0.03	0.02	0.03	0.06	0.08	0.04	0.04	0.04	0.04	0	0	0
13	10.16	0.26	0	10.12	0.04	0.11	0.01	0	0	0.03	0.05	0.04	0.01	0	0.01	0	0	0
15	9.7	1.36	0.01	9.65	0.05	0.16	0.05	0.05	0.27	0.29	0.31	0.09	0.05	0.07	0.02	0.01	0	0
17	6.21	0.36	0	6.18	0.03	0.12	0.03	0.02	0.03	0.03	0.05	0.04	0.02	0.02	0	0	0	0
19	8.69	0.55	0	8.65	0.04	0.15	0.05	0.03	0.03	0.04	0.08	0.07	0.03	0.03	0.04	0	0	0
21	10.81	0.56	0.02	10.75	0.06	0.19	0.04	0.03	0.04	0.04	0.07	0.06	0.03	0.03	0.03	0.02	0	0
23	7.16	0.63	0.03	7.09	0.07	0.18	0.05	0.05	0.04	0.03	0.07	0.09	0.05	0.05	0.02	0	0.03	0
25	9.67	0.55	0.07	9.64	0.03	0.15	0.04	0.02	0.02	0.05	0.08	0.1	0.04	0.03	0.02	0.01	0.06	0
27	7.3	0.45	0	7.28	0.02	0.17	0.05	0.02	0.03	0.04	0.06	0.06	0.02	0	0	0	0	0
29	8.86	0.71	0.19	8.82	0.04	0.17	0.07	0.05	0.04	0.06	0.1	0.1	0.07	0.03	0.02	0.07	0.04	0.08
31	6.51	0.59	0.13	6.45	0.06	0.17	0.07	0.04	0.05	0.04	0.07	0.05	0.04	0.02	0.04	0.04	0.07	0.02
33	7.08	0.28	0.02	7.02	0.06	0.06	0.07	0	0.02	0.03	0.04	0.04	0.01	0	0.01	0.01	0.01	0
35	9.99	0.77	0.29	9.94	0.05	0.17	0.03	0.01	0.03	0.07	0.11	0.11	0.08	0.06	0.1	0.07	0.11	0.11
37	8.23	0.94	0.08	8.18	0.05	0.25	0.09	0.04	0.02	0.07	0.13	0.16	0.07	0.06	0.05	0	0.08	0
39	8.42	0.95	0.1	8.36	0.06	0.33	0.09	0.02	0.03	0.06	0.11	0.14	0.11	0.05	0.01	0.02	0.08	0
41	6.1	1.09	0.2	6.01	0.09	0.33	0.16	0.03	0.05	0.06	0.12	0.15	0.08	0.07	0.04	0.01	0.03	0.16
43	6.59	2.1	0.27	6.52	0.07	0.45	0.24	0.09	0.11	0.27	0.29	0.25	0.16	0.05	0.19	0.14	0.13	0
45	6.48	1.66	2.04	6.4	0.08	0.41	0.22	0.08	0.1	0.11	0.15	0.22	0.14	0.07	0.16	0.11	0.11	1.82
47	2.47	0.37	0	2.47	0	0.1	0.02	0	0.01	0.01	0.05	0.1	0.07	0.01	0	0	0	0
49	8.72	1.81	0	8.65	0.07	0.49	0.31	0.08	0.07	0.14	0.2	0.24	0.17	0.08	0.03	0	0	0
51	8.56	2.69	0.05	8.49	0.07	0.56	0.4	0.08	0.2	0.46	0.26	0.36	0.22	0.11	0.04	0.05	0	0
53	10.55	2.37	0.01	10.42	0.13	1.22	0.68	0.11	0.06	0.06	0.09	0.07	0.05	0	0.03	0	0.01	0
55	10.18	8.19	0.33	9.94	0.24	1.47	1.35	0.36	0.27	0.62	1.08	1.35	0.93	0.48	0.28	0.23	0.1	0
57	7.53	13.84	0.27	7.19	0.34	1.91	2.15	0.67	0.6	1.51	2.39	2.37	1.35	0.58	0.31	0.1	0.17	0
59	5.36	5.81	1.14	5.23	0.13	1.11	0.98	0.23	0.25	0.5	0.97	1.01	0.44	0.13	0.19	0.03	0.02	1.09
61	6.65	15.54	0.2	6.34	0.31	1.74	1.86	0.46	0.43	1.31	2.73	3.4	2.24	0.95	0.42	0.09	0.11	0
63	6.92	18.13	0.39	6.56	0.36	2.41	2.01	0.5	0.43	1.24	3.19	4.36	2.36	0.6	1.03	0.23	0.04	0.12
65	12.04	16.77	0.49	11.4	0.64	3.56	2.59	0.54	0.45	1.19	2.13	2.79	2	0.99	0.53	0.35	0.14	0

