THE INFLUENCE OF AQUACULTURE ON FORAMINIFERA AND SEDIMENT PROPERTIES IN THE SETIU ESTUARY AND LAGOON OF TERENGGANU, MALAYSIA

By

Alisha Ellis

March, 2013

Director of Thesis: Dr. Stephen J. Culver

Major Department: Geological Sciences

In order to address how aquaculture has influenced the Setiu estuary and lagoon of northeast peninsular Malaysia, foraminifera, sediment grain-size, and carbon and nitrogen isotope ratios and abundances were analyzed in surface samples collected from beneath and around three floating fish cage complexes. Two currently active floating fish cage complexes, SET11-S43 and SET11-S40, in the Setiu lagoon, within four km of an inlet (salinity in the 20s), have mixed agglutinated and calcareous foraminiferal assemblages, generally dominated by *Ammonia* aff. *A. aoteana* and *Ammobaculites exiguus*. The majority of live foraminifera at these sites are agglutinated species; percent of live specimens is greater around the SET11-S43 fish cage complex, likely related to the presence of aquaculture-related organic rich mud. Percent agglutinated specimens decreases towards the inlet as density and diversity increase as a function of salinity. At an abandoned fish cage complex, SET11-S9A, located in a low salinity (<5) estuarine setting, *Miliammina fusca* and *Ammobaculites exiguus* dominate entirely agglutinated assemblages; there is no evidence of fish farm influence in surficial sediments. Side scan sonar data as well as grain-size analysis of surface sediment samples indicate that a muddy substrate extends up to tens of meters to the north of the lagoonal fish cage complexes with a surrounding

sandier substrate, typical of most of the Setiu estuary and lagoon system. The percent carbon and nitrogen in sediment exhibit distributional patterns that strongly correlate with the distribution of fish cage mud. Greater concentrations of mud, carbon, and nitrogen in sediment are found to the north of the active fish cage complexes, SET11-S43 and SET11-S40, than to the south. The $\delta^{13}C$ and $\delta^{15}N$ signatures of the sediment are attributed to organic matter input from the surrounding mangrove forest while their distribution is a result of tidal currents, water depth, and the presence of the fish farm complexes. Since the abandonment of the SET11-S9A fish cage complex, sediment distribution and foraminiferal assemblages surrounding the complex are indistinguishable from the surrounding estuary. The influence of the active fish cages at SET11-S40 is minimal as a result of tidal currents and mixing although environmental effects are evident further north at the SET11-S43 fish cage complex which receives less marine influence.

THE INFLUENCE OF AQUACULTURE ON FORAMINIFERA AND SEDIMENT PROPERTIES IN THE SETIU ESTUARY AND LAGOON OF TERENGGANU, MALAYSIA

A Thesis

Presented to the Faculty of the Department of Geological Sciences

East Carolina University

In Partial Fulfillment of the Requirements for the Degree of

Master of Science in Geology

By

Alisha M. Ellis

May, 2013

B.S. East Carolina University

Greenville, NC

The Influence of Aquaculture on Foraminifera and Sediment Properties in the Setiu Estuary and Lagoon of Terengganu, Malaysia

By

Alisha M. Ellis

Approved By:

Director of Thesis____

Dr. Stephen J. Culver

Committee Member ____

Dr. D. Reide Corbett

Committee Member____

Dr. David J. Mallinson

External Committee Member____

Dr. Martin A. Buzas

Department of Geological Sciences Chair______________________________________

Dr. Stephen J. Culver

Dean of the Graduate School______________________________________

Dr. Paul Gemperline

Acknowledgements

I would like to thank my advisor, Dr. Stephen Culver, for the countless hours of help on everything from planning this project to foraminiferal identifications and writing. I would also like to thank my other committee members including Dr. David Mallinson, Dr. Reide Corbett, and Dr. Martin Buzas for helping me analyze and interpret my data as well as editing my writing. Dr. Eduardo Leorri, despite not being on my committee, helped with statistical analyses and provided a support system for me. For that I am grateful. John Woods and Jim Watson, thank you for everything from helping me to always have a working computer and for being supportive and friendly upon every encounter. Megan Javonovich and Jaimi Flynn helped with some foraminiferal lab work, saving me time and energy. My friend and colleague, Hanna Thornberg, has been one of the most influential, helpful, supportive, and friendly people I have ever met and I am glad I was able to work so closely with her for the last two years. Dr. Noor Shazili at Universiti Malaysia Terengganu, was essential in the planning and sample collection for this thesis. This project was co-funded by East Carolina University and Universiti Malaysia Terengganu and without that funding, this project would not have been possible. I would also like to thank Dr. Mohd Lokman Husain, Director of the Institute of Oceanography at Universiti Malaysia Terengganu for all of the help we received as well as for all of the hospitality. Finally, I would like to thank my parents, Rick and Lauren Ellis, for always being there to vent to, to bounce ideas off, and to give me a helping hand whenever I needed it.

TABLE OF CONTENTS

List of Figures

List of Formulas and Tables

INTRODUCTION

Fluctuations in foraminiferal populations (e.g., Alve, 1991, 1995; Culver and Buzas, 1995; Martin 2000; Scott et al., 2001; Cearreta et al., 2002) along with sediment grain-size and stable carbon and nitrogen isotope ratios are proven indicators of environmental stress and change (Thornton and McManus, 1994; Maksymowska et al., 2000; Corbett et al., 2006). Foraminifera in coastal environments, particularly estuaries and lagoons, are good indicators of salinity (Parker, 1952; Nichols, 1974) and pH (Debenay et al., 1998, 2002; Debenay and Guiral, 2006). Geochemical analysis of carbon and nitrogen through the use of δ^{13}C and δ^{15}N in sediment indicate the source of the organic material present (Hood, 1970; Yokoyama et al., 2006). Similarly, analysis of sediment grain-size paired with side scan sonar images indicate grain-size distribution patterns and can help explain distributional patterns of δ^{13}C, δ^{15}N, and foraminifera. Through interpretation of the aforementioned proxies, a clearer understanding of how coastal environments are impacted by aquaculture can be established.

The Setiu wetland, part of the Setiu-Chalok-Bari-Merang wetland system of Terengganu, Malaysia, is located along the northeast coast of Malaysia, and is connected to the South China Sea by a small inlet through a narrow barrier island system (Figure 1). A mixed-mangrove forest dominated by *Nypa fruticans*, *Avicennia alba*, and *Rhizophora apiculata*, covers the back-barrier island and mainland coasts of the estuary and lagoon. The Setiu estuary and lagoon (SEL) is a conservation site under the World Wildlife Fund for Nature-Malaysia (WWF-Malaysia).

The Setiu wetland, despite its status as a conservation site, is being threatened by anthropogenic impact. Approximately 1.6 km inland from the SEL is a large, 40 km^2, palm oil plantation with canals emptying into the Setiu lagoon, likely transporting fertilizers (Figure 2). Mangrove forests have been cleared for the construction of fish cages and shrimp pens. Floating fish cage complexes, established in the 1970s, are located in the lagoon 1.5 to 3 km north of the inlet. Smaller fish cage complexes are located around the perimeter of the estuary. The number of floating fish cages in the SEL is increasing as aquaculture becomes progressively more important to the local economy. As a result of these fish farms, nutrients, antibiotics, fish food, and waste are being emptied into the wetland system, potentially stressing the environment. Several studies of fish farms elsewhere have indicated the environmental stress that can result from aquaculture (Gowen and Bradbury, 1987; Holmer and Kristensen, 1992; Ackefors and Enell, 1994; Wu, 1995; Axler et al., 1996; Kelly et al., 1996; Holmer et al., 2002; Carroll et al., 2003; Holmer et al., 2007).

The objective of this study is to determine, through the use of several proxies (grain-size analysis, carbon and nitrogen analysis, and foraminiferal analysis, and the known distribution of benthic foraminifera in the SEL system (Culver et al., 2012)), whether fish farms have affected benthic foraminiferal populations and sediment characteristics in the estuary and lagoon directly underneath and surrounding the fish cage complexes.

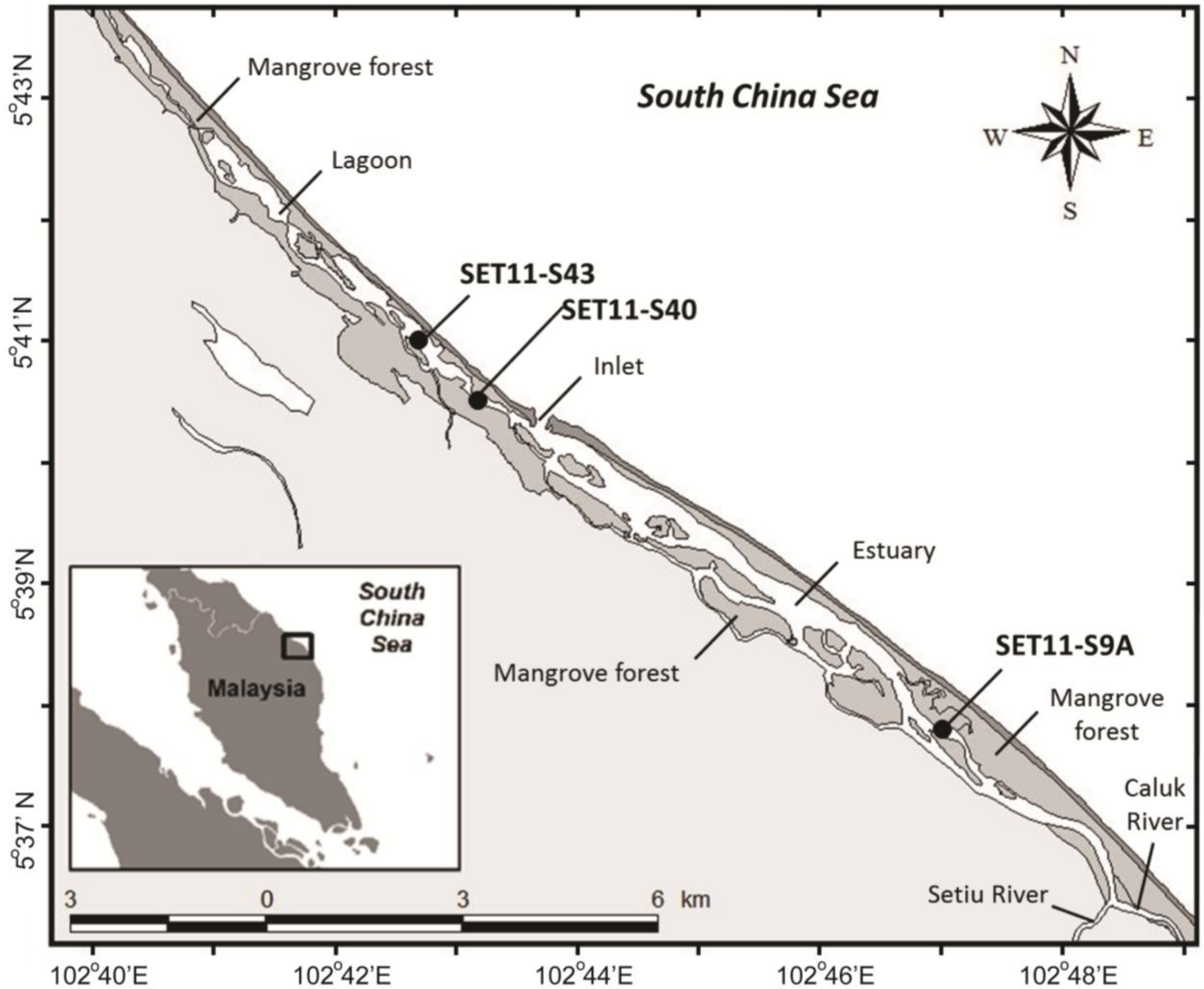


Figure 1: Location map of the Setiu estuary and lagoon and three floating fish cage complexes. Dark gray shading indicates the location of the sandy barrier island and medium gray shading indicates mangrove forest vegetation.

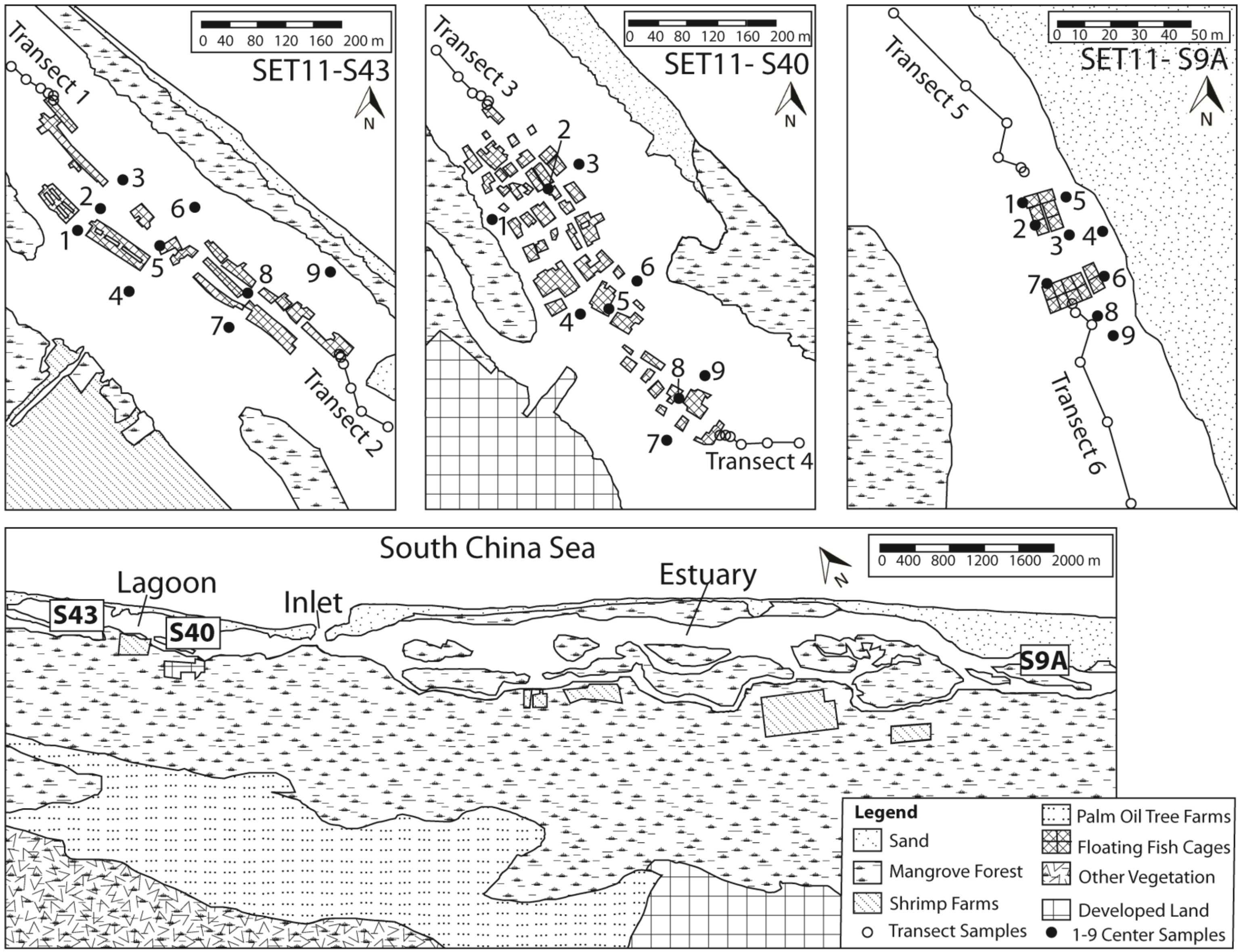


Figure 2: Detailed maps of the three fish cage complexes in the Setiu estuary and lagoon indicating all sample locations.

ENVIRONMENTAL SETTING

The Setiu estuary and lagoon are located in the state of Terengganu, peninsular Malaysia. The SEL system is 21 km long and is characterized by a narrow (~50 m), low elevation barrier island with only one, small, 300 meter-wide inlet connecting the system to the South China Sea (Figures 1, 2). A second inlet was present about 4 km south of the current inlet and closed naturally in 2003. The mean spring tidal range along the Terengganu coast is 1.8 m and does not exceed 2 m Phillips (1985). Spring tides can flood in six to eight hours and take up to 18 hours to ebb. In contrast neap tides can remain low and slack for 14 to 18 hours (Phillips, 1985). A nearshore surface current flows generally parallel to the coastline and is dictated by wind patterns; during the northeast monsoon season (November–March) the current flows southward whereas during the southwest monsoon season (May–August) it flows to the north (Yaacob et al., 1995; Yaacob and Husain, 2005; Yaacob and Mustapa, 2010).

Within the Setiu estuary, south of the inlet, the water depth ranges from approximately 1.5 to 3.0 m; the estuary is floored primarily by medium- to coarse-grained sand (Culver et al., 2012). Emptying into the estuary from the south and southwest are the Caluk and Setiu Rivers, respectively (Figure 1). Salinity at the inlet is 32 to 33 (Culver et al., 2012). Discharge is amplified during the northeast monsoon season, resulting in salinity decreasing from 29 near the inlet to zero where the rivers enter the estuary (Yaacob et al., 1995; Culver et al., 2012).

In the lagoon, the salinity is considerably higher (18 to 32; Culver et al., 2012) than in the estuary as it has much less fluvial input, salinity decreases northwards in the lagoon (Culver et al., 2012). In June 2009 dissolved oxygen values were greatest near the inlet (~7 mg/L) and lowest near a floating fish cage complex and the mangrove forest (Culver et al., 2012).The Setiu lagoon is slightly shallower than the estuary with depths ranging from 0.5–2.5 m and its floor consists of poorly to moderately sorted very fine-grained muddy sand to gravelly coarse-grained sand (Yaacob and Mustapa, 2010; Culver et al., 2012). The differences in grain-size between the estuary and lagoon are likely the result of hydraulic energy levels with the current speeds greater in the estuary compared to the lagoon (Yaacob, 1988).

PREVIOUS WORK/ BACKGROUND

In southeast Asia, seabass (*Lates calcarifer*) fish farms are increasingly abundant. Malaysia is one of the largest producers of cultured fish, particularly seabass and grouper (*Ephinephelus* spp.) in southeast Asia (Rimmer and Russell, 1998; Alongi et al, 2003; World Wildlife Fund for Nature-Malaysia). Fish cage farming in peninsular Malaysia is growing nearly six times faster than shrimp farming and is as productive as pond farming (Alongi et al., 2003). In restricted environments such as estuaries and lagoons, the risk of nutrient accumulation, which can cause hypernutrification, increases (Midlen and Redding, 1998). A study by Holmer et al. (2002) indicated that a one to two month abandonment period of juvenile milkfish pens in the Philippines allowed for much of the liable organic matter to be removed. Carroll (2003), investigating the effects of salmon farming in Norway, confirmed that one of the best management tools for sustainable fish farming is the practice of periodic abandonment of fish farm sites in order to allow for recovery. The length of abandonment is dependent upon many factors including but not limited to: temperature, depth, bottom topography, feeding rates, length of operation, sedimentation rates, current strength, and whether the fish farms are located in restricted flow or an open water environment (Carroll, 2003). Previous foraminiferal, geochemical, and sedimentological research in the Setiu wetland system suggests that aquacultural operations might be causing stress on the environment (Culver et al., 2012).