67	6.75	19.36	0.39	6.39	0.36	1.99	1.6	0.4	0.41	1.61	3.4	4.49	3.09	1.51	0.86	0.34	0.05	0
69	2.15	9.4	0.3	2.02	0.13	0.8	0.52	0.03	0.19	0.86	1.54	2.28	1.84	0.87	0.47	0.25	0.05	0
71	3.49	17.47	1.56	3.28	0.21	1.17	0.81	0.15	0.27	1.14	2.89	4.22	3.28	2.13	1.41	0.7	0.86	0

				Weight (g) by phi size														
				Mud		Sand										Gravel		
S40 Depth (cm)	**Total Mud (g)**	**Total Sand (g)**	**Total Gravel (g)**	**Wet Sieving Mud (g)**	**>4**	**4 to 3.5**	**3.5 to 3**	**3 to 2.5**	**2.5 to 2**	**2 to 1.5**	**1.5 to 1**	**1 to 0.5**	**0.5 to 0**	**0 to -0.5**	**-0.5 to -1**	**-1 to -1.5**	**-1.5 to -2**	**> -2**
1	3.94	8.08	0	3.53	0.41	4.13	3.02	0.58	0.13	0.06	0.04	0.03	0.03	0.04	0.02	0	0	0
3	5.1	9.46	0.13	4.62	0.48	5	3.27	0.66	0.17	0.11	0.08	0.08	0.05	0.02	0.02	0.02	0.02	0.09
5	4.16	9.23	0.13	3.67	0.49	4.87	3.18	0.63	0.13	0.1	0.07	0.09	0.05	0.05	0.06	0.06	0.05	0.02
7	4.68	9.52	0.42	4.14	0.54	4.88	3.11	0.66	0.19	0.14	0.11	0.13	0.11	0.1	0.09	0.09	0.06	0.27
9	9.89	12.64	0.53	8.91	0.98	6.68	3.76	0.82	0.33	0.22	0.19	0.2	0.17	0.12	0.15	0.16	0.07	0.3
11	10.38	7.99	0.33	9.72	0.66	4.17	2.25	0.4	0.23	0.22	0.21	0.21	0.13	0.06	0.11	0.17	0.01	0.15
13	12.81	9.05	0.09	12.1	0.71	5.07	2.58	0.49	0.23	0.16	0.17	0.17	0.1	0.01	0.07	0.04	0.03	0.02
15	12.24	3.71	0.59	11.83	0.41	1.75	1.15	0.23	0.11	0.09	0.1	0.1	0.08	0.07	0.03	0.04	0.23	0.32
17	13.92	2.28	0	13.71	0.21	1.17	0.54	0.15	0.09	0.05	0.06	0.08	0.07	0.03	0.04	0	0	0
19	9.5	1.98	0	9.33	0.17	0.99	0.63	0.14	0.05	0.03	0.03	0.05	0.04	0.01	0.01	0	0	0
21	9.23	1.86	0	9.09	0.14	0.96	0.56	0.12	0.07	0.05	0.05	0.03	0.02	0	0	0	0	0
23	9.19	1.74	0.02	8.96	0.23	0.87	0.57	0.13	0.05	0.04	0.02	0.02	0.02	0	0.02	0.01	0.01	0
25	11.59	2	0.1	11.36	0.23	0.95	0.68	0.15	0.08	0.04	0.04	0.03	0.02	0.01	0	0	0.1	0
27	12.45	1.45	0.5	12.3	0.15	0.69	0.47	0.09	0.04	0.04	0.04	0.04	0.02	0.02	0	0	0	0.5
29	11.63	1.35	0	11.54	0.09	0.62	0.35	0.11	0.07	0.06	0.05	0.04	0.02	0.02	0.01	0	0	0
31	8.81	1.38	0.02	8.7	0.11	0.56	0.3	0.1	0.09	0.12	0.06	0.04	0.06	0.02	0.03	0.02	0	0
33	8.44	2.2	0	8.35	0.09	0.8	0.77	0.2	0.11	0.08	0.06	0.06	0.05	0.03	0.04	0	0	0
35	9.02	2.87	0	8.92	0.1	1.26	1.08	0.27	0.1	0.05	0.03	0.04	0.02	0.01	0.01	0	0	0
37	12.98	4.16	0	12.79	0.19	1.57	1.69	0.47	0.15	0.12	0.07	0.05	0.02	0.02	0	0	0	0
39	7.62	2.73	0	7.56	0.06	0.91	1.13	0.4	0.15	0.06	0.03	0.03	0.01	0.01	0	0	0	0
41	11.12	11.85	0	10.61	0.51	3.81	4.95	1.87	0.73	0.2	0.09	0.07	0.06	0.04	0.03	0	0	0
43	9.16	10.48	0.03	8.58	0.58	4.86	3.9	1.08	0.28	0.13	0.06	0.06	0.06	0.03	0.02	0	0.03	0
45	10.19	8.61	0	9.42	0.77	3.97	3.54	0.66	0.21	0.1	0.06	0.04	0.02	0.01	0	0	0	0
47	9.9	19.68	0	9.2	0.7	8.27	8.61	1.72	0.44	0.2	0.15	0.13	0.09	0.03	0.04	0	0	0
49	4.29	16.65	0	3.81	0.48	5.67	8.72	1.44	0.28	0.16	0.14	0.11	0.07	0.06	0	0	0	0
51	6.51	24.93	0.03	5.75	0.76	8.38	12.94	2.27	0.42	0.25	0.19	0.17	0.15	0.1	0.06	0	0.03	0
53	4.37	19.74	0	3.8	0.57	8.28	8.86	1.79	0.29	0.17	0.1	0.08	0.07	0.05	0.05	0	0	0
55	2.49	16.52	0.07	2.07	0.42	7.09	6.92	1.51	0.25	0.16	0.15	0.16	0.14	0.08	0.06	0.03	0.04	0

S9A Depth (cm)	Total Mud (g)	Total Sand (g)	Total Gravel (g)	Wet Sieving Mud (g)	>4	4 to 3.5	3.5 to 3	3 to 2.5	2.5 to 2	2 to 1.5	1.5 to 1	1 to 0.5	0.5 to 0	0 to -0.5	-0.5 to -1	-1 to -1.5	-1.5 to -2	> -2
					Weight (g) by phi size													
				Mud		Sand										Gravel		
1	2.49	13.5	0	2.49	0	0.01	0.02	0.11	0.6	3.26	4.44	3.29	1.27	0.41	0.09	0	0	0
3	1	40.77	0.22	0.98	0.02	0.04	0.05	0.21	1.25	6.88	10.8	10.93	6.86	2.57	1.18	0.22	0	0
5	0.33	50.68	0.95	0.31	0.02	0.01	0.01	0.21	1.05	5.48	10.52	14.62	11.37	4.92	2.49	0.84	0.11	0
7	0.08	42.49	0.49	0.06	0.02	0.01	0.05	0.19	1.07	5.36	13.82	13.93	5.27	1.26	1.53	0.35	0.14	0
9	7.97	24.14	0.53	7.91	0.06	0.07	0.11	0.22	0.5	1.7	3.88	6.93	5.88	3.11	1.74	0.38	0.15	0
11	10.34	4.86	0.33	10.32	0.02	0.09	0.12	0.19	0.36	0.92	1.03	1	0.57	0.31	0.27	0.09	0.14	0.1
13	6.24	0.2	0	6.24	0	0.01	0	0.01	0.02	0.04	0.03	0.03	0.03	0.03	0	0	0	0
15	6.67	0.14	0	6.65	0.02	0.03	0.01	0.01	0.02	0.02	0.02	0.01	0	0.01	0.01	0	0	0
17	8.68	0.1	0	8.67	0.01	0.02	0.02	0	0	0.02	0.02	0.02	0	0	0	0	0	0
19	10.23	0.17	0	10.22	0.01	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.01	0	0	0	0	0
21	4.67	16.28	1.02	4.64	0.03	0.2	0.26	0.58	1.27	2.84	2.94	2.92	2.29	1.57	1.41	0.64	0.38	0
23	4.17	18.87	1.78	4.13	0.04	0.23	0.23	0.36	1.2	2.69	3.7	3.9	2.55	1.07	2.94	1.34	0.44	0
25	5.22	11.68	0.83	5.14	0.08	0.29	0.23	0.3	0.98	1.9	2.38	2.22	1.3	0.54	1.54	0.65	0.18	0
27	3.87	29.4	3.83	3.85	0.02	0.11	0.2	0.75	2.17	5.14	5.78	5.13	3.77	3.04	3.31	2	1.83	0
29	4.26	44.88	2.63	4.23	0.03	0.16	0.44	1.32	3.97	8	11.23	9.58	4.59	1.61	3.98	1.59	0.93	0.11