FORAMINIFERA

Foraminifera are valuable indicators of natural and anthropogenic environmental stress (e.g., Alve, 1991, 1995; Culver and Buzas, 1995; Schafer et al., 1995; Yanko et al., 1999;

Martin, 2000; Scott et al., 2001; Cearreta et al., 2002; Scott et al., 2005; Alve et al., 2009; Debenay and Fernandez, 2009). Populations are not only affected by aquacultural operations but foraminifera can also document pre-pollution conditions and be utilized for future environmental monitoring (e.g., Clark, 1971; Grant et al., 1995; Schafer et al., 1995; Scott et al., 1995; Angel et al., 2000; Hallock et al., 2003; Luan and Debenay, 2005; Tarasova, 2006; Tarasova and Preobrazhenskaya, 2007; Debenay et al., 2009a,b). Benthic foraminifera are a preferred proxy for pollution due to their small size and typically high abundance, high diversity, and good preservation potential (Alve, 1991; Grant et al., 1995; Scott et al., 1995; Bresler and Yanko, 1995; Angel et al., 2000).

A review paper on benthic foraminiferal responses to estuarine pollution by Alve (1995) noted that a gross enrichment of organic compounds from agriculture and aquaculture may eliminate the local benthic community, whereas a slight enrichment may stimulate the growth of benthic populations by as much as several orders of magnitude greater than the surrounding areas unaffected by the organic enrichment. If pollution input increases gradually, populations of the more tolerant species will increase at the expense of the less tolerant taxa until the most tolerant or opportunistic species take over, corresponding in a reduced number of species (e.g., Resig, 1960; Watkins, 1961; Bandy et al., 1964a, 1965; Clark, 1971; Schafer, 1973; Schafer and Cole, 1974; Bates and Spencer, 1979; Hayek and Buzas, 2006). When enrichment of organic compounds and other pollutants are introduced relatively abruptly to a moderately closed system, a decrease in number of live taxa, in relation to the surrounding area, may be seen followed by a collapse of the community (Bandy et al., 1964b; Buckley et al., 1974; Schafer and Cole, 1974; Pearson and Rosenberg, 1978; Angel et al., 2000; Hayek and Buzas, 2006). A change in foraminiferal density, diversity, or assemblage may be an indicator of a reaction to aquacultural practices (e.g., Schafer et al., 1995; Angel et al., 2000; Luan and Debenay, 2005; Hayek and Buzas, 2006; Tarasova and Preobrazhenskaya, 2007). Brown et al. (1987) found that effects are usually localized and do not exceed beyond 25 to 120 m from fish cages. Angel et al. (2000) observed that foraminiferal abundances, total and stained (live), generally decline directly below the fish cages in the Gulf of Eilat compared with more distant sample locations up to 100 m away.

CARBON AND NITROGEN

The values of $\delta^{13}C$, $\delta^{15}N$, and C:N ratios allows for the delineation of different sources of organic matter, terrestrial or marine (Matson and Brinson, 1990). Terrestrial C_3 plants make up approximately 90% of all plants (including algae, autotrophic bacteria, and cultivated plants like rice and wheat) and have a depleted (low) carbon isotope ratio due to the preferential intake of ^{12}C to ^{13}C (with a mean $\delta^{13}C$ value of -28‰ and a range generally between -23‰ to -30‰; Fry and Sherr, 1984; Peterson and Fry, 1987, Sampaio et al., 2010) for photosynthesis. C_3 plants have a more depleted carbon isotope ratio than C_4 plants whose $\delta^{13}C$ value averages -13.46‰ +/- 1.55‰ (Waller and Lewis, 1979), thus making the use of carbon isotopes a reliable method for differentiating between C_3 and C_4 plants (Bender, 1971). As $\delta^{13}C$ becomes more negative, it is more depleted in ^{13}C compared with ^{12}C, which diffuses quicker into plants due to weaker, covalent C=O bonds making it easier to form phosphoglyceric acid (Faure, 1991). An increased marine influence will cause $\delta^{13}C$ values to become less negative or heavier (Sackett, 1964; Shultz and Calder, 1976; Sherr, 1982; Matson et al., 1983; Matson and Brinson, 1990; Thornton and McManus, 1994; Bratton et al., 2003) with marine $\delta^{13}C$ ranging from -18‰ to -24‰ (Fry and Sherr, 1984; Tucker et al., 1999; Sampaio et al., 2010).

Marine $\delta^{15}N$ values are generally greater and range between 4‰ and 9‰ (Fry and Sherr, 1984; Tucker et al., 1999; Sampaio et al., 2010) while terrestrial $\delta^{15}N$ values averages about 2‰ to 5‰ (Sweeney and Kaplan, 1980; Owens, 1987; Maksymowska et al., 2000). Anthropogenic inputs of nitrate (NO_3) in water, particularly from fertilizers at agricultural sites, tend to result in discernible changes to the nitrogen isotopic values (increased $\delta^{15}N$ values) of the organic matter in the ecosystem (Heaton, 1986; Thornton and McManus, 1994; Harrington et al., 1998; Kuramoto and Minagawa, 2001; Corbett et al., 2007) causing eutrophication in estuaries. Relatively high $\delta^{15}N$ values may also be a result of decomposition and denitrification of mangrove plant materials; ^{14}N denitrifies faster than ^{15}N leaving soils more enriched in ^{15}N.

Generally, high C:N ratios (~10:1 and greater) indicate terrestrial organic matter while smaller or lighter C:N ratios (~6.6:1) indicate a marine influence (Thornton and McManus, 1994; Maksymowska et al., 2000; Yamamuro, 2000) as the amount of carbon decreases and the amount of nitrogen increases. The amount of nitrogen increases in marine waters compared with terrestrial waters since the amount nitrogen produced by plants is less than biologically produced nitrogen (Thornton and McManus, 1994). Small C:N ratios could also indicate nitrogen loading/contamination.

Sediments collected from beneath and around fish cages and pens have been characterized by high organic matter content (Hall et al., 1990; Hargrave et al., 1993; Holmer and Kristensen, 1992, 1996; Holmer et al., 2002, 2003, 2007; Alongi et al., 2003; Carroll et al., 2003). Yokoyama et al. (2006) used TOC (total organic carbon), TN (total nitrogen), $\delta^{13}C$, $\delta^{15}N$, and C:N ratios of fish foods and their constituents, fish feces, sediment samples, and marine particulate organic matter values to investigate both the degree and extent of impacts from fish-farms in Gokasho Bay, Japan. The $\delta^{13}C$ and $\delta^{15}N$ values for the six samples of pellet feed were -

20.3 +/- 0.3‰ and 9.1+/- 1.2‰, respectively, while the mean $\delta^{13}C$ and $\delta^{15}N$ values for fish feces were -24.7 +/- 0.1‰ and 5.6 +/- 0.3‰, respectively. Elevated $\delta^{15}N$ values near the cages may be the result of an accumulation of fish food or a result of denitrification as a result of decomposition of fish food. They concluded that the effects of the fish farms extended up to 300 m from fish cages.

SEDIMENT DISTRIBUTION

Tropical mangrove swamps, like those surrounding the Setiu estuary and lagoon, often have high production rates resulting in high sedimentation rates and consequently a rapid accumulation of organic carbon depleted in ^{13}C in the surrounding areas (Kuramoto and Minagawa, 2001). Seagrasses can increase sediment deposition and burial by hindering wave and current velocities (Gacia et al., 2002). Seagrass decline has been identified around fish farms as a result of organic enrichment in sediments (Delgado et al., 1997; Holmer et al., 2003; Marbá et al., 2006). Sediment accumulation rates beneath and surrounding floating fish cages are dependent on many factors such as water depth, bottom topography, variations in settling velocity, variations in current speed and direction, cage coverage, and the surrounding vegetation (Brown et al., 1987; Hevia et al., 1996). Holmer et al., (2007) found that sedimentation rates below fish cages in the Mediterranean Sea were greater than for the surrounding area but decreased rapidly with increased distance (5–40 m) from the farms and that some seagrass sediments were enriched in carbon and nitrogen. The presence of "fish farm sediment" (Hall et al., 1990; Karakassis, et al., 1998), described as "loose and flocculent black sediment" related to fish food input has been reported below fish farm cages (Hall et al., 1990; Angel et al., 1995; Grant et al., 1995; Scott et al., 1995; Karakassis et al., 1998).

METHODS

SAMPLING SITES

Sampling sites were chosen to provide a contrast between active, lagoonal fish farm complexes and an abandoned estuarine complex. Fish cage complexes in the Setiu lagoon are concentrated in two areas (Figure 2), SET11-S43 and SET11-S40. These active fish cage complexes have about four hundred fish cages, each of which is approximately 3.6 m^2 and holds up to 500 fish. Fish cage complexes are less abundant in the Setiu estuary. To provide a contrast with the lagoon, a single abandoned fish cage complex, SET11-S9A, was selected in the estuary, (Figure 2). Although salinity does vary throughout the year, the inlet-influenced Setiu lagoon has higher salinity than the river-dominated estuary. In June 2009 and 2011, the salinity at the SET11-S43 and SET11-S40 fish cage complexes was in the mid to upper 20s whereas at SET11-S9A it was about 1 (Culver et al., 2012).

SAMPLE COLLECTION

At each fish cage complex a sampling scheme was designed to determine the extent of environmental impact around and within the fish cage complexes. Ponar grab samples of surface sediment were taken along transects extending from the northernmost and southernmost ends of each fish cage complex (i.e., along the axis of the Setiu estuary and lagoon, the direction of the tidal current flow). The top 1 cm of sediment was sampled from each ponar grab. Six grab samples were collected along each transect at distances of 0 m, 5 m, 15 m, 30 m, 60 m and 100 m from the outer, northern and southern margins of the fish cage complexes. These samples are referred to as transect and number-distance in meters (e.g., T1-100, T3-30). In addition, at each fish cage complex, nine ponar grab samples were collected within and surrounding the cages in three transects approximately perpendicular to the transects extending along the lagoon/estuary axis. Thus, a total of 21 sediment samples were collected at each fish cage complex. Latitude and longitude, salinity, dissolved oxygen, pH, and depth were recorded at each sample location at the time of collection.

Surface sediment samples were subdivided as follows: 20 ml for sediment grain-size analyses, 10 ml for geochemical analyses, and 20 ml for foraminiferal analyses. Foraminiferal samples were preserved in 70% alcohol with a calcium carbonate buffering agent and stained with rose Bengal in order to distinguish live from dead foraminifera at the time of collection (Walton, 1952). Staining foraminifera using rose Bengal may produce misleading results as the success of staining may vary due to variations in test thickness, the presence of bacteria, algae or other microorganisms, a slow protoplasm degradation rate, and transport processes (Martin and Steinker, 1973; Walker et al., 1974; Bernhard, 1988, 2000; Goldstein et al., 1995; Goldstein and Watkins, 1999; Angel et al., 2000; Murray and Bowser, 2000), although it remains the most common form of staining as it is relatively inexpensive and simple to use.

LABORATORY AND ANALYTICAL PROCEDURES

Sedimentological Analysis

Sediment samples from the SET11-S40 fish cage complex were dried at a constant 60° in order to obtain an initial total dry weight for the samples. Dry samples were then re-wet, soaked in a 0.05% Calgon (sodium metaphosphate) solution, sonicated to disaggregate the clays, and subsequently wet sieved with a 63 µm (four phi) sieve in order to separate the sand from mud. Sediment samples from the SET11-S43 and SET11-S9A fish cage complexes were wet sieved over a 63 µm sieve initially to separate the sand from mud. The mud fraction from all samples was collected and soaked overnight in bleach (sodium hypochlorite) to remove organics (Anderson, 1963) and centrifuged to concentrate the fine particles (Starkey et al., 1984). Mud samples were then rinsed with a 0.05% Calgon (sodium metaphosphate) solution and centrifuged three more times to remove all remaining bleach. All 63 samples (except for those run on the sedigraph) were subsequently dried in order to determine percent mud.

Due to the amount of organics, small sample size, and time constraints, only ten samples (T1-100, T1-60, T1-30, T1-5, T1-0, SET11-S43-1, SET11-S43-2, SET11-S43-5, SET11-S43-6, and SET11-S43-8), which were considered to exhibit variable grain-size based on side scan sonar images, were run on the sedigraph. These samples were soaked in a 0.05% Calgon solution, sonicated for approximately three minutes each, and run through a Sedigraph III 5120 Particle Size Analyzer to determine the amount of silt and clay. Afterwards, these ten samples were also dried in order to determine percent mud.

The sand fraction for all 63 samples was dried after wet sieving and weighed in order to determine percent sand. Grain-size analysis was conducted on all 63 samples using standard sieving techniques (Ro-Tap method). The sand samples were placed in sieves ranging from -2.0 to 4.0 phi in increments of 0.5 phi. Weight percentages were then calculated to determine average grain-size for each sample.

Side Scan Sonar Acquisition and Analysis

Side scan sonar imaging of the floor of the estuary and lagoon was conducted using the Starfish 390 kHz towfish and acquisition software, and a Garmin WAAS enabled GPS. The images provided by the Starfish extended 50 m on either side of the device and, thus, provided imaging data for the area directly under the cages as well as either side of the cages. Data were processed using Triton Ebis Isis and Delph Map software to produce mosaics with a 1-m pixel resolution. Data were exported as geotif files, and analyzed using ArcMap GIS software. Specific acoustic backscatter data were averaged around individual sample sites (±2 m from the site; i.e., 16 pixels arranged in a 4x4 pattern), and regressed against %mud ($R^2 = 0.54$). This regression defines the distribution of the sandy to muddy sand facies, and the sandy mud to mud facies with the boundary occurring at a backscatter value of 110.

Geochemical Analysis

All geochemical samples were dried at 60°C at the Institute of Oceanography, Universiti Malaysia Terengganu over a period of three days immediately following field work. Samples were then returned to East Carolina University for analysis.

A. Loss on Ignition (LOI)

Each of the surface samples were homogenized using a mortar and pestle after removing large pieces of organic material (e.g., roots and shells). Following homogenization, approximately 2 to 5 g of sediment were stored in pre-weighed crucibles in a desiccator overnight in order to remove any moisture. Samples were weighed before being placed in a small furnace for four hours at 550°C. The samples were cooled in a desiccator overnight and re-weighed. LOI was calculated via (Dean, 1974):

$$LOI\% = ((\text{Initial Mass} - \text{Final Mass})/\text{Initial Mass}) \times 100$$

B. Carbon and Nitrogen Stable Isotope Signatures

Dried sediment was placed in 8 x 5 mm silver capsules, wet with 50 µL deionized water and placed in a dessicator with 100 mL of concentrated HCl for eight hours to remove inorganic carbon (Harris et al., 2001). The samples were then dried at 60°C for 6 hours. The capsules were sent to the Stable Isotope Laboratory at the University of California Davis for bulk and stable carbon and nitrogen isotopic analysis. Fish food samples (pellets and a fish head) sent to the Yale Stable Isotope Facility for stable carbon and nitrogen isotopic analysis were prepared using the same protocol.

Percent carbon and nitrogen was determined by dividing the weight of carbon and nitrogen in each sample by the total amount of sample analyzed. Molar C:N values were determined by converting the amount of carbon and nitrogen from µg to moles and subsequently dividing the amount of carbon by the amount of nitrogen.

Foraminiferal Analysis

During the three days immediately following field work, samples were washed over a 63 µm sieve in order to remove silt, clay, alcohol, and excess rose Bengal and dried at a constant 60°C. Dried samples were later washed over a 710 µm and 63 µm sieve in order to separate the very coarse-grained sand and larger organic material; both subsamples were dried at 40°C. Foraminifera were concentrated using a sodium polytungstate solution (Munsterman and Kerstholt, 1996). Samples were split into aliquots using a microsplitter and approximately 200 specimens were picked from randomly selected squares on a gridded picking tray. Specimens were identified via comparison with the published illustrations of Miocene to modern foraminifera from Southeast Asia and the Southeast Pacific (e.g., Whittaker and Hodgkinson, 1979; Brönnimann and Keij, 1986; van Marle, 1991; Brönnimann et al., 1992; Brönnimann and Whittaker, 1993; Loeblich and Tappan, 1994; Jones, 1994; Hayward et al., 1999a; Horton et al., 2003, 2005; Woodroffe and Horton, 2005; Culver et al., 2012). Identifications were confirmed through comparison with specimens in the collections at the Smithsonian Institution, Washington, D.C.

Patterns of foraminiferal distribution were determined using Q-mode cluster analysis (Sokal and Sneath, 1963; Mello and Buzas, 1968) of relative abundance of total foraminifera (live and dead) and dead foraminifera. A cluster analysis was not run on live data due to the patchy nature and general lack of live specimens. Prior to analysis, relative abundance data were transformed using the equation $2\arcsin\sqrt{p}$ (p=abundance) (Bartlett, 1947; Culver et al., 2012). The cluster analyses were run in SYSTAT using Ward's linkage method and Euclidean distances.

Foraminiferal data were also analyzed using Fisher's alpha index, species richness (S), density, comparison of test type, and comparison of live versus dead specimens and species. Fisher's alpha index (Fisher et al., 1943; Murray, 1973; Hayek and Buzas, 2010), run on the total assemblage data, compares the number of individual specimens picked in each sample against the number of different species picked from each sample, taking into account rare species. The corresponding calculated alpha value represents the number of species represented by a single specimen (Murray, 1973).

When analyzing for species richness, the number of live, dead, and total foraminiferal species were considered for each location. Density was calculated by determining the number of live, dead, and total foraminifera in each 20 mL sample by multiplying out the number of specimens picked by the fraction of the sample picked. When comparing test types, no division was made between porcelaneous and hyaline due to the lack of porcelaneous foraminifera.

Detrended correspondence analysis (DCA) and detrended canonical correspondence analysis (DCCA) were run using CANOCO 4.5 (ter Braak and Smilauer, 2002) to help determine which environmental variables control the distribution of the abundance (total) of the different species (Sejrup et al., 2004) in the SEL. Environmental variables that were included were salinity, pH, depth (m), dissolved oxygen (mg/L), grain-size, $\delta^{13}C$, $\delta^{15}N$, and C:N. Environmental variables including percent gravel, percent sand, percent LOI, percent carbon, and percent nitrogen were not included in order to reduce the amount of redundant data. In order to amplify the "signal to noise" ratio, the square root of the foraminiferal abundance was used. DCA and DCCA break down and detrend segments, down-weighting rare species, with nonlinear rescaling (ter Braak, 1998; Sejrup et al., 2004).