APPENDIX L. Weights of gravel, sand, and mud and relative percents for each sample. Mud weights were acquired after wet sieving and drying. Gravel and sand weights were acquired after wet sieving, drying, and dry sieving (Ro-Tap method). % G+S, percent gravel and sand fraction combined. Farrell/Folk, classification of grain size based on Folk (1954), modified by Farrell and others (2012).

S43 Mid Sample Depth (cm)	Gravel Weight (g)	Sand Weight (g)	Mud Weight (g)	Total Weight (g)	% Gravel	% Sand	% G+S	% Mud	Farrell/ Folk
1	0.00	0.64	1.87	2.51	0.00	25.50	25.50	74.50	sM
3	0.13	0.49	5.35	5.97	2.18	8.21	10.39	89.61	(g)sM
5	0.00	0.06	1.09	1.15	0.00	5.22	5.22	94.78	sM
7	0.04	0.18	4.87	5.09	0.79	3.54	4.32	95.68	(s)M
9	0.00	0.20	7.83	8.03	0.00	2.49	2.49	97.51	(s)M
11	0.00	0.49	7.79	8.28	0.00	5.92	5.92	94.08	sM
13	0.00	0.26	10.16	10.42	0.00	2.50	2.50	97.50	(s)M
15	0.01	1.36	9.70	11.07	0.09	12.29	12.38	87.62	sM
17	0.00	0.36	6.21	6.57	0.00	5.48	5.48	94.52	sM
19	0.00	0.55	8.69	9.24	0.00	5.95	5.95	94.05	sM
21	0.02	0.56	10.81	11.39	0.18	4.92	5.09	94.91	(s)M
23	0.03	0.63	7.16	7.82	0.38	8.06	8.44	91.56	sM
25	0.07	0.55	9.67	10.29	0.68	5.34	6.03	93.97	sM
27	0.00	0.45	7.30	7.75	0.00	5.81	5.81	94.19	sM
29	0.19	0.71	8.86	9.76	1.95	7.27	9.22	90.78	sM
31	0.13	0.59	6.51	7.23	1.80	8.16	9.96	90.04	sM
33	0.02	0.28	7.08	7.38	0.27	3.79	4.07	95.93	(s)M
35	0.29	0.77	9.99	11.05	2.62	6.97	9.59	90.41	(g)sM
37	0.08	0.94	8.23	9.25	0.86	10.16	11.03	88.97	sM
39	0.10	0.95	8.42	9.47	1.06	10.03	11.09	88.91	sM
41	0.20	1.09	6.10	7.39	2.71	14.75	17.46	82.54	(g)sM
43	0.27	2.10	6.59	8.96	3.01	23.44	26.45	73.55	(g)sM
45	2.04	1.66	6.48	10.18	20.04	16.31	36.35	63.65	sgM
47	0.00	0.37	2.47	2.84	0.00	13.03	13.03	86.97	sM
49	0.00	1.81	8.72	10.53	0.00	17.19	17.19	82.81	sM
51	0.05	2.69	8.56	11.30	0.44	23.81	24.25	75.75	sM
53	0.01	2.37	10.55	12.93	0.08	18.33	18.41	81.59	sM
55	0.33	8.19	10.18	18.70	1.76	43.80	45.56	54.44	sM
57	0.27	13.84	7.53	21.64	1.25	63.96	65.20	34.80	mS

59	1.14	5.81	5.36	12.31	9.26	47.20	56.46	43.54	gmS
61	0.20	15.54	6.65	22.39	0.89	69.41	70.30	29.70	mS
63	0.39	18.13	6.92	25.44	1.53	71.27	72.80	27.20	mS
65	0.49	16.77	12.04	29.30	1.67	57.24	58.91	41.09	mS
67	0.39	19.36	6.75	26.50	1.47	73.06	74.53	25.47	mS
69	0.30	9.40	2.15	11.85	2.53	79.32	81.86	18.14	(g)mS
71	1.56	17.47	3.49	22.52	6.93	77.58	84.50	15.50	gmS

S40 Mid Sample Depth (cm)	**Gravel Weight (g)**	**Sand Weight (g)**	**Mud Weight (g)**	**Total Weight (g)**	**% Gravel**	**% Sand**	**% G+S**	**% Mud**	**Farrell/ Folk**
1	0.00	8.08	3.94	12.02	0.00	67.22	67.22	32.78	mS
3	0.13	9.46	5.10	14.69	0.88	64.40	65.28	34.72	mS
5	0.13	9.23	4.16	13.52	0.96	68.27	69.23	30.77	mS
7	0.42	9.52	4.68	14.62	2.87	65.12	67.99	32.01	(g)mS
9	0.53	12.64	9.89	23.06	2.30	54.81	57.11	42.89	(g)mS
11	0.33	7.99	10.38	18.70	1.76	42.73	44.49	55.51	sM
13	0.09	9.05	12.81	21.95	0.41	41.23	41.64	58.36	sM
15	0.59	3.71	12.24	16.54	3.57	22.43	26.00	74.00	(g)sM
17	0.00	2.28	13.92	16.20	0.00	14.07	14.07	85.93	sM
19	0.00	1.98	9.50	11.48	0.00	17.25	17.25	82.75	sM
21	0.00	1.86	9.23	11.09	0.00	16.77	16.77	83.23	sM
23	0.02	1.74	9.19	10.95	0.18	15.89	16.07	83.93	sM
25	0.10	2.00	11.59	13.69	0.73	14.61	15.34	84.66	sM
27	0.50	1.45	12.45	14.40	3.47	10.07	13.54	86.46	(g)sM
29	0.00	1.35	11.63	12.98	0.00	10.40	10.40	89.60	sM
31	0.02	1.38	8.81	10.21	0.20	13.52	13.71	86.29	sM
33	0.00	2.20	8.44	10.64	0.00	20.68	20.68	79.32	sM
35	0.00	2.87	9.02	11.89	0.00	24.14	24.14	75.86	sM
37	0.00	4.16	12.98	17.14	0.00	24.27	24.27	75.73	sM
39	0.00	2.73	7.62	10.35	0.00	26.38	26.38	73.62	sM
41	0.00	11.85	11.12	22.97	0.00	51.59	51.59	48.41	mS
43	0.03	10.48	9.16	19.67	0.15	53.28	53.43	46.57	mS
45	0.00	8.61	10.19	18.80	0.00	45.80	45.80	54.20	sM
47	0.00	19.68	9.90	29.58	0.00	66.53	66.53	33.47	mS

49	0.00	16.65	4.29	20.94	0.00	79.51	79.51	20.49	mS
51	0.03	24.93	6.51	31.47	0.10	79.22	79.31	20.69	mS
53	0.00	19.74	4.37	24.11	0.00	81.87	81.87	18.13	mS
55	0.07	16.52	2.49	19.08	0.37	86.58	86.95	13.05	mS