RESULTS

ENVIRONMENTAL VARIABLES

Salinity in the Setiu lagoon increased from an average of 22 along transect 1 to 27 along transect 4 (Table 1), closest to the inlet. The greatest jump in salinity occurred between transect 3 and the nine samples of the SET11-S40 floating fish cage complex. The average salinity in the lagoon in June 2011 was 24. Salinity at the Setiu estuary site SET11-S9A, including transects, was much lower and averaged 1 in June 2011.

The pattern of lagoonal pH values tracked variations in salinity, increasing from an average of 7.5 for transect 1 to 8.0 for transect 4, closest to the inlet (Table 1). Even though estuarine site SET11-S9A covered a relatively small area, pH values showed a distinct pattern of pH decreasing southwards towards the river (Table 1; Figure 1). Average pH at estuarine sampling stations was 7.2, slightly less than the average of 7.9 at lagoonal sites.

Dissolved oxygen values varied considerably at the lagoonal sample sites ranging from 3.2 to 9.9 mg/L (Table 1). Transect averages exhibited a much smaller range from 4.2, closest to the inlet (transect 4) to 5.7 (transect 2) with an average dissolved oxygen value for all samples in the Setiu lagoon of 5.7. In comparison, dissolved oxygen values at estuarine site SET11-S9A showed little variation and averaged slightly less than lagoonal sites at 4.5 mg/L (Table 1).

SEDIMENT DISTRIBUTION

Sediments range from mud to gravelly coarse sand in the lagoon and are generally poorly sorted (Appendix K). Most samples in the lagoon were negatively skewed and trended more positive closer to the inlet (Appendix K; Figure 3). The kurtosis of the sediments sampled in the lagoon ranged from very leptokurtic to platykurtic with only 11 of the 42 mesokurtic (Appendix K). The mean grain-size for 26 of the 63 samples was mud and all but four were in the lagoon (Figure 3). All samples associated with the SET11-S43 fish cage complex are characterized by >87% mud except for SET11-S43-1, SET11-S43-4, SET11-S43-7 (Table 2), all located to the west of the fish cage complex closest to the mangrove forest, and all samples along transect 2 (Figures 3, 4; Table 2; Appendix J). At site SET11-S40, percent mud is greatest along transect 3 to the north of the fish cage complex and lowest within the fish cage complex (Figures 3, 4; Table 2; Appendix J). Percent mud has a high correlation with percent loss on ignition ($r = 0.98$, $P = 0.00$), percent carbon ($r = 0.88$, $P = 0.00$), and percent nitrogen ($r = 0.81$, $P = 0.00$; Figure 4).

Sediments in the estuary range from mud to slightly gravelly coarse-grained sand and are moderately to moderately well sorted (Appendix K). Most samples in the Setiu estuary were negatively skewed and leptokurtic to very leptokurtic (Appendix K; Figure 3). Samples SET11-S9A-4, SET11-S9A-5, SET11-S9A-6, SET11-S9A-9 all have >82% mud (Figure 4; Tables 4, 3) and border the sandy barrier island which has little vegetation (Appendix J). The mean percent mud for the SET11-S9A fish cage complex is 42.35% (Table 3).

The sedigraph data on percent silt and clay was not analyzed. These data are presented in Appendix M.

SIDE SCAN SONAR

Side scan sonar images with acoustic backscatter color values corresponding to backscatter intensity values show the distribution of coarse and fine-grained material under and around the fish cage complexes (Figures 5–7; Appendix F). The SET11-S43 fish cage complex has the overall lowest backscatter intensity of the three sites (Figures 5–7; Appendix F).

Backscatter intensity is lowest directly under the cages and to the north of the complex and increases to the south and along the western side of the fish cage complex. The SET11-S40 fish cage complex has an overall higher backscatter intensity than SET11-S43 with little variation under and around the fish cage complex (Figure 6; Appendix F). The SET11-S9A abandoned fish cage complex has the overall highest backscatter intensity of the three sites (Figure 7; Appendix F). Backscatter intensity is the lowest in the center of the estuary and becomes higher towards the barrier island to the east and mangrove forest to the west.

Table 1: Location of Setiu estuary and lagoon samples and values for environmental variables. DO = Dissolved oxygen. Stations are listed from north to south.

Sample Location	Latitude (N)	Longitude (E)	Dist. from inlet (km)	Depth (m)	Salinity	pH	DO (mg/L)
S43-T1-100	5.69363	102.70014	3.72	1.6	21.6	7.9	6.2
S43-T1-60	5.69341	102.70041	3.68	1.6	21.5	7.6	6.1
S43-T1-30	5.69326	102.70067	3.65	1.5	21.8	7.6	6.0
S43-T1-15	5.69317	102.70081	3.63	1.5	20.6	7.4	4.6
S43-T1-5	5.69314	102.7009	3.62	1.6	22.4	7.4	5.8
S43-T1-0	5.69305	102.70089	3.53	1.7	24.0	7.3	5.2
TI Averages			3.63	1.6	22.0	7.5	5.7
S43-1	5.69092	102.70149	3.31	1.3	20.7	8.0	6.9
S43-2	5.69128	102.7018	3.31	1.3	21.5	7.9	6.6
S43-3	5.69175	102.70213	3.31	1.4	21.4	8.0	7.5
S43-4	5.69001	102.70235	3.19	1.3	21.0	7.9	6.8
S43-5	5.69072	102.70278	3.19	1.7	20.9	8.0	7.1
S43-6	5.69135	102.70328	3.19	1.0	22.0	8.0	6.7
S43-7	5.68954	102.70387	3.02	0.6	22.6	7.7	7.2
S43-8	5.69005	102.70414	3.02	1.8	24.6	7.9	5.6
S43-9	5.69044	102.70540	3.02	1.3	23.8	7.9	5.2
S43 1-9 Averages			3.17	1.3	22.1	7.9	6.6
S43-T2-0	5.68921	102.70552	2.84	2.1	22.3	7.9	5.7
S43-T2-5	5.68918	102.70554	2.83	2.0	21.5	8.0	4.5
S43-T2-15	5.68908	102.70558	2.82	1.4	20.3	8.0	5.8
S43-T2-30	5.68875	102.70569	2.78	0.9	23.6	8.0	5.1
S43-T2-60	5.68843	102.70583	2.74	1.2	19.1	8.0	3.2
S43-T2-100	5.68824	102.70621	2.69	1.2	25.7	8.0	9.9
T2 Averages			2.78	1.5	22.1	8.0	5.7
S43 Averages			3.19	1.4	22.0	7.8	6.1
S40-T3-100	5.68463	102.70955	2.14	1.0	21.8	7.8	4.4
S40-T3-60	5.68437	102.70987	2.09	1.0	23.0	7.9	4.6
S40-T3-30	5.68400	102.71014	2.04	0.9	24.8	7.9	5.8
S40-T3-15	5.68396	102.71030	2.02	1.0	22.1	7.8	5.6
S40-T3-5	5.68389	102.71042	2.00	1.2	21.6	7.9	6.7
S40-T3-0	5.68383	102.71040	1.93	1.3	21.5	7.8	6.4
T3 Averages			2.04	1.1	22.5	7.9	5.6
S40-1	5.68203	102.71060	1.78	1.9	29.2	8.0	5.4
S40-2	5.683	102.71145	1.78	2.3	28.9	8.0	4.0
S40-3	5.6830	102.7119	1.78	1.7	32.2	8.0	5.7
S40-4	5.68065	102.71209	1.50	2.6	27.8	8.0	7.5
S40-5	5.68075	102.71253	1.50	2.5	25.0	8.1	6.2
S40-6	5.68122	102.71295	1.50	1.1	25.1	8.1	8.0

S40-7	5.67876	102.71356	1.30	1.5	26.6	8.0	4.1
S40-8	5.67942	102.71372	1.30	2.6	26.1	8.1	5.3
S40-9	5.6798	102.71411	1.30	1.5	28.1	8.1	6.0
S40 1-9 Averages			1.53	2.0	27.7	8.0	5.8
S40-T4-0	5.67889	102.71441	1.20	1.9	26.9	8.0	5.3
S40-T4-5	5.6789	102.71448	1.12	1.8	26.6	8.1	4.3
S40-T4-15	5.67888	102.71457	1.11	1.8	27.6	8.0	4.2
S40-T4-30	5.67877	102.71475	1.09	2.0	26.7	8.0	4.9
S40-T4-60	5.6788	102.71516	1.04	1.7	26.2	8.1	3.4
S40-T4-100	5.67884	102.71566	0.98	0.4	26.0	8.1	3.2
T4 Averages			1.09	1.6	26.7	8.0	4.2
S40 Averages			1.55	1.6	25.9	8.0	5.3
North of Inlet Averages			2.37	1.5	24.0	7.9	5.7
S9A-T5-100	5.62941	102.78568	8.52	3.3	2.1	7.8	4.8
S9A-T5-60	5.62908	102.78604	8.57	3.0	2.0	7.9	3.9
S9A-T5-30	5.62891	102.78624	8.61	2.7	2.1	7.9	4.1
S9A-T5-15	5.62875	102.78621	8.64	2.7	1.3	7.8	3.3
S9A-T5-5	5.62871	102.78632	8.65	2.8	2.0	7.9	6.2
S9A-T5-0	5.62869	102.78633	8.66	2.9	0.5	7.5	3.2
T5 Averages			8.61	2.9	1.7	7.8	4.2
S9A-1	5.62855	102.78633	8.67	2.7	1.7	7.5	3.7
S9A-2	5.62846	102.78641	8.67	2.4	0.6	7.2	4.6
S9A-3	5.62842	102.78655	8.67	2.1	0.8	7.2	4.7
S9A-4	5.62845	102.7867	8.69	0.7	0.7	7.0	4.5
S9A-5	5.62859	102.78653	8.69	1.6	0.5	7.0	3.2
S9A-6	5.62825	102.78671	8.69	1.4	0.6	7.0	4.8
S9A-7	5.62818	102.78647	8.72	2.0	0.4	6.8	4.8
S9A-8	5.62807	102.78669	8.72	2.0	0.6	6.9	5.1
S9A-9	5.62799	102.78676	8.72	2.0	0.8	7.0	3.6
S9A 1-9 Averages			8.69	1.9	0.7	7.1	4.3
S9A-T6-0	5.62812	102.78657	8.73	2.0	0.5	6.9	5.4
S9A-T6-5	5.62808	102.78659	8.81	1.9	1.0	6.9	4.6
S9A-T6-15	5.62803	102.78666	8.82	2.0	0.6	6.9	4.8
S9A-T6-30	5.62786	102.78662	8.84	2.0	0.7	6.8	5.8
S9A-T6-60	5.62761	102.78675	8.87	1.8	0.5	6.7	4.0
S9A-T6-100	5.62727	102.78686	8.91	1.9	0.5	6.7	4.9
T6 Averages			8.83	1.9	0.7	6.8	4.9
S9A Averages			8.70	2.2	1.0	7.2	4.5

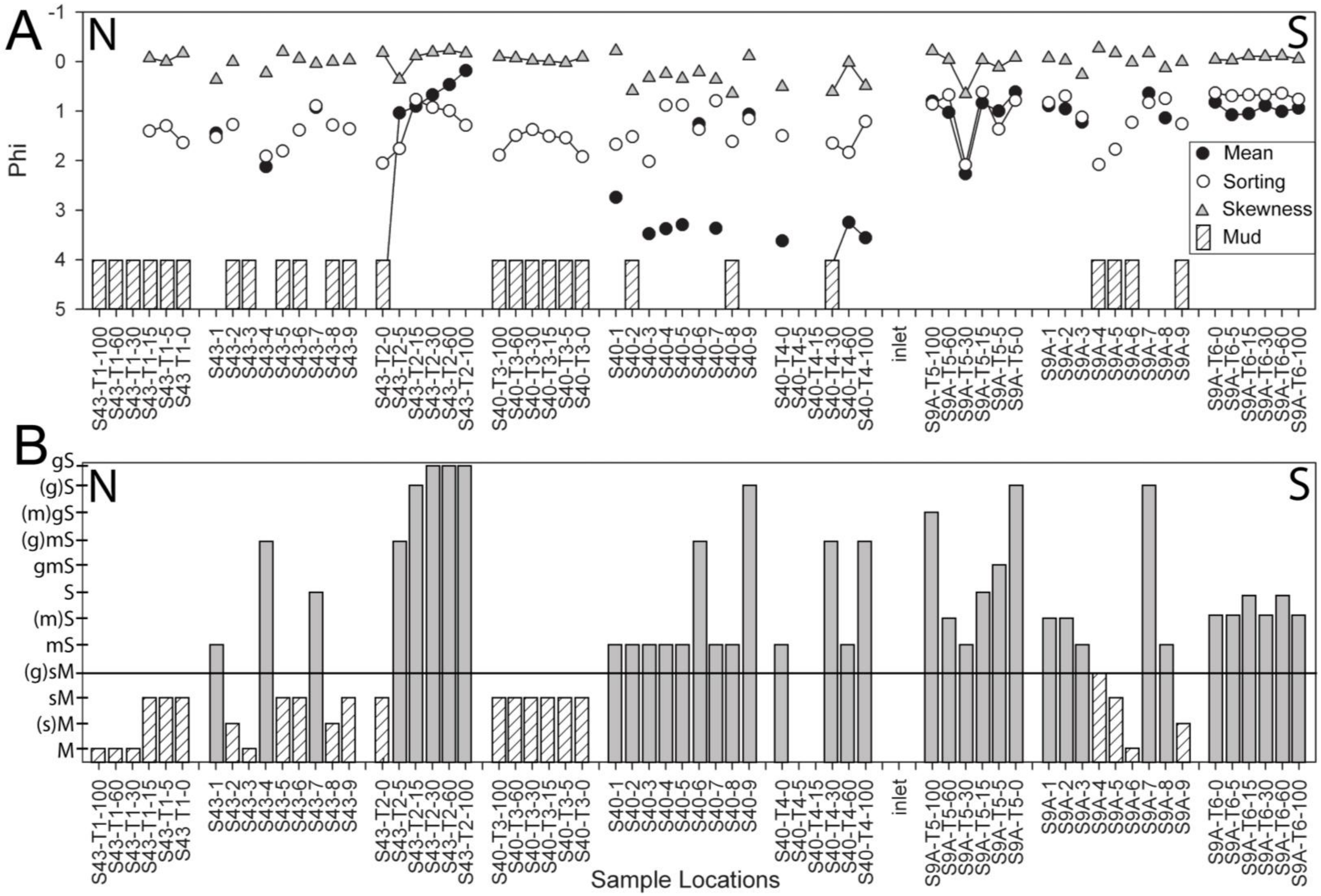


Figure 3: A: Sediment grain-size results for the Setiu estuary and lagoon samples produced by Gradistat. Samples where the mean grain-size is 4 phi or greater are indicated by the hashed columns indicating mud. Two samples (T4-5 and T4-15) were lost. Transects indicated by connected symbols. **B:** Sediment grain-size classification according to Farrell/Folk method for the Setiu estuary and lagoon samples. Samples dominated by mud are indicated by the hashed columns whereas those dominated by sand are indicated by grey columns. Two samples (T4-5 and T4-15) were lost.

Table 2: Gravel, sand, and mud weights and their relative percent's. Calculated values after wet sieving, drying, and dry sieving (Ro-Tap). Total weight values are dry values added together, not initial dry weight. %G&S, percent gravel and sand fraction combined. Farrell/Folk refers to sediment grain size nomenclature as originally defined by Folk (1954) and modified by Farrell et al. (2012).