S9A Mid Sample Depth (cm)	**Gravel Weight (g)**	**Sand Weight (g)**	**Mud Weight (g)**	**Total Weight (g)**	**% Gravel**	**% Sand**	**% G+S**	**% Mud**	**Farrell/ Folk**
1	0.00	13.50	2.49	15.99	0.00	84.43	84.43	15.57	mS
3	0.22	40.77	1.00	41.99	0.52	97.09	97.62	2.38	(m)S
5	0.95	50.68	0.33	51.96	1.83	97.54	99.36	0.64	S
7	0.49	42.49	0.08	43.06	1.14	98.68	99.81	0.19	S
9	0.53	24.14	7.97	32.64	1.62	73.96	75.58	24.42	mS
11	0.33	4.86	10.34	15.53	2.12	31.29	33.42	66.58	(g)sM
13	0.00	0.20	6.24	6.44	0.00	3.11	3.11	96.89	(s)M
15	0.00	0.14	6.67	6.81	0.00	2.06	2.06	97.94	(s)M
17	0.00	0.10	8.68	8.78	0.00	1.14	1.14	98.86	M
19	0.00	0.17	10.23	10.40	0.00	1.63	1.63	98.37	M
21	1.02	16.28	4.67	21.97	4.64	74.10	78.74	21.26	(g)mS
23	1.78	18.87	4.17	24.82	7.17	76.03	83.20	16.80	gmS
25	0.83	11.68	5.22	17.73	4.68	65.88	70.56	29.44	(g)mS
27	3.83	29.40	3.87	37.10	10.32	79.25	89.57	10.43	gmS
29	2.63	44.88	4.26	51.77	5.08	86.69	91.77	8.23	gmS

APPENDIX M. Percent LOI and minimum and maximum amounts of sediment required for isotopic analysis.

S43 Depth (cm)	Initial Mass (g)	Final Mass (g)	LOI %	Min. Sed. (g)	Max. Sed. (g)
1	1.042	0.931	10.650	0.019	0.028
3	1.062	0.925	12.972	0.015	0.023
5	2.451	2.159	11.912	0.017	0.025
7	2.039	1.830	10.256	0.020	0.029
9	2.286	2.015	11.876	0.017	0.025
11	2.271	1.995	12.134	0.016	0.025
13	2.378	2.071	12.938	0.015	0.023
15	2.388	2.087	12.601	0.016	0.024
17	2.179	1.909	12.413	0.016	0.024
19	2.642	2.361	10.647	0.019	0.028
21	2.255	2.038	9.618	0.021	0.031
23	2.226	1.998	10.238	0.020	0.029
25	2.101	1.855	11.741	0.017	0.026
27	2.257	2.007	11.089	0.018	0.027
29	2.035	1.810	11.067	0.018	0.027
31	2.305	2.014	12.626	0.016	0.024
33	2.446	2.152	12.010	0.017	0.025
35	2.668	2.395	10.246	0.020	0.029
37	2.450	2.177	11.108	0.018	0.027
39	2.555	2.312	9.504	0.021	0.032
41	2.300	2.065	10.235	0.020	0.029
43	2.402	2.173	9.507	0.021	0.032
45	2.073	1.894	8.662	0.023	0.035
47	2.586	2.344	9.355	0.021	0.032
49	2.313	2.078	10.165	0.020	0.030
51	2.274	2.026	10.895	0.018	0.028
53	2.475	2.252	8.999	0.022	0.033
55	2.924	2.723	6.851	0.029	0.044
57	2.667	2.498	6.362	0.031	0.047
59	2.784	2.632	5.474	0.037	0.055
61	3.044	2.896	4.875	0.041	0.062
63	3.828	3.689	3.652	0.055	0.082
65	2.708	2.595	4.180	0.048	0.072
67	3.118	3.018	3.236	0.062	0.093
69	3.700	3.607	2.497	0.080	0.120
71	3.872	3.802	1.785	0.112	0.168

S40 Depth (cm)	Initial Mass (g)	Final Mass (g)	LOI %	Min. Sed. (g)	Max. Sed. (g)
1	2.911	2.726	6.358	0.031	0.047
3	2.771	2.583	6.798	0.029	0.044
5	2.927	2.717	7.158	0.028	0.042
7	2.719	2.554	6.051	0.033	0.050
9	2.942	2.708	7.938	0.025	0.038
11	2.585	2.390	7.543	0.027	0.040
13	2.640	2.436	7.736	0.026	0.039
15	2.475	2.267	8.377	0.024	0.036
17	2.841	2.574	9.371	0.021	0.032
19	2.520	2.269	9.967	0.020	0.030
21	2.808	2.566	8.625	0.023	0.035
23	3.011	2.752	8.611	0.023	0.035
25	3.217	2.935	8.760	0.023	0.034
27	2.837	2.585	8.879	0.023	0.034
29	2.912	2.650	8.988	0.022	0.033
31	2.572	2.362	8.170	0.024	0.037
33	2.249	2.077	7.640	0.026	0.039
35	2.046	1.874	8.396	0.024	0.036
37	2.062	1.890	8.341	0.024	0.036
39	1.419	1.306	7.938	0.025	0.038
41	2.581	2.411	6.595	0.030	0.045
43	2.301	2.170	5.714	0.035	0.053
45	2.104	1.966	6.536	0.031	0.046
47	2.912	2.749	5.605	0.036	0.054
49	3.533	3.393	3.977	0.050	0.075
51	3.134	3.030	3.303	0.061	0.091
53	2.831	2.739	3.239	0.062	0.093
55	2.914	2.807	3.692	0.054	0.081

S9A Depth (cm)	Initial Mass (g)	Final Mass (g)	LOI %	Min. Sed. (g)	Max. Sed. (g)
1	2.535	2.468	2.658	0.075	0.113
3	2.057	2.042	0.690	0.290	0.434
5	3.361	3.348	0.393	0.509	0.764
7	3.581	3.566	0.408	0.491	0.736
9	3.579	3.513	1.852	0.108	0.162
11	2.639	2.357	10.690	0.019	0.028
13	2.095	1.828	12.732	0.016	0.024
15	2.156	1.861	13.699	0.015	0.022
17	2.620	2.250	14.133	0.014	0.021
19	2.379	2.049	13.871	0.014	0.022
21	3.603	3.445	4.372	0.046	0.069
23	3.781	3.717	1.700	0.118	0.176
25	4.129	3.945	4.466	0.045	0.067
27	3.697	3.605	2.488	0.080	0.121
29	3.908	3.837	1.832	0.109	0.164

APPENDIX N. Carbon and nitrogen isotopic results. Shaded values indicate results with low precision due to low carbon and/or nitrogen content or small sample size.

S43 Sample Depth (cm)	$\delta^{13}C$	$\delta^{15}N$	%C	%N	C:N
1	-25.21	-0.22	2.09	0.71	3.41
3	-25.53	0.22	2.79	0.67	4.84
5	-21.36	4.36	3.91	1.35	3.38
7	-25.24	0.09	2.77	0.75	4.32
9	-25.52	0.27	2.79	0.61	5.30
11	-25.46	-0.02	2.76	0.80	4.02
13	-25.79	0.02	2.85	0.82	4.04
15	-25.55	0.39	2.66	0.54	5.73
17	-25.38	0.14	2.58	0.70	4.30
19	-25.28	0.37	2.42	0.60	4.66
21	-25.17	0.51	2.48	0.61	4.71
23	-25.05	0.50	2.61	0.58	5.28
25	-25.62	0.11	2.70	0.72	4.38
27	-25.03	0.23	2.77	0.66	4.92
29	-25.45	0.82	2.69	0.53	5.93
31	-25.09	0.58	2.85	0.70	4.78
33	-25.19	0.28	2.68	0.71	4.40
35	-25.11	0.21	2.70	0.67	4.71
37	-25.13	1.03	2.62	0.51	5.94
39	-25.23	0.64	2.50	0.46	6.28
41	-24.80	0.39	2.63	0.76	4.01
43	-25.03	0.85	2.37	0.47	5.89
45	-25.06	0.05	2.05	0.57	4.21
47	-24.95	-0.27	2.29	0.60	4.43
49	-25.01	0.05	2.44	0.44	6.43
51	-25.23	0.02	2.43	0.54	5.21
53	-25.36	-0.12	2.33	0.72	3.77
55	-25.32	-0.12	1.52	0.43	4.15
57	-25.68	-0.16	1.24	0.35	4.14
59	-25.59	0.17	1.56	0.30	6.05
61	-25.55	-0.16	1.28	0.31	4.73
63	-25.50	0.69	0.90	0.17	6.09
65	-25.05	0.10	0.95	0.23	4.89
67	-24.88	0.19	0.59	0.15	4.64
69	-24.89	0.20	0.57	0.15	4.47
71	-24.89	-0.05	0.47	0.12	4.40