Site Location	TC	DC	Gravel Weight (g)	Sand Weight (g)	Mud Weight (g)	Total Weight (g)	%Gravel	%Sand	%G&S	%Mud	Farrell/ Folk
S43-T1-100	TB2	DB2	0.00	0.00	1.23	1.23	0.00	0.00	0.00	100.00	M
S43-T1-60	TB2	DB2	0.00	0.00	1.15	1.15	0.00	0.00	0.00	100.00	M
S43-T1-30	TB1	DB2	0.00	0.00	1.65	1.65	0.00	0.00	0.00	100.00	M
S43-T1-15	TB2	DB2	0.00	0.10	1.57	1.67	0.00	5.99	5.99	94.01	sM
S43-T1-5	TB2	DB2	0.00	0.08	1.50	1.58	0.00	5.06	5.06	94.94	sM
S43 T1-0	TB2	DB2	0.00	0.13	1.51	1.64	0.00	7.93	7.93	92.07	sM
Mean			0.00	0.05	1.44	1.49	0.00	3.16	3.16	96.84	
S43-1	TB2	DB2	0.06	4.52	0.46	5.04	1.19	89.68	90.87	9.13	mS
S43-2	TB1	DB2	0.00	0.06	1.60	1.66	0.00	3.61	3.61	96.39	(s)M
S43-3	TB1	DB2	0.00	0.00	1.48	1.48	0.00	0.00	0.00	100.00	M
S43-4	TB2	DB1	0.26	7.12	1.20	8.58	3.03	82.98	86.01	13.99	(g)mS
S43-5	TB1	DB1	0.00	0.18	1.22	1.40	0.00	12.86	12.86	87.14	sM
S43-6	TB1	DB2	0.00	0.11	1.66	1.77	0.00	6.21	6.21	93.79	sM
S43-7	TB2	DB1	0.06	11.05	0.15	11.26	0.53	98.13	98.67	1.33	S
S43-8	TB1	DB1	0.00	0.10	2.22	2.32	0.00	4.31	4.31	95.69	(s)M
S43-9	TB1	DB1	0.00	0.16	2.03	2.19	0.00	7.31	7.31	92.69	sM
Mean			0.04	2.59	1.34	3.97	0.53	33.90	34.43	65.57	
S43-T2-0	TB2	DB1	0.15	2.05	6.04	8.24	1.82	24.88	26.70	73.30	sM
S43-T2-5	TB2	DB1	0.94	20.36	2.35	23.65	3.97	86.09	90.06	9.94	(g)mS
S43-T2-15	TB1	DB1	0.66	29.21	0.39	30.26	2.18	96.53	98.71	1.29	(g)S
S43-T2-30	TA1	DA1	1.81	30.97	0.25	33.03	5.48	93.76	99.24	0.76	gS
S43-T2-60	TA1	DA1	4.08	40.29	0.25	44.62	9.14	90.30	99.44	0.56	gS
S43-T2-100	TA1	DA1	6.33	27.28	0.28	33.89	18.68	80.50	99.17	0.83	gS
Mean			2.33	25.03	1.59	28.95	6.88	78.68	85.56	14.44	
S40-T3-100	TB2	DB2	0.01	2.16	5.52	7.69	0.13	28.09	28.22	71.78	sM
S40-T3-60	TB1	DB1	0.07	0.57	4.80	5.44	1.29	10.48	11.76	88.24	sM
S40-T3-30	TB1	DB1	0.02	0.53	6.06	6.61	0.30	8.02	8.32	91.68	sM
S40-T3-15	TB1	DB1	0.00	1.54	7.02	8.56	0.00	17.99	17.99	82.01	sM
S40-T3-5	TA2	DA2	0.00	1.08	3.82	4.90	0.00	22.04	22.04	77.96	sM
S40-T3-0	TA2	DA2	0.08	2.64	6.32	9.04	0.88	29.20	30.09	69.91	sM
Mean			0.03	1.42	5.59	7.04	0.43	19.30	19.74	80.26	
S40-1	TA2	DA2	0.10	25.60	4.10	29.80	0.34	85.91	86.24	13.76	mS
S40-2	TB1	DB1	0.01	8.16	4.92	13.09	0.08	62.34	62.41	37.59	mS
S40-3	TA2	DA2	0.00	11.49	4.77	16.26	0.00	70.66	70.66	29.34	mS
S40-4	TA2	DA2	0.00	6.45	0.86	7.31	0.00	88.24	88.24	11.76	mS
S40-5	TA2	DA2	0.00	17.67	2.48	20.15	0.00	87.69	87.69	12.31	mS
S40-6	TB2	DB1	0.35	19.24	1.32	20.91	1.67	92.01	93.69	6.31	(g)mS
S40-7	TA2	DA2	0.09	12.20	1.49	13.78	0.65	88.53	89.19	10.81	mS
S40-8	TA2	DA2	0.01	10.92	6.25	17.18	0.06	63.56	63.62	36.38	mS
S40-9	TA1	DA1	1.42	32.59	0.03	34.04	4.17	95.74	99.91	0.09	(g)S
Mean			0.22	16.04	2.91	19.17	0.77	81.63	82.41	17.59	
S40-T4-0	TA2	DA2	0.05	9.94	3.07	13.06	0.38	76.11	76.49	23.51	mS
S40-T4-5	TA2	DA2	0.00	9.26	LOST	LOST	LOST	LOST	LOST	LOST	
S40-T4-15	TA2	DA2	0.41	12.10	LOST	LOST	LOST	LOST	LOST	LOST	
S40-T4-30	TA2	DA2	0.25	9.96	5.59	15.80	1.58	63.04	64.62	35.38	(g)mS
S40-T4-60	TA2	DA2	0.07	15.76	4.07	19.90	0.35	79.20	79.55	20.45	mS
S40-T4-100	TA2	DA2	0.36	15.73	3.86	19.95	1.80	78.85	80.65	19.35	(g)mS
Mean			0.19	12.13	4.15	17.18	1.03	74.30	75.33	24.67	
S9A-T5-100	TC2	DC1	1.97	32.48	0.57	35.02	5.63	92.75	98.37	1.63	(m)gS
S9A-T5-60	TC2	DC1	0.03	28.62	0.60	29.25	0.10	97.85	97.95	2.05	(m)S
S9A-T5-30	TC2	DC1	0.05	15.69	3.96	19.70	0.25	79.64	79.90	20.10	mS
S9A-T5-15	TC2	DC1	0.09	25.17	0.20	25.46	0.35	98.86	99.21	0.79	S
S9A-T5-5	TC2	DC1	1.27	19.05	1.41	21.73	5.84	87.67	93.51	6.49	gmS
S9A-T5-0	TC2	DC1	1.29	36.81	0.19	38.29	3.37	96.13	99.50	0.50	(g)S
Mean			0.78	26.30	1.16	28.24	2.59	92.15	94.74	5.26	
S9A-1	TC2	DC2	0.20	14.45	0.33	14.98	1.34	96.46	97.80	2.20	(m)S
S9A-2	TC2	DC2	0.09	19.74	0.58	20.41	0.44	96.72	97.16	2.84	(m)S
S9A-3	TC2	DC2	0.04	25.68	1.85	27.57	0.15	93.14	93.29	6.71	mS
S9A-4	TC2	DC2	0.10	1.11	5.53	6.74	1.48	16.47	17.95	82.05	(g)sM
S9A-5	TC1	DC1	0.02	0.80	4.89	5.71	0.35	14.01	14.36	85.64	sM
S9A-6	TC1		0.00	0.04	4.70	4.74	0.00	0.84	0.84	99.16	M
S9A-7	TC1	DC1	1.30	31.62	0.19	33.11	3.93	95.50	99.43	0.57	(g)S
S9A-8	TC2	DC2	0.01	39.10	2.02	41.13	0.02	95.06	95.09	4.91	mS
S9A-9	TC2	DC2	0.00	0.18	5.89	6.07	0.00	2.97	2.97	97.03	(s)M
Mean			0.20	14.75	2.89	17.83	0.86	56.80	57.65	42.35	
S9A-T6-0	TC2	DC1	0.16	36.57	0.61	37.34	0.43	97.94	98.37	1.63	(m)S
S9A-T6-5	TC2	DC2	0.20	32.89	1.14	34.23	0.58	96.09	96.67	3.33	(m)S
S9A-T6-15	TC2	DC2	0.29	34.51	0.45	35.25	0.82	97.90	98.72	1.28	S
S9A-T6-30	TC2	DC2	0.07	26.72	0.48	27.27	0.26	97.98	98.24	1.76	(m)S
S9A-T6-60	TC2	DC2	0.11	56.29	0.39	56.79	0.19	99.12	99.31	0.69	S
S9A-T6-100	TC2	DC2	0.44	36.67	1.50	38.61	1.14	94.98	96.11	3.89	(m)S
Mean			0.21	37.28	0.76	38.25	0.57	97.33	97.90	2.10	

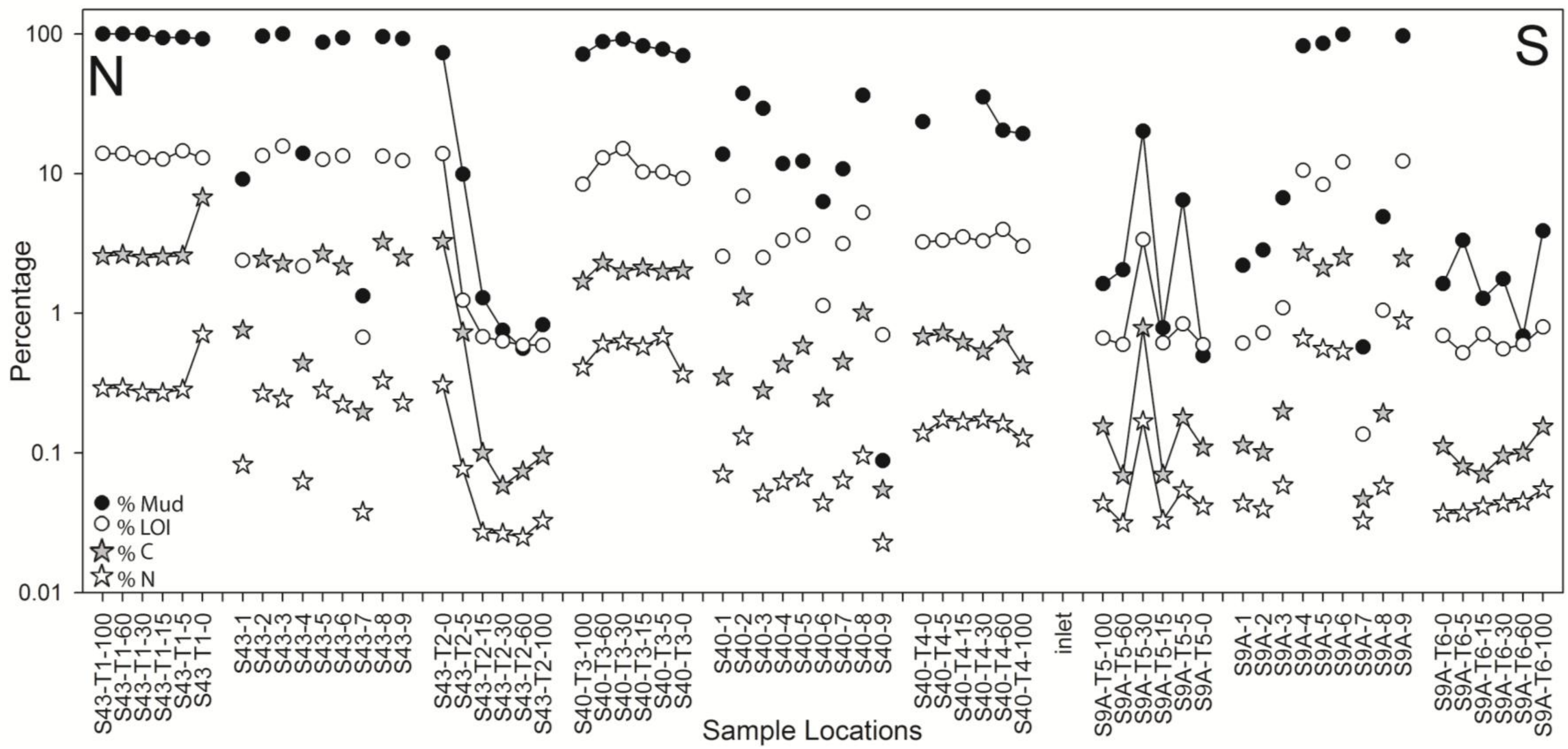


Figure 4: Log scale plot of percent mud (% Mud), percent loss on ignition (% LOI), percent carbon (% C), and percent nitrogen (%N). Transects indicated by connected symbols.

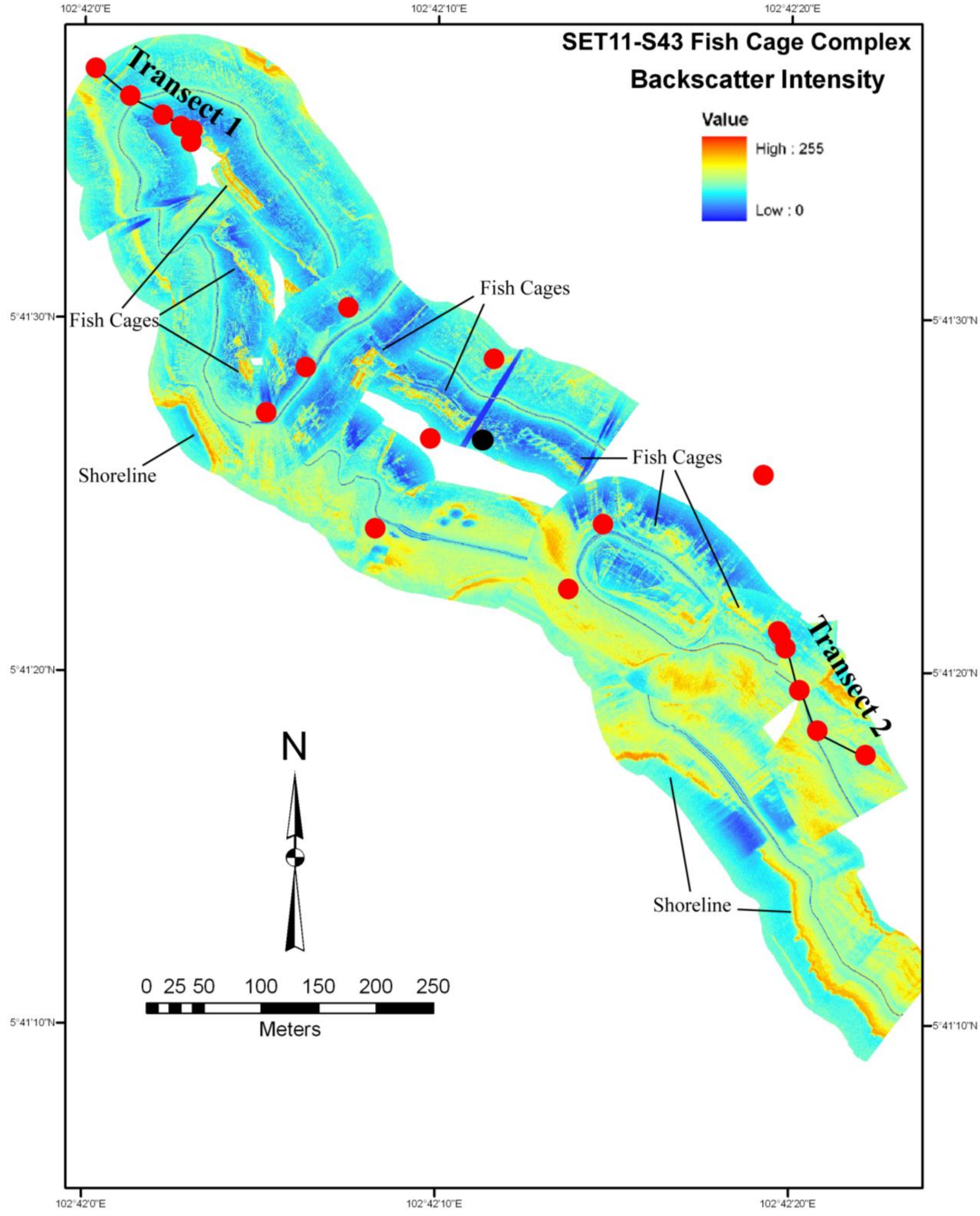


Figure 5: Side scan sonar image for the northernmost SET11-S43 fish cage complex. Sample locations are indicated by red circles. The black circle indicates the location where a core was collected but not analyzed for this project.

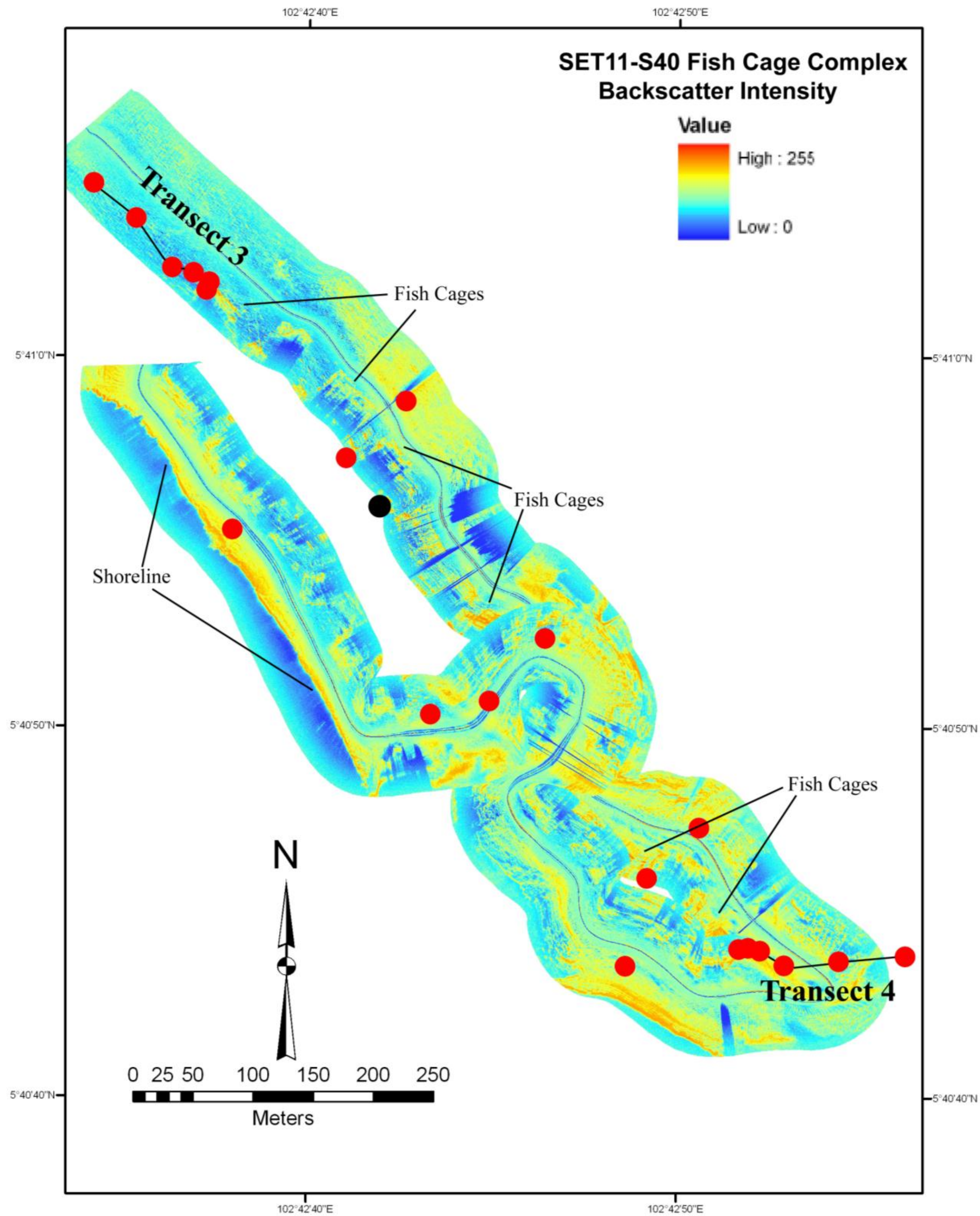


Figure 6: Side scan sonar image for the northernmost SET11-S40 fish cage complex. Sample locations are indicated by red circles. The black circle indicates the location where a core was collected but not analyzed for this project.

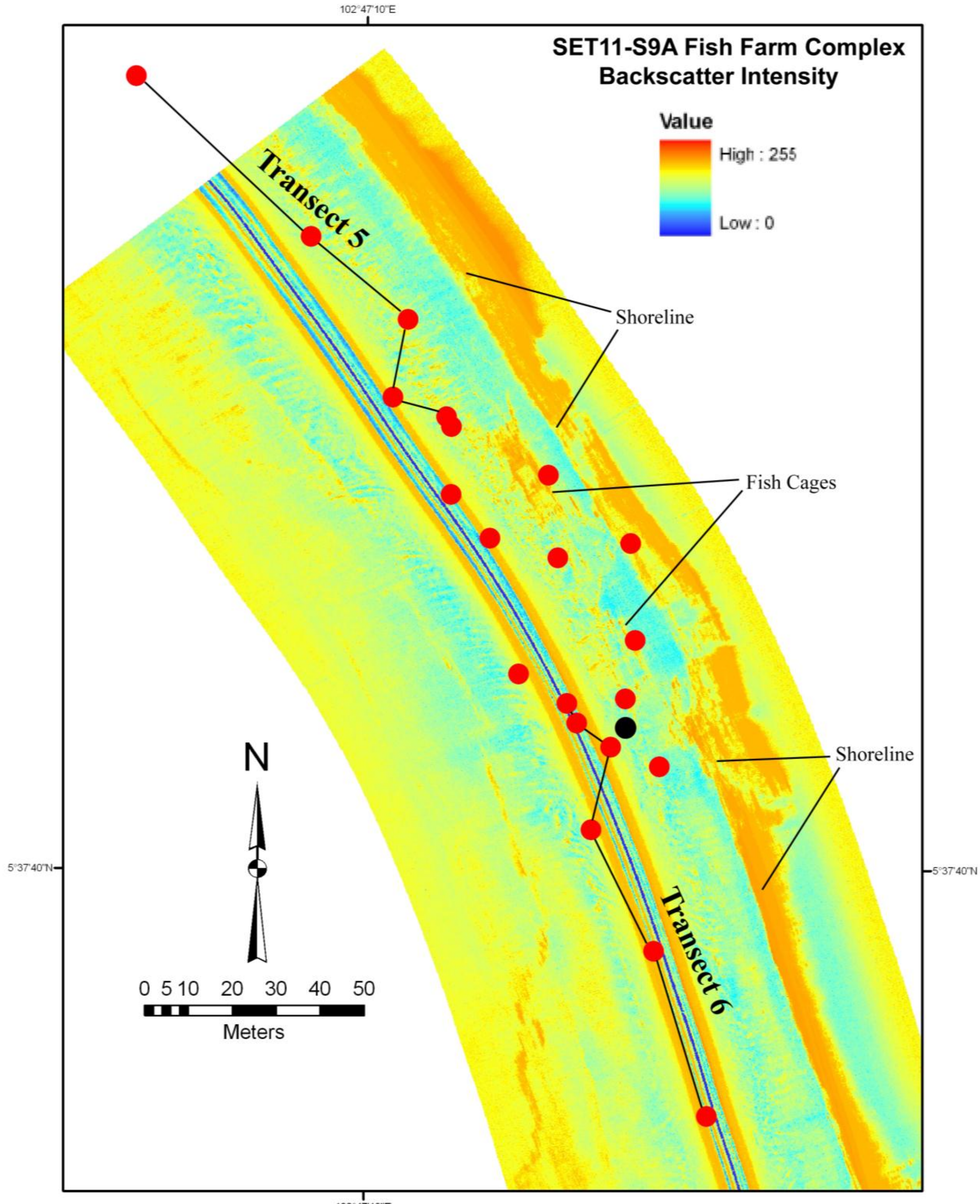


Figure 7: Side scan sonar image for the northernmost SET11-S9A abandoned fish cage complex. Sample locations are indicated by red circles. The black circle indicates the location where a core was collected but not analyzed for this project.

CARBON AND NITROGEN

Loss on Ignition and Percent Carbon

Percent carbon and percent LOI exhibit the same general trend with few exceptions (Figures 4, 8) and have a high correlation (r = 0.89, p = 0.00). In the Setiu lagoon, north of the inlet, percent carbon ranges between 0.1% and 6.8% while percent LOI ranges from 0.6% to 16.0% (Table 3). The greatest average for both percent carbon and LOI occurs along transect 1, with 3.3% and 13.5%, respectively (Table 3). Values for both parameters generally decrease towards the inlet (Figures 4, 8) except at T2-15 to T2-100, which were collected from a sandy barrier island overwash deposit.

In the Setiu estuary, percent carbon ranges between 0.1% and 2.5% with an average value of 0.6% (Table 3). Percent LOI ranges from 0.1% to 12.3% with an average of 2.7% (Table 3). Transects 5 and 6 exhibit a very small range in percent carbon and LOI while the nine samples within and surrounding the SET11-S9A floating fish cage complex have values that vary greatly (Figure 8; Table 3).

$\delta^{13}C$, $\delta^{15}N$, and Carbon:Nitrogen

In the Setiu lagoon, no trends of increasing or decreasing $\delta^{13}C$ values are evident from north to south except along transect 2 which exhibits the greatest range between -20.31‰ and -25.80‰ (Figure 9; Table 3). In contrast, $\delta^{15}N$ values generally decrease from north to south with samples from the SET11-S40 fish cage complex exhibiting the greatest range between 0.63‰ and 4.15‰ (Figure 10; Table 3). The $\delta^{13}C$ vs. $\delta^{15}N$ plot of all samples in the SEL exhibits a significant, weak positive correlation (r = 0.43, P = 0.0005) with $\delta^{13}C$ becoming more positive from the estuary to the lagoon and $\delta^{15}N$ becoming heavier from the lagoon towards the estuary

(Figure 11). The three $\delta^{13}C$ vs. $\delta^{15}N$ values provided for *Nypa fruticans, Rhizophora apiculata, and Avicennia alba* are averages from Kuramoto and Minagawa (2001) while the two fish food values are averages from samples of food taken from the floating fish cage complexes in June 2011. The $\delta^{13}C$ vs. $\delta^{15}N$ values for three of the most abundant mangrove plants in this area are very similar to those of the sediments whereas the $\delta^{13}C$ vs. $\delta^{15}N$ values for the fish food exhibit enriched values of $\delta^{13}C$ and $\delta^{15}N$ compared to the sediment (Figure 11).

Carbon nitrogen ratios of the sediment vary between 2.6 and 12.8 in the Setiu lagoon and 2.0 to 13.0 in the Setiu estuary (Table 3). Ratios are greatest along transect 1 (10.7), within the nine samples of the SET11-S43 floating fish cage complex (10.4), and nine samples of the SET11-S40 floating fish cage complex (8.0; Table 3; Figures 12-14). The C:N of the mangrove plants is much greater than the sediment (~40:1; Kuramoto and Minagawa, 2001) whereas the C:N of the fish foods is closer to that of the sediment (~ 3.5:1; Figures 12-14; Table 3). $\delta^{13}C$ vs. C:N exhibits a non-significant, very weak positive correlation ($r = 0.22$, $P = 0.0764$) with C:N increasing and $\delta^{13}C$ becoming more enriched from the estuary into the lagoon (Figure 13). The strongest and most significant positive correlation ($r = 0.73$, $P = 0.0000$) exists between $\delta^{15}N$ vs. C:N with C:N increasing and $\delta^{15}N$ becoming heavier and more enriched from the estuary towards northernmost SET11-S43 fish cage complex (Figure 14).

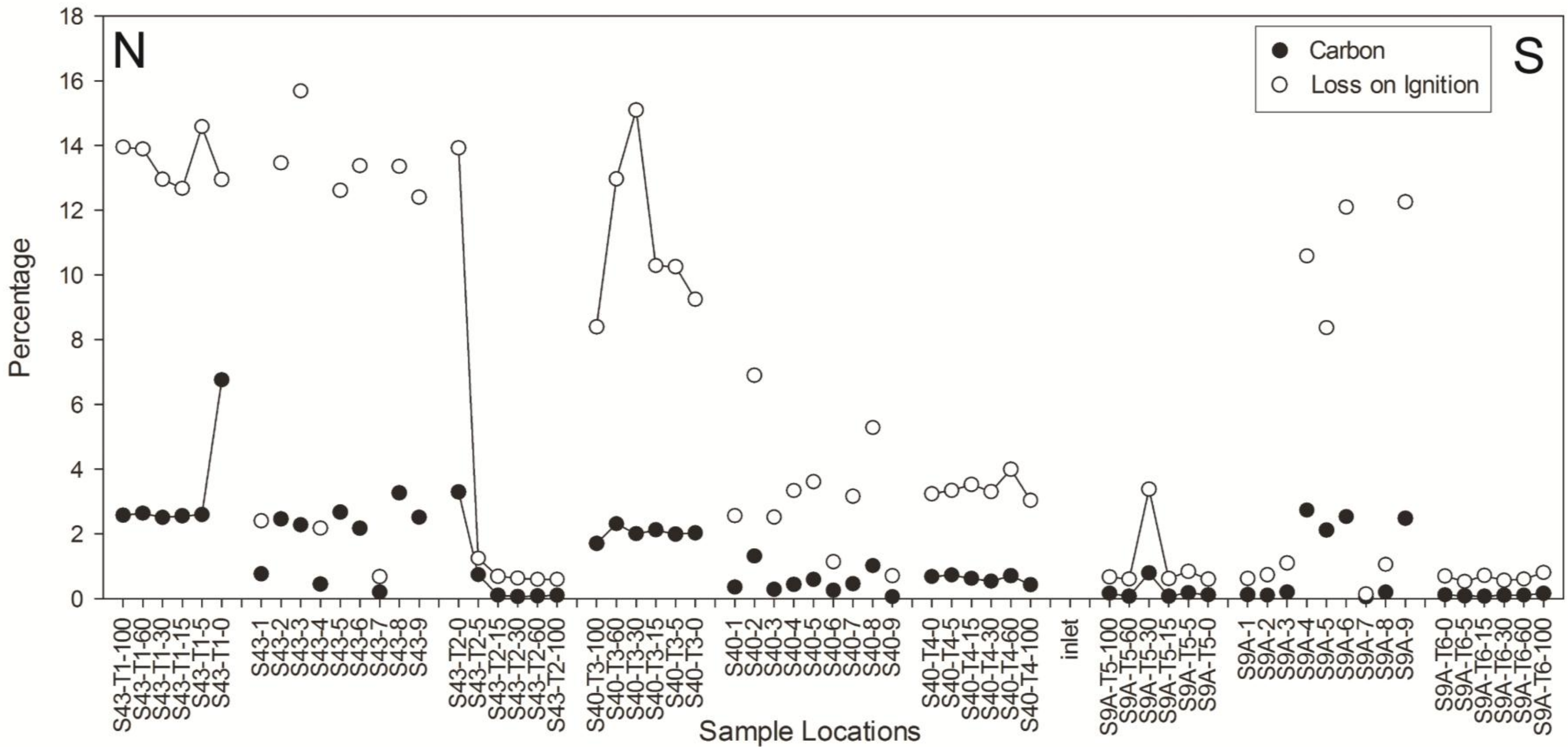


Figure 8: Percent loss on ignition in comparison with percent carbon results for each sample location. Transects indicated by connected symbols.

Table 3: Carbon and nitrogen sediment and fish food sample results from the Setiu estuary and lagoon. %C= Percent carbon; %N= percent nitrogen; %LOI= percent loss on ignition. Stations are listed from north to south.

Sample Location	$\delta^{13}C$	$\delta^{15}N$	C:N	%C	%N	%LOI	Sample Location	$\delta^{13}C$	$\delta^{15}N$	C:N	%C	%N	%LOI	Sample Location	$\delta^{13}C$	$\delta^{15}N$	C:N	%C	%N	%LOI
S43-T1-100	-24.93	3.45	10.32	2.57	0.29	13.95	S40-T3-100	-25.58	1.99	4.81	1.70	0.41	8.39	S9A-T5-100	-28.26	1.66	4.14	0.16	0.04	0.66
S43-T1-60	-25.15	3.21	10.49	2.63	0.29	13.89	S40-T3-60	-26.34	1.22	4.44	2.30	0.61	12.96	S9A-T5-60	-27.59	1.54	2.57	0.07	0.03	0.60
S43-T1-30	-25.14	2.27	10.77	2.50	0.27	12.95	S40-T3-30	-25.59	1.31	3.71	2.00	0.63	15.10	S9A-T5-30	-28.34	1.55	5.43	0.79	0.17	3.38
S43-T1-15	-24.91	2.71	11.01	2.55	0.27	12.67	S40-T3-15	-25.66	1.42	4.29	2.12	0.58	10.29	S9A-T5-15	-26.44	2.09	2.48	0.07	0.03	0.61
S43-T1-5	-25.25	2.86	10.63	2.59	0.28	14.58	S40-T3-5	-25.81	1.37	3.41	1.99	0.68	10.25	S9A-T5-5	-28.37	1.71	3.85	0.18	0.05	0.84
S43-T1-0	-25.11	4.07	11.14	6.76	0.71	12.94	S40-T3-0	-26.24	2.10	6.43	2.03	0.37	9.24	S9A-T5-0	-27.85	2.05	3.08	0.11	0.04	0.60
T1 Averages	-25.08	3.09	10.73	3.27	0.35	13.50	T3 Averages	-25.87	1.57	4.52	2.02	0.54	11.04	T5 Averages	-27.81	1.77	3.59	0.23	0.06	1.11
S43-1	-25.17	3.08	10.69	0.76	0.08	2.40	S40-1	-25.44	1.51	5.79	0.35	0.07	2.55	S9A-1	-27.88	1.71	3.04	0.11	0.04	0.61
S43-2	-25.44	3.20	10.75	2.46	0.27	13.46	S40-2	-25.28	4.15	11.60	1.31	0.13	6.89	S9A-2	-28.05	1.96	2.98	0.10	0.04	0.73
S43-3	-25.18	3.25	10.83	2.27	0.24	15.68	S40-3	-25.63	2.72	6.36	0.28	0.05	2.51	S9A-3	-28.20	2.16	3.95	0.20	0.06	1.09
S43-4	-24.92	3.19	8.16	0.44	0.06	2.17	S40-4	-26.36	0.87	8.07	0.43	0.06	3.33	S9A-4	-28.58	0.82	4.82	2.73	0.66	10.58
S43-5	-25.48	2.01	10.99	2.66	0.28	12.61	S40-5	-26.41	3.77	10.29	0.58	0.07	3.61	S9A-5	-28.29	0.95	4.43	2.11	0.56	8.36
S43-6	-25.08	3.20	11.37	2.17	0.22	13.38	S40-6	-23.07	3.57	6.58	0.25	0.04	1.13	S9A-6	-28.67	1.33	5.52	2.53	0.53	12.09
S43-7	-23.33	3.32	6.05	0.20	0.04	0.67	S40-7	-26.45	0.63	8.22	0.45	0.06	3.16	S9A-7	-26.35	0.86	1.66	0.05	0.03	0.14
S43-8	-25.41	3.60	11.48	3.26	0.33	13.36	S40-8	-26.73	3.32	12.31	1.01	0.10	5.28	S9A-8	-27.86	1.65	3.86	0.19	0.06	1.05
S43-9	-25.53	3.20	12.79	2.51	0.23	12.40	S40-9	-23.77	1.35	2.79	0.05	0.02	0.70	S9A-9	-28.59	1.32	3.26	2.48	0.89	12.25
S43 1-9 Averages	-25.06	3.12	10.35	1.86	0.20	9.57	S40 1-9 Averages	-25.46	2.43	8.00	0.52	0.07	3.24	S9A 1-9 Averages	-28.05	1.42	3.72	1.17	0.32	5.21
S43-T2-0	-25.80	3.22	12.43	3.29	0.31	13.92	S40-T4-0	-25.52	2.27	5.71	0.68	0.14	3.23	S9A-T6-0	-27.64	1.88	3.54	0.11	0.04	0.69
S43-T2-5	-24.26	4.04	11.08	0.73	0.08	1.24	S40-T4-5	-25.54	1.95	4.86	0.72	0.17	3.33	S9A-T6-5	-27.50	1.78	2.51	0.08	0.04	0.52
S43-T2-15	-20.31	2.79	4.33	0.10	0.03	0.68	S40-T4-15	-26.02	1.25	4.34	0.62	0.17	3.52	S9A-T6-15	-27.80	0.71	1.99	0.07	0.04	0.71
S43-T2-30	-20.49	2.69	2.57	0.06	0.03	0.63	S40-T4-30	-25.82	1.14	3.59	0.53	0.17	3.30	S9A-T6-30	-27.81	1.46	2.55	0.10	0.04	0.56
S43-T2-60	-21.17	1.43	3.47	0.07	0.02	0.59	S40-T4-60	-26.10	2.42	5.07	0.70	0.16	3.99	S9A-T6-60	-27.52	1.78	2.63	0.10	0.04	0.60
S43-T2-100	-22.58	2.30	3.39	0.10	0.03	0.59	S40-T4-100	-24.72	1.25	3.88	0.42	0.13	3.03	S9A-T6-100	-27.75	1.39	3.28	0.15	0.05	0.80
T2 Averages	-22.43	2.74	6.21	0.72	0.08	2.94	T4 Averages	-25.62	1.72	4.58	0.61	0.16	3.40	T6 Averages	-27.67	1.50	2.75	0.10	0.04	0.65
Fish Pellet 1	-22.44	5.81	4.29	33.16	5.41	88.28	Fish Head 1	-18.68	11.09	2.67	27.06	7.1	67.60							
Fish Pellet 2	-22.37	5.84	4.31	43.18	7.02	88.28	Fish Head 2	-17.83	11.71	2.76	25.56	6.49	67.60							
Pellet Average	-22.405	5.825	4.30	38.17	6.215	88.28	Head Average	-18.255	11.4	2.71	26.31	6.795	67.60							

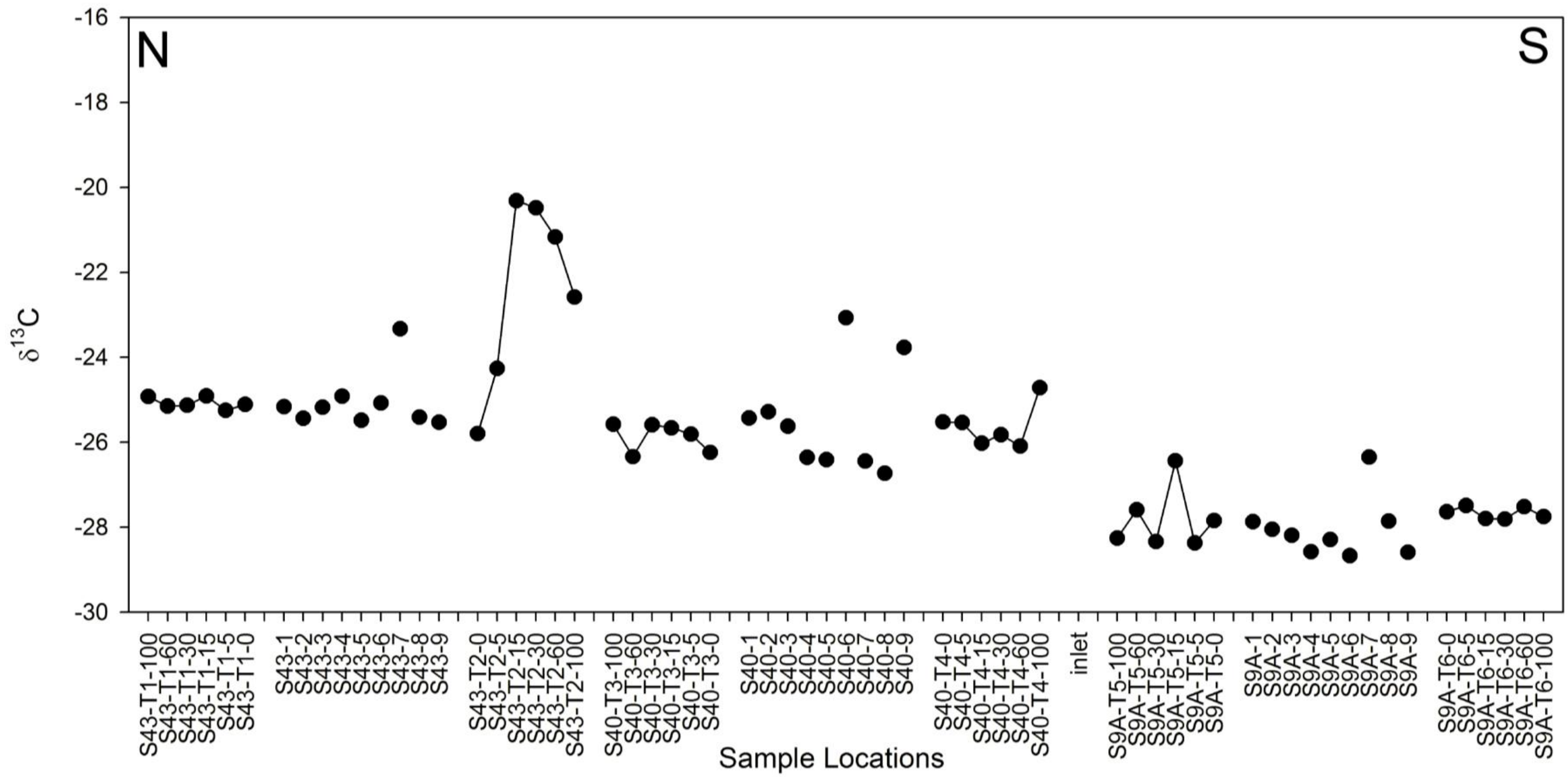


Figure 9: $\delta^{13}C$ values for each sample location in the Setiu estuary and lagoon. $\delta^{13}C$ is the ratio of the amount of carbon-12 to carbon-13 of total organic carbon. Transects indicated by connected symbols.