S40 Sample Depth (cm)	$\delta^{13}C$	$\delta^{15}N$	%C	%N	C:N
1	-26.37	0.39	1.65	0.32	5.98
3	-26.44	-0.26	1.53	0.37	4.82
5	-26.55	-0.29	1.46	0.39	4.33
7	-26.33	-0.24	1.31	0.30	5.12
9	-26.08	-0.20	1.68	0.47	4.15
11	-26.37	0.45	1.95	0.37	6.20
13	-25.39	0.11	1.88	0.54	4.05
15	-25.62	-0.30	2.14	0.50	4.97
17	-25.64	-0.28	2.45	0.63	4.50
19	-25.12	-0.14	2.35	0.59	4.67
21	-25.42	-0.08	2.26	0.49	5.42
23	-25.53	-0.35	2.09	0.58	4.22
25	-25.28	0.23	2.02	0.41	5.80
27	-25.39	0.15	2.18	0.51	4.94
29	-25.46	-0.18	2.04	0.50	4.79
31	-25.46	-0.38	1.97	0.45	5.08
33	-25.35	2.42	1.93	0.19	11.56
35	-25.49	2.14	2.08	0.23	10.65
37	-25.20	2.68	1.96	0.19	11.73
39	-25.31	3.44	1.80	0.15	14.42
41	-25.73	2.75	1.39	0.13	12.71
43	-25.54	2.30	1.22	0.13	10.75
45	-25.42	3.57	1.27	0.11	13.23
47	-25.43	2.40	0.95	0.10	11.33
49	-26.06	3.41	0.84	0.08	12.54
51	-25.42	1.52	0.44	0.06	8.04
53	-26.92	1.81	0.95	0.08	14.46
55	-24.94	2.59	0.58	0.07	9.65

S9A Sample Depth (cm)	$\delta^{13}C$	$\delta^{15}N$	%C	%N	C:N
1	-28.38	0.75	0.66	0.12	6.35
3	-28.15	0.11	0.09	0.03	3.01
5	-28.04	-0.47	0.04	0.03	1.60
7	-28.00	-0.05	0.05	0.03	1.87
9	-28.42	0.76	0.59	0.10	6.70
11	-28.43	-0.16	2.52	0.74	3.95
13	-28.45	-0.05	2.75	0.66	4.87
15	-28.77	-0.20	3.09	0.68	5.34
17	-28.74	-0.34	2.90	0.65	5.23
19	-28.81	1.09	3.40	0.48	8.19
21	-29.16	-0.34	1.03	0.22	5.49
23	-29.32	-0.31	0.58	0.11	6.27
25	-29.18	0.24	1.56	0.30	6.09
27	-28.04	0.22	0.70	0.17	4.84
29	-28.30	0.27	0.41	0.11	4.24

Fish Food	$\delta^{13}C$	$\delta^{15}N$	%C	%N	C:N
Fish Pellet 1	-22.4	5.81	33.2	5.41	6.13
Fish Pellet 2	-22.4	5.84	43.2	7.02	6.15
Fish Head 1	-18.7	11.09	27.1	7.10	3.81
Fish Head 2	-17.8	11.71	25.6	6.49	3.94