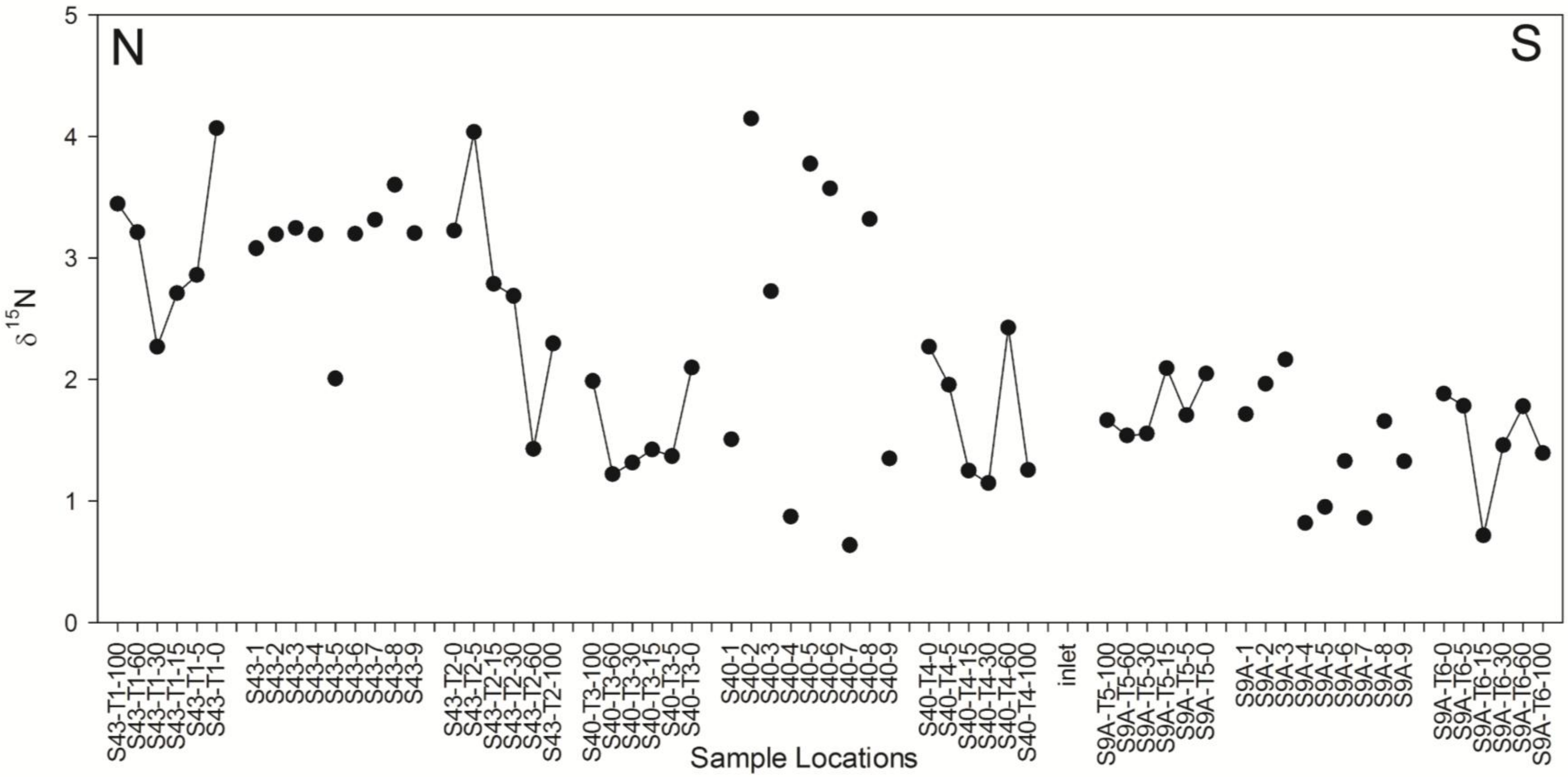


Figure 10: $\delta^{15}N$ values for each sample location in the Setiu estuary and lagoon. $\delta^{15}N$ is the ratio of the amount of nitrogen-14 to nitrogen-15. Transects indicated by connected symbols.

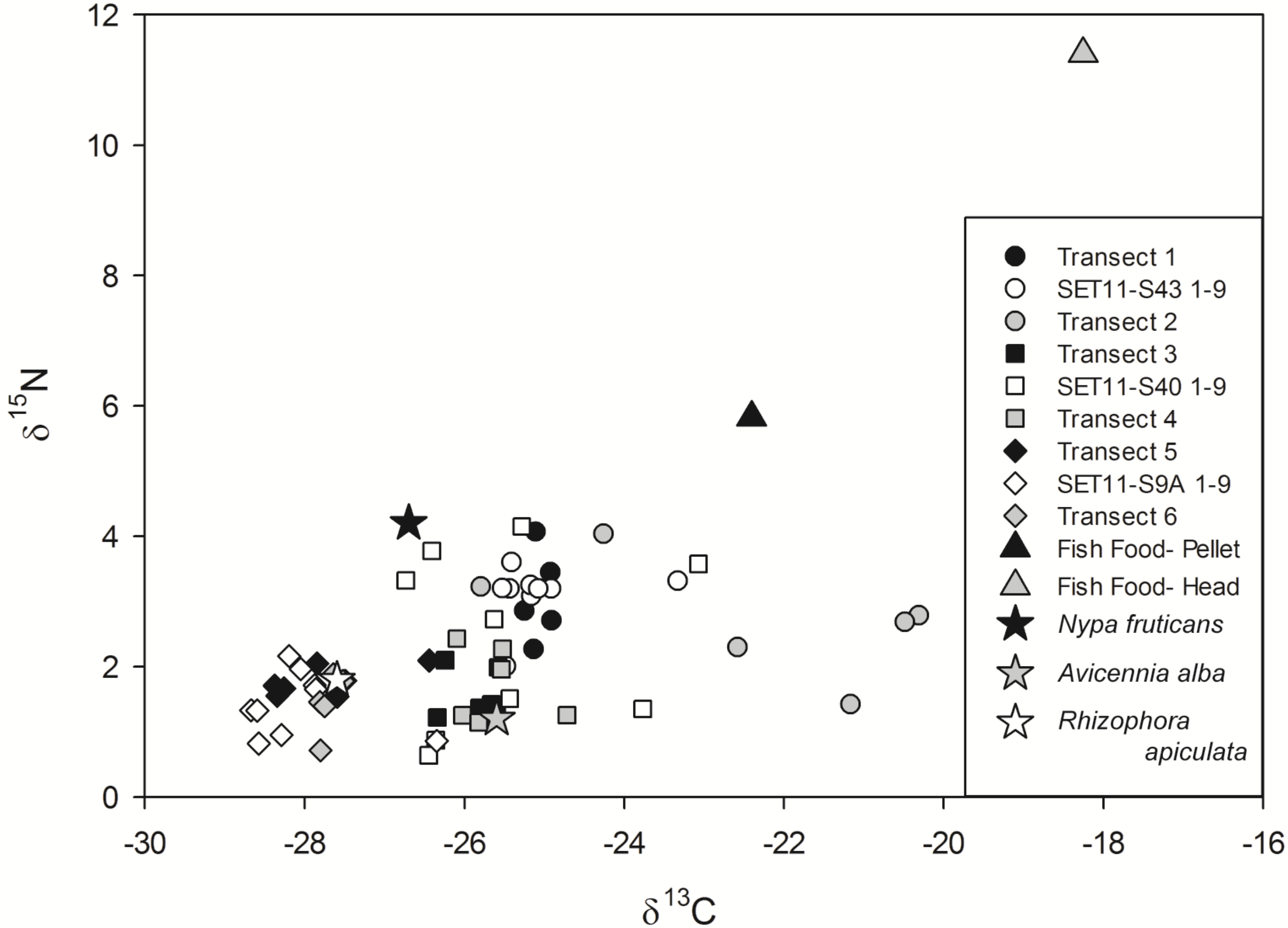


Figure 11: $\delta^{13}C$ vs. $\delta^{15}N$ signatures of all sediment samples and average fish food values from the Setiu estuary and lagoon. *Nypa fruticans*, *Avicennia alba*, and *Rhizophora apiculata* values are averages from southeast Thailand by Kuramoto and Minagawa, 2001.

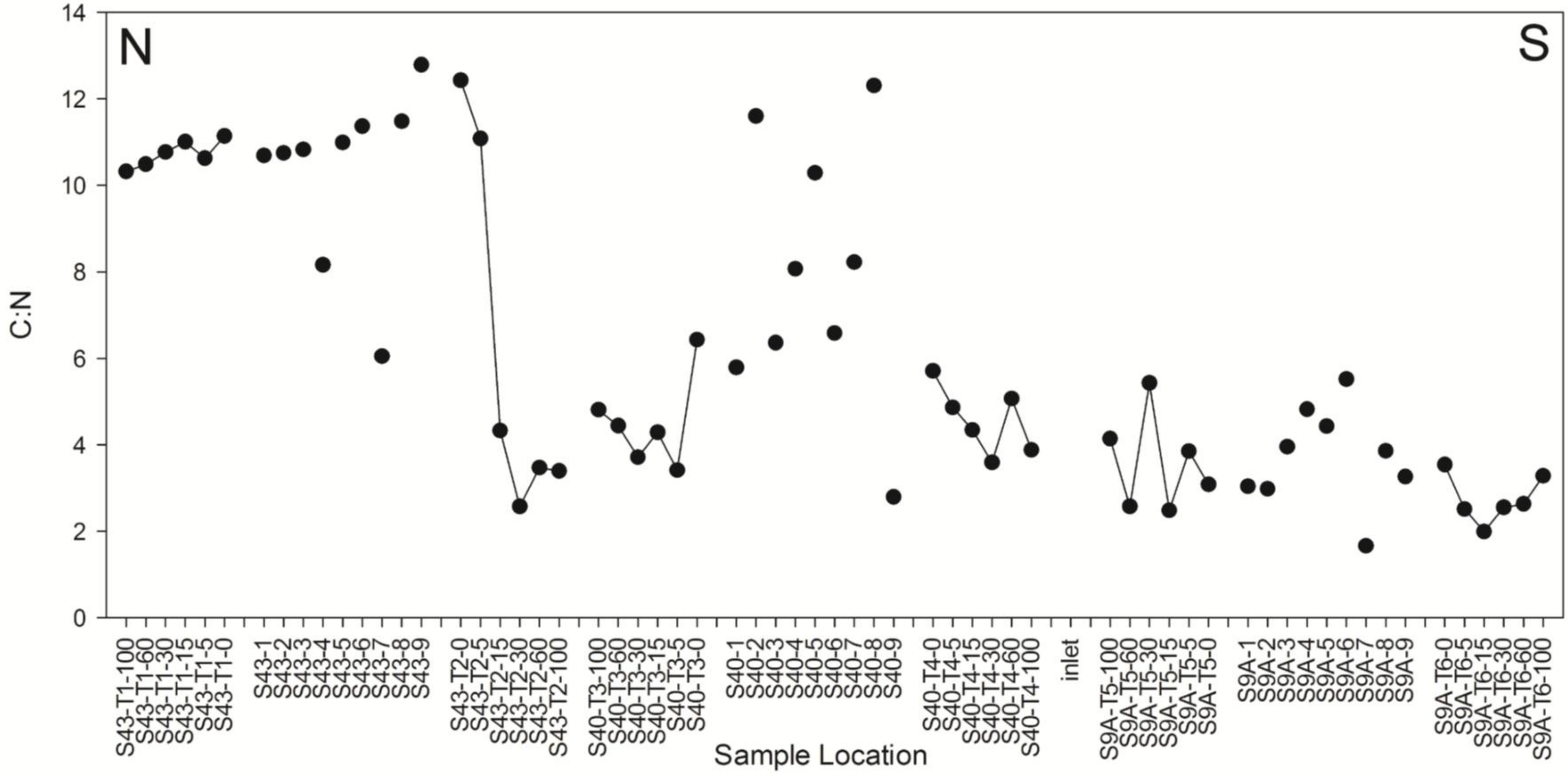


Figure 12: C:N ratio values for each sample location in the Setiu estuary and lagoon. Transects indicated by connected symbols.

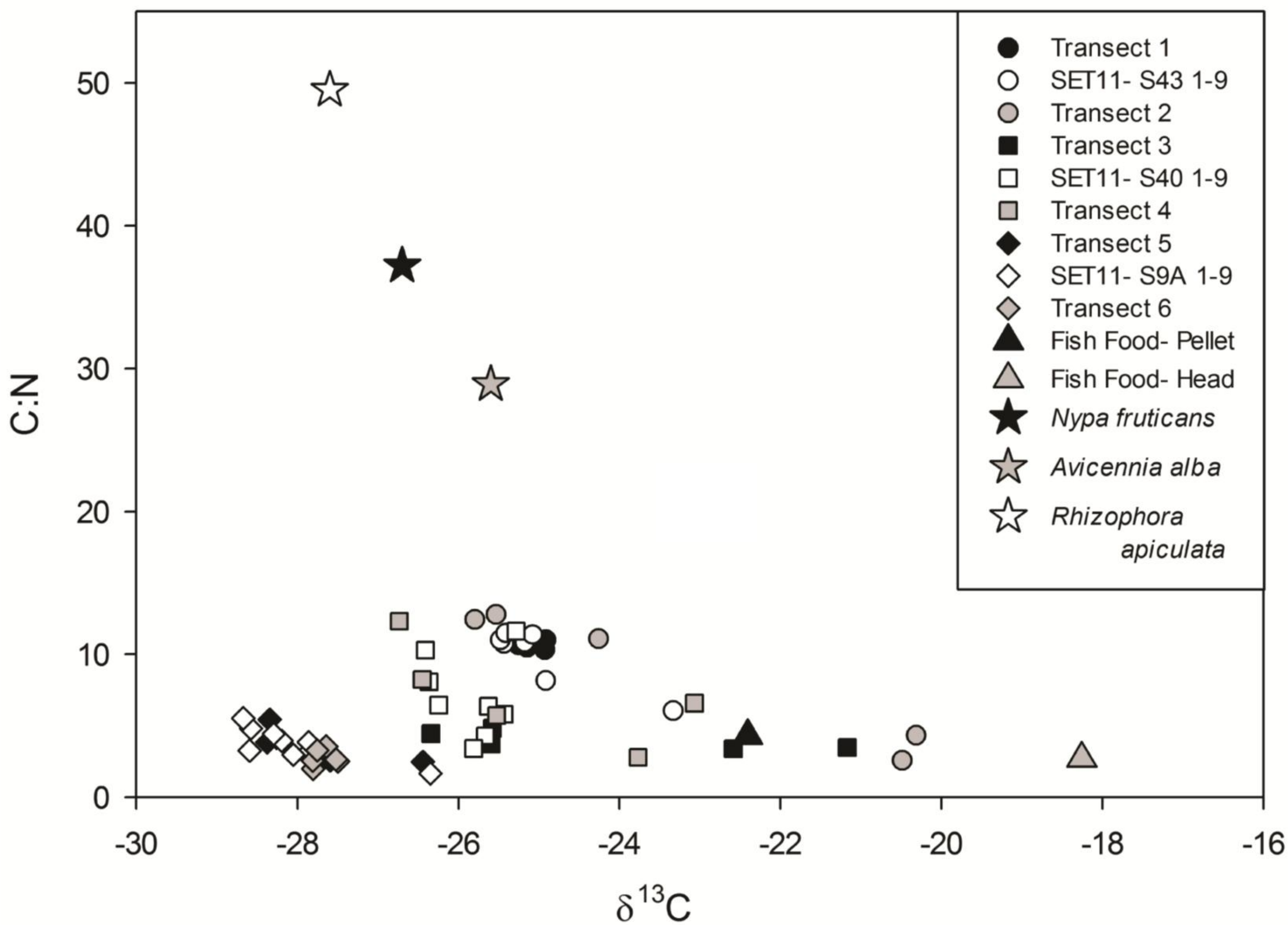


Figure 13: $\delta^{13}C$ vs. C:N. Values indicate the relative molar amount of carbon compared to nitrogen in comparison with how enriched in ^{13}C the sediment, fish food and plants are in relation to ^{12}C.

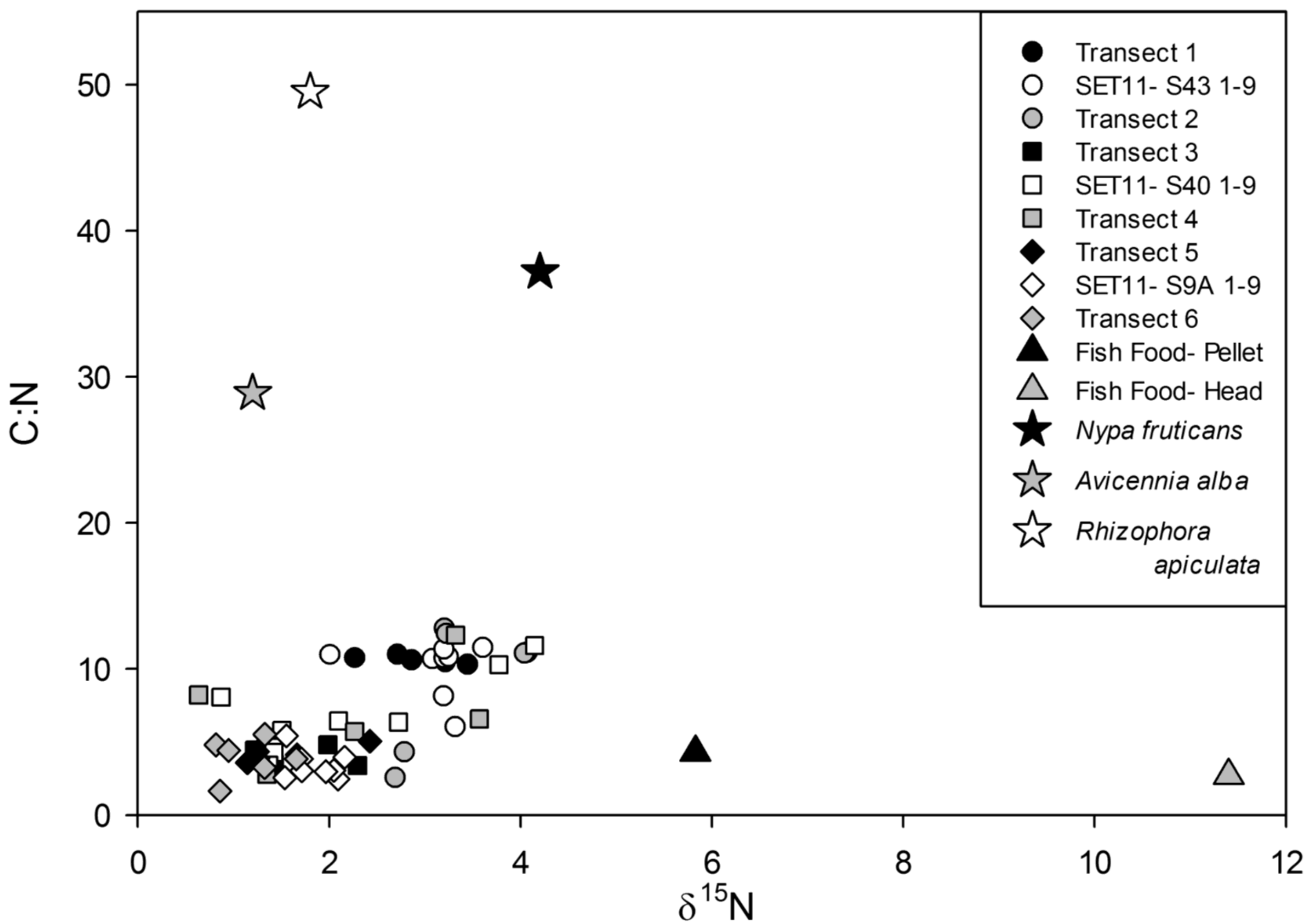


Figure 14: $\delta^{15}N$ vs. C:N. Values indicate the relative molar amount of carbon compared to nitrogen in comparison with how enriched in ^{15}N the sediment, fish food and plants are in relation to ^{14}N.

FORAMINIFERAL DISTRIBUTION

CLUSTER ANALYSIS

Sixty-three samples contained 83 species. Two cluster analyses are presented, one on total (live plus dead) assemblages and one on dead assemblages (Figures 15, 16). A cluster analysis was not run on live populations due to the patchy distribution and generally low numbers of live foraminifera north of the inlet. SET11-S43 and its corresponding transects (one and two) contained only five samples with more than 50 live specimens. SET11-S40 and its corresponding transects (3 and 4) did not contain any samples with more than 50 live specimens. In contrast, SET11-S9A and its corresponding transects (5 and 6), in the Setiu estuary, contained 15 samples with more than 50 live specimens.

Total Foraminifera

The total cluster analysis was run on all samples and specimens, live and dead (i.e., total), except for ten taxa (*Buliminella elegantissima*, *Cheilochanus* sp., *Hanzawaia nipponica,* ?*Jadammina* sp., *Neoconorbina* sp., ?*Neoconorbina, nodosariid, Planodiscorbis* sp., *Spirolina cylindracea,* and *Wiesnerella* sp.) that were each represented by one specimen. The dendrogram (Figure 15) exhibited three major groups of samples, TA, TB, and TC. Each of these groups contained two subdivisions resulting in groups TA1, TA2, TB1, TB2, TC1, and TC2.

Group TA1 contains 35 taxa in four samples (Tables 4, 5; Figure 15). Of the six groups, TA1 has the lowest average density (NT) and mean number of specimens picked (nT) and an average of 28% live specimens (%L) and 35% live species (%SL) (Table 6). It is dominated by *Amphistegina lessonii* and *Ammonia* aff. *A. aoteana*; *Pararotalia* sp., "*Trochammina ochracea*", and *Ammotium morenoi* are important subsidiary taxa (Table 5). Group TA1 has a mean of 80%

calcareous specimens (T%c) (Table 6). Three samples contained within this cluster are at the southern end of transect 2 (T2-30, T2-60, T2-100) and the other, SET11-S40-9, occurs on the southeast barrier island side of the fish cage complex (Table 4; Figure 15). Of the three samples along transect 2, none contained more than 18 specimens whereas foraminifera were abundant in SET11-S40-9.

Group TA2 contains 66 taxa in 14 samples (Figure 15; Table 5). Of the six groups, TA2 has the highest average density (NT), is the most diverse with a Fisher's alpha value of 12.3, has the lowest mean percent live specimens (%L) and percent agglutinated specimens (T%t), and has the greatest mean number of species (ST) of the six groups with 12% of species live (%SL) (Table 6). It is dominated by *Ammonia* aff. *A. aoteana* with *Sagrinella lobata, Ammobaculites exiguus*, *Quinqueloculina* sp., *Reussella pulchra* and *Bolivina* sp. as important subsidiary taxa (Table 5). All samples in group TA2 are from the SET11-S40 fish cage complex and its associated transects 3 and 4 (Table 4; Figure 15).

Group TB1 contains 55 taxa and 12 samples (Table 5). Group TB1 has mean values of 26% live specimens (%L), 41% live species, 54% agglutinated specimens (T%t) and an average density of 2,480 specimens per 20 mL of sediment (NT) (Table 6). *Ammonia* aff. *A. aoteana* and *Ammobaculites exiguus* dominate the assemblage with *Paratrochammina stoeni* and *Trochammina amnicola* as important subsidiaries (Table 5).

Group TB2 contains 46 taxa and 12 samples and has the same four most abundant taxa as TB1 but *Ammobaculites exiguus* strongly dominates (Table 5). *Trochammina* sp. E and *Ammotium morenoi* are also important subsidiary taxa in TB2 (Table 5). Group TB2 is characterized by a mean of 83% agglutinated specimens (T%t) and 85% of all live specimens were agglutinated (T%Lt) though on average, only 16% of specimens and 41% of species were live (%L, %SL) in group TB2 (Table 6). It has an average density of 2,696 specimens per 20 mL of sediment (Table 6).

Groups TB1 and TB2 combined characterize the SET11-S43 fish cage complex and its associated transect 1 and part of transect 2 (T2-0, T2-5, T2-15) as well as the majority of transect 3 (T3-100, T3-60, T3-30, T3-15) and three samples (SET11-S40-2, SET11-S40-3, and SET11-S40-6) in the SET11-S40 fish cage complex (Table 4; Figure 15). The westernmost samples of the SET11-S43 fish cage complex (SET11-S43-1, SET11-S43-4, and SET11-S43-7) cluster in group TB2 while samples within and to the east of the fish cage complex cluster in group TB1.

Groups TC1 and TC2 include all samples at the SET11-S9A abandoned fish farm complex (Table 4; Figures 15, 17). Group TC1 is comprised of three samples (S9A-5, S9A-6, S9A-7) and is dominated by four agglutinated taxa, *Ammobaculites exiguus, Trochammina amnicola*, *Miliammina fusca* and *Ammotium directum* (Table 5) and has an average density of 602 specimens per 20 mL of sediment (NT) and 100% agglutinated specimens (T%t) (Table 6). Group TC2 has the same most abundant four taxa but it is strongly dominated by *Miliammina fusca* (Table 5) and has an average density of 2,277 specimens per 20 mL of sediment (Table 6). Group TC2 characterizes 18 of 21 samples from the abandoned fish cage complex SET11-S9A (Table 4; Figure 15). On average, group TC2 is composed of 99% agglutinated specimens (T%t) and one calcareous taxon (STc) (Table 6). Groups TC1 and TC2 have the highest mean percent live species (%SL) and relatively low species richness with 64% and 43% live specimens (%L) and 79% and 73% live species (%SL), respectively (Table 6; Figure 17). Groups TC1 and TC2 also have the lowest mean number of species (ST) and diversity (α) (Table 6).

Dead Foraminifera

The cluster analysis for dead foraminifera was run on all samples except SET11-S9A-6, which contained no dead foraminifera, and all dead specimens except for twelve taxa (*Ammonia* sp., *Buliminella elegantissima*, *Cheilochanus* sp., *Hanzawaia nipponica*, ?*Jadammina* sp., *Neoconorbina* sp., ?*Neoconorbina*, *nodosariid*, *Nonion* sp., *Planodiscorbis* sp., *Spirolina cylindracea*, and *Wiesnerella* sp.) that were each represented by one specimen. Similar to the total cluster analysis, the dead cluster analysis provided a dendrogram (Figure 16) with three major groups of samples, DA, DB, and DC. Each of these groups contained two subdivisions resulting in groups DA1, DA2, DB1, DB2, DC1, and DC2.

Cluster groups DA1 and DA2 are characterized by the same samples as groups TA1 and TA2, respectively (Table 4). TA1 and DA1 are similar in composition and are the only groups dominated by *Amphistegina lessonii* with *Pararotalia* sp. and *Ammonia* aff. *A. aoteana* (Tables 5, 7). Like TA1, DA1 has 80% calcareous specimens (T%c) and the lowest average density (NT) of all dead cluster groups (Table 6). Similar to group TA2, group DA2 is the most diverse (α) of the six groups with 65 taxa in the same 14 samples (Tables 6, 7), has the highest average density (NT) of all dead cluster groups (Table 6), and has the same dominant and subsidiary taxa (Table 7).

Groups DB1 and DB2 combined represent the same sample locations as TB1 and TB2 (Figures 15, 16; Table 4), although TB1 and DB1 do not represent the same sample locations. Groups TB1 and DB1 are similar in distribution with eight identical samples whereas TB2 and DB2 have seven identical samples. DB1 with 55 taxa, 13 samples, and the same two dominant taxa as TB2 and DB2, is more similar compositionally to TB2 and DB2 than to TB1 (Table 7). Group DB1 has a higher mean density (NT), but similar mean diversity value (α) and mean percent agglutinated specimens (T%t) as TB1 (Table 6). Group DB1 characterizes the southern portion of the SET11-S43 fish cage complex and part of its associated transect 2 (T2-0, T2-5, T2-15), part of transect 3 (T3-15, T3-30, T3-60) and two sample locations in the SET11-S40 fish cage complex (SET11-S40-2, SET11-S40-6) whereas group DB2 characterizes the northern portion of the SET11-S43 fish cage complex as well as its associated transect 1 and T3-100 (Table 4; Figure 16). The same three taxa (*Ammobaculites exiguus*, *Ammonia* aff. *A. aoteana*, and *Paratrochammina stoeni*) dominate group DB2 and TB2 with similar mean percent abundances (Table 7), percent agglutinated specimens (T%t), and similar diversity values (α), although the mean density of DB2 (NT) is much lower than the mean density of TB2 (Table 6).

Like groups TC1 and TC2, DC1 and DC2 include all samples at the SET11-S9A abandoned fish farm complex except for SET11-S9A-6, which contained no dead foraminifera (Table 4; Figure 16). Groups TC2 and DC2 are most similar in distribution with nine identical samples (Table 4). Groups DC1 and DC2 are most similar in foraminiferal composition but not abundance. Like groups TC1 and TC2, groups DC1 and DC2 are composed of nearly 100% agglutinated species and specimens (T%t) and have low diversity values (α) (Table 6). Group DC1 occurs at nine sample locations and includes 16 taxa (Table 4; Figure 16). It is dominated by *Miliammina fusca* and *Ammotium directum*, with *Trochammina amnicola* and *Ammobaculites exiguus* as significant subsidiary taxa (Table 7), and has a similar mean density (NT) as TC1 (Table 6). Group DC1 characterizes all of transect 5, one sample along transect 6 (T6-0), and four samples within the SET11-S9A abandoned fish cage complex (SET11-S9A-5, SET11-S9A-6, SET11-S9A-7) (Table 4; Figure 16). Group DC2 includes the remaining 11 sample locations (except SET11-S9A-6 which contained no dead foraminifera) and contains 15 taxa. It has a density (NT) similar to TC2 (Table 6) and the same four most abundant taxa as DC1 but it is strongly dominated by *Miliammina fusca* (Table 7).

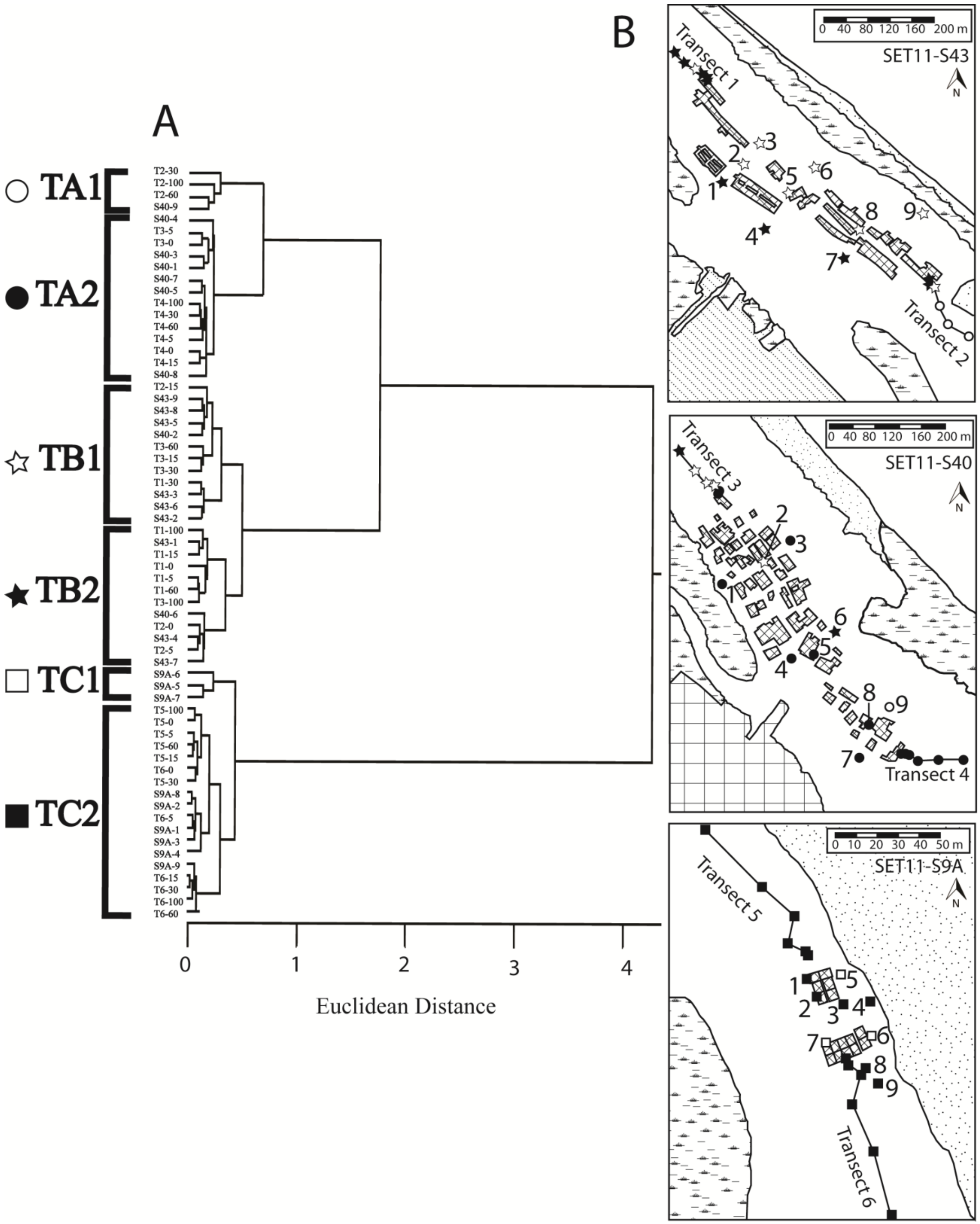


Figure 15: A, Total cluster analysis dendrogram of all specimens (excluding species which occurred at only one station and had only one specimen) indicating six groups. **B,** distribution of total cluster groups defined in A.

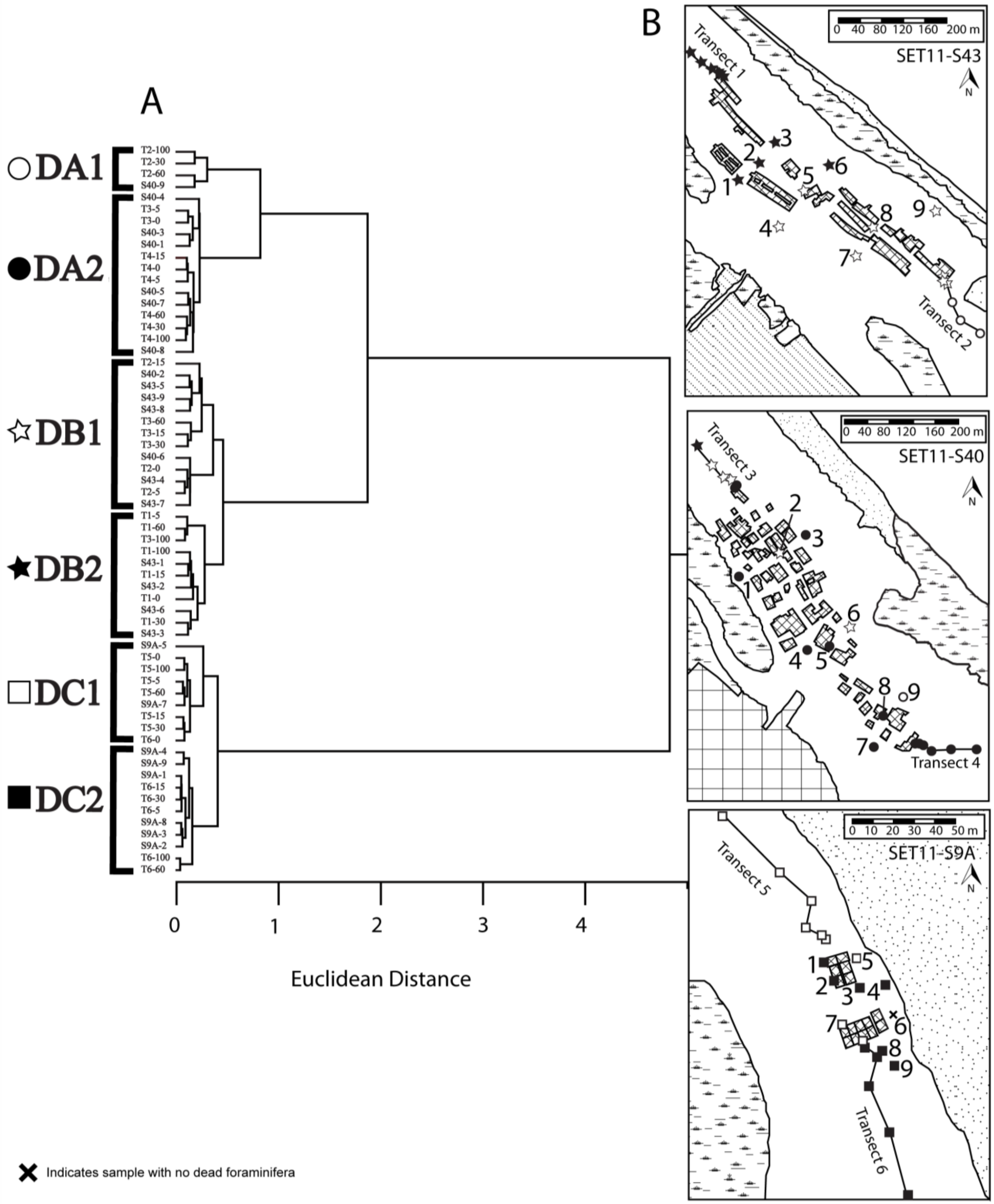


Figure 16: A, Dead cluster analysis dendrogram of all specimens (excluding species which occurred at only one station and had only one specimen) indicating six groups. **B,** distribution of dead cluster groups defined in A.

Table 4: Values for various assemblage characteristics for each sample arranged from north to south. TC, total cluster group; DC, dead cluster group; nT, total number of specimens picked; nL, number of live specimens picked; nD, number of dead specimens picked; NT, total number of foraminifera/20 mL of sediment; NL, number of live foraminifera/20 mL of sediment; ND, number of dead foraminifera/20 mL of sediment; %L, percent live specimens; %D, percent dead specimens; ST, total number of species; SL, number of live species; SD, number of dead species; %SL, percent live species; %SD, percent dead species; α, Fisher's alpha for total assemblages; 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; %Lt, percent of live textulariid species; %Lc, percent of live calcareous species; T%t, percent of textulariid specimens in total assemblage; T%c, percent calcareous specimens in total assemblage; T%Lt, percent of live textulariid specimens of all live specimens; T%Lc, percent live calcareous specimens of all live specimens; T%Dt, percent dead textulariid specimens of all dead specimens; T%Dc, percent of dead calcareous specimens of all dead specimens.

Sample Location	TC	DC	nT	nL	nD	NT	NL	ND	%L	%D	ST	SL	SD	%SL	%SD	α	STt	STc	SDt	SDc	SLt	SLc	%Lt	%Lc	T%t	T%c	T%Lt	T%Lc	T%Dt	T%Dc
S43-T1-100	TB2	DB2	130	17	113	130	17	113	13	87	9	5	9	56	100	2.2	7	2	7	2	5		71		94	6	100		93	7
S43-T1-60	TB2	DB2	96	11	85	96	11	85	11	89	10	3	10	30	100	2.8	9	1	9	1	3		33		97	3	100		96	4
S43-T1-30	TB1	DB2	219	53	166	246	60	187	24	76	11	6	11	55	100	2.4	8	3	8	3	5	1	63	33	79	21	94	6	73	27
S43-T1-15	TB2	DB2	113	18	95	113	18	95	16	84	13	4	13	31	100	3.8	9	4	9	4	4		44		82	18	100		79	21
S43-T1-5	TB2	DB2	105	20	85	105	20	85	19	81	9	5	8	56	89	2.4	6	3	5	3	5	1	83	33	93	7	95	5	93	7
S43 T1-0	TB2	DB2	49	11	38	49	11	38	22	78	13	6	12	46	92	5.8	8	5	7	5	5	1	63	20	71	29	91	9	66	34
Average			119	22	97	123	23	100	18	82	11	5	11	45	97	3.2	8	3	8	3	5	1	60	14	86	14	97	3	3	3
S43-1	TB2	DB2	210	48	162	2100	480	1620	23	77	21	11	19	52	90	5.8	9	12	9	10	6	5	67	42	77	23	77	23	77	23
S43-2	TB1	DB2	166	61	105	166	61	105	37	63	18	11	13	61	72	5.1	12	6	8	5	8	2	67	33	57	43	43	2	66	34
S43-3	TB1	DB2	162	87	75	162	87	75	54	46	17	8	16	47	94	4.8	10	7	9	7	8	1	80	14	60	40	54	46	68	32
S43-4	TB2	DB1	216	29	187	12960	1740	11220	13	87	13	6	12	46	92	3.0	7	6	6	6	5	1	71	17	77	23	86	14	76	24
S43-5	TB1	DB1	195	55	140	5850	1650	4200	28	72	29	11	23	38	79	9.4	10	19	8	15	5	6	50	32	35	65	36	64	34	66
S43-6	TB1	DB2	205	29	176	205	29	176	14	86	16	8	14	50	88	4.1	9	7	8	6	6	2	67	29	57	43	55	45	57	43
S43-7	TB2	DB1	225	33	192	2531	371	2160	15	85	8	4	7	50	88	1.6	5	3	5	2	3	1	60	33	96	4	94	6	96	4
S43-8	TB1	DB1	196	38	158	490	95	395	19	81	16	7	14	44	88	4.1	6	10	5	9	4	3	67	30	44	56	37	63	46	54
S43-9	TB1	DB1	193	25	168	2573	333	2240	13	87	30	8	28	27	93	9.9	10	20	9	19	5	4	50	20	38	62	32	68	39	61
Average			196	45	151	3004	539	2466	24	76	19	8	16	46	87	5.3	9	10	7	9	6	3	64	28	60	40	57	37	37	37
S43-T2-0	TB2	DB1	232	53	179	6960	1590	5370	23	77	22	6	20	27	91	6.0	10	12	8	12	4	2	40	17	66	34	58	42	68	32
S43-T2-5	TB2	DB1	217	24	193	1395	154	1241	11	89	16	5	15	31	94	4.0	6	10	5	10	5	1	83	10	76	24	79	21	76	24
S43-T2-15	TB1	DB1	72	40	32	72	40	32	56	44	15	7	12	47	80	5.8	6	9	3	9	5	2	83	22	47	53	53	48	41	59
S43-T2-30	TA1	DA1	5	1	4	5	1	4	20	80	3	1	2	33	67	3.2	1	2		2	1		100		20	80	100			100
S43-T2-60	TA1	DA1	18	4	14	18	4	14	22	78	8	4	7	50	88	5.5	3	5	2	5	2	1	67	20	28	72	75	25	14	86
S43-T2-100	TA1	DA1	14	9	5	14	9	5	64	36	8	4	4	50	50	7.8	3	5	1	3	2	2	67	40	29	71	33	67	20	80
Average			93	22	71	1411	300	1111	33	67	12	5	10	40	78	5.4	5	7	3	7	3	1	73	18	44	56	66	34	34	34
S40-T3-100	TB2	DB2	189	23	166	1701	207	1494	12	88	16	6	15	38	94	4.2	11	5	11	4	4	2	36	40	94	6	91	9	95	5
S40-T3-60	TB1	DB1	201	36	165	1096	196	900	18	82	19	8	17	42	89	5.1	8	11	7	10	5	3	63	27	65	35	81	19	61	39
S40-T3-30	TB1	DB1	172	22	150	2580	330	2250	13	87	22	6	21	27	95	6.7	10	12	8	12	5	1	50	8	79	21	59	41	82	18
S40-T3-15	TB1	DB1	197	35	162	7092	1260	5832	18	82	24	6	23	25	96	7.2	9	14	8	14	5	1	56	7	51	49	31	69	56	44
S40-T3-5	TA2	DA2	184	6	178	12044	393	11651	3	97	37	4	36	11	97	13.4	8	27	8	27		4		15	25	75		100	26	74
S40-T3-0	TA2	DA2	189	7	182	11340	420	10920	4	96	33	6	32	18	97	11.6	7	26	6	26	3	3	43	12	26	74	43	57	26	74
Average			189	22	167	5976	468	5508	11	89	25	6	24	27	95	8.0	9	16	8	16	4	2	41	18	57	43	51	49	58	42
S40-1	TA2	DA2	177	17	160	63720	6120	57600	10	90	37	8	35	22	95	14.3	5	32	5	31	3	4	60	13	19	81	35	65	18	83
S40-2	TB1	DB1	205	26	179	9225	1170	8055	13	87	27	7	25	26	93	8.3	8	19	8	17	3	4	38	21	32	68	12	127	35	65
S40-3	TA2	DA2	189	7	182	38887	1440	37440	4	96	27	2	26	7	96	8.2	4	22	4	22	1	1	25	5	14	86	14	86	14	86
S40-4	TA2	DA2	150	3	147	9600	192	9408	2	98	31	2	30	6	97	11.9	4	26	4	25		2		8	13	87		100	13	87
S40-5	TA2	DA2	208	10	198	74880	3600	71280	5	95	32	3	32	9	100	10.8	3	29	3	29	1	2	33	7	12	88	20	80	12	88
S40-6	TB2	DB1	193	26	167	4211	567	3644	13	87	21	7	19	33	90	6.0	7	14	6	16	4	3	57	21	75	25	54	46	78	22
S40-7	TA2	DA2	174	8	166	38541	1772	36775	5	95	32	3	31	9	97	11.5	5	26	5	26	2	1	40	4	15	85	25	75	14	86
S40-8	TA2	DA2	180	4	176	51840	1152	50688	2	98	32	3	30	9	94	11.3	2	30	2	28		4		13	1	99		100	1	99
S40-9	TA1	DA1	190	7	183	1267	47	1220	4	96	31	2	31	6	100	10.5	4	27	4	27		2		7	4	96		100	4	96
Average			185	12	173	32463	1784	30679	6	94	30	4	29	14	96	10.3	5	25	5	25	2	3	28	11	20	80	18	86	21	79
S40-T4-0	TA2	DA2	160	7	153	32920	1440	31474	4	96	34	4	33	12	97	13.2	4	30	4	29		4		13	7	93		86	7	93
S40-T4-5	TA2	DA2	184	9	175	66240	3240	63000	5	95	37	7	34	19	92	14.0	5	31	4	30	3	3	60	10	12	88	44	56	10	90
S40-T4-15	TA2	DA2	181	12	169	43440	2880	40560	7	93	38	3	36	8	95	14.7	5	33	4	33	1	2	20	6	8	92	8	92	8	92
S40-T4-30	TA2	DA2	175	10	165	84000	4800	79200	6	94	35	6	32	17	91	13.2	3	32	2	30	1	4	33	13	8	92	10	80	8	92
S40-T4-60	TA2	DA2	261	13	248	62640	3120	59520	5	95	35	1	36	3	103	11.3	4	32	4	32		1		3	9	91		100	10	90
S40-T4-100	TA2	DA2	209	14	195	37620	2520	35100	7	93	37	5	34	14	92	13.1	5	32	2	32	3	2	60	6	5	95	21	79	4	96
Average			195	11	184	54477	3000	51476	6	94	36	4	34	12	95	13.2	4	32	3	31	1	3	29	8	8	92	14	82	8	92
S9A-T5-100	TC2	DC1	192	54	138	272	77	196	28	72	12	8	11	67	92	2.8	11	1	10	1	7	1	64	100	97	3	96	4	98	2
S9A-T5-60	TC2	DC1	222	128	94	850	490	360	58	42	6	6	5	100	83	1.1	5	1	5		5	1	100	100	99	1	98	2	100	
S9A-T5-30	TC2	DC1	191	10	181	625	33	592	5	95	7	3	7	43	100	1.4	6	1	6	1	3		50		99	1	100		99	1
S9A-T5-15	TC2	DC1	196	72	124	231	85	146	37	63	8	5	7	63	88	1.7	7	1	6	1	5		71		99	1	100		98	2
S9A-T5-5	TC2	DC1	178	42	136	4577	1080	3497	24	76	7	5	7	71	100	1.5	7		7		5		71		100		100		100	
S9A-T5-0	TC2	DC1	180	67	113	360	134	226	37	63	9	5	9	56	100	2.0	8	1	8	1	5		63		99	1	100		99	1
Average			193	62	131	1153	316	836	31	69	8	5	8	67	94	1.8	7	1	7	1	5	0	70	33	99	1	99	1	99	1
S9A-1	TC2	DC2	220	95	125	220	95	125	43	57	5	4	5	80	100	0.9	5		5		4		80		100		100		100	
S9A-2	TC2	DC2	222	141	81	2854	1813	1041	64	36	6	6	5	100	83	1.4	6	1	5		5	1	83	100	99	1	99	1	100	
S9A-3	TC2	DC2	225	90	135	6750	2700	4050	40	60	6	6	4	100	67	1.1	6		4		6		100		100		100		100	
S9A-4	TC2	DC2	166	8	158	6640	320	6320	5	95	10	3	11	30	110	2.6	10	1	10	1	3		30		99	1	100		99	1
S9A-5	TC1	DC1	166	37	129	332	74	258	22	78	11	6	11	55	100	2.6	10	1	10	1	6		60		99	1	100		99	1
S9A-6	TC1		18	18		18	18		100		3	3		100	0	1.0	3				3		100		100		100			
S9A-7	TC1	DC1	194	134	60	1455	1005	450	69	31	6	5	6	83	100	1.4	6		6		5		83		100		100		100	
S9A-8	TC2	DC2	224	64	160	10080	2880	7200	29	71	9	5	8	56	89	1.9	7	2	7	1	4	1	57	50	99	1	98	2	99	1
S9A-9	TC2	DC2	187	109	78	1870	1090	780	58	42	6	5	6	83	100	1.2	6		6		5		83		100		100		100	
Average			180	77	103	3358	1111	2247	48	52	7	5	7	76	83	1.6	7	1	6	0	5	0	75	17	100	1	100	0	100	0
S9A-T6-0	TC2	DC1	57	27	30	57	27	30	47	53	6	5	5	83	83	1.7	5	1	5		4	1	80	100	98	2	96	4	100	
S9A-T6-5	TC2	DC2	196	71	125	980	355	625	36	64	6	4	6	67	100	1.2	4	2	4	2	4		100		98	2	100		98	2
S9A-T6-15	TC2	DC2	186	123	63	452	299	153	66	34	5	3	5	60	100	0.9	5		5		3		60		100		100		100	
S9A-T6-30	TC2	DC2	203	119	84	446	261	184	59	41	4	4	4	100	100	0.7	4		4		4		100		100		100		100	
S9A-T6-60	TC2	DC2	194	137	57	1091	771	321	71	29	4	2	4	50	100	0.7	4		4		2		50		100		100		100	
S9A-T6-100	TC2	DC2	205	148	57	2636	1903	733	72	28	5	5	5	100	100	0.9	5		5		5		100		100		100		100	
Average			174	104	69	944	603	341	59	41	5	4	5	77	97	1.0	5	1	5	0	4	0	82	17	99	1	99	1	100	0

Table 5: Mean percent abundance of all species included in and defined by the total cluster analysis of all data (species which only occurred once and with one specimen not included).

Group TA1	**Mean**	**Group TA2**	**Mean**	**Group TB1**	**Mean**	**Group TB2**	**Mean**	**Group TC1**	**Mean**	**Group TC2**	**Mean**
4 samples, 35 taxa	**%**	**14 samples, 66 taxa**	**%**	**12 samples, 55 taxa**	**%**	**12 samples, 46 taxa**	**%**	**3 samples, 12 taxa**	**%**	**18 samples, 17 taxa**	**%**
Amphistegina lessonii	36.19	*Ammonia* aff. *A. aoteana*	14.29	*Ammonia* aff. *A. aoteana*	29.74	*Ammobaculites exiguus*	55.60	*Ammobaculites exiguus*	32.55	*Miliammina fusca*	63.36
Ammonia aff. *A. aoteana*	17.96	*Sagrinella lobata*	8.71	*Ammobaculites exiguus*	26.84	*Ammonia* aff. *A. aoteana*	9.84	*Trochammina amnicola*	27.66	*Ammobaculites exiguus*	12.53
Pararotalia sp.	6.79	*Ammobaculites exiguus*	8.67	*Paratrochammina stoeni*	5.84	*Paratrochammina stoeni*	7.64	*Miliammina fusca*	18.33	*Ammotium directum*	12.53
"Trochammina ochracea"	6.79	*Quinqueloculina* sp.	6.94	*Trochammina amnicola*	5.06	*Trochammina amnicola*	4.19	*Ammotium directum*	11.71	*Trochammina amnicola*	7.74
Ammotium morenoi	6.48	*Reussella pulchra*	6.73	*Trochammina* sp.	3.98	*Trochammina* sp. E	4.08	Indeterminate agglutinated	4.38	Indeterminate agglutinated	1.23
Quinqueloculina sp.	4.75	*Bolivina* sp.	6.63	*Ammotium morenoi*	3.57	*Ammotium morenoi*	4.05	*Trochammina* sp.	2.21	*Siphotrochammina lobata*	0.63
Ammobaculites exiguus	3.30	Indeterminate calcareous	6.46	*Trochammina* sp. E	3.51	*Trochammina* sp.	3.26	*Haplophragmoides* cf. *H. manilaensis*	0.80	*Haplophragmoides* cf. *H. manilaensis*	0.44
Indeterminate calcareous	2.97	*Cibicides* cf. *C. fletcheri*	3.74	*Bolivina* sp.	2.62	*Cavarotalia annectens*	1.58	*Ammotium morenoi*	0.60	*"Glomospira" fijiensis*	0.34
Cavarotalia annectens	2.18	*Sagrina zanzibarica*	3.74	*Reussella pulchra*	2.44	*"Trochammina ochracea"*	1.33	*Siphotrochammina lobata*	0.60	*Ammotium morenoi*	0.24
Ammotium directum	1.79	*Gavelinopsis praegeri*	2.75	*Sagrinella lobata*	1.59	*Ammotium directum*	1.28	*Trochammina laevigata*	0.60	*Arenoparrella mexicana*	0.22
Cellanthus sp.	1.52	Indeterminate rotaliid	2.55	Indeterminate calcareous	1.54	Indeterminate calcareous	1.09	*"Trochammina ochracea"*	0.35	*Trochammina laevigata*	0.22
Trochammina sp.	1.39	*Rosalina globularis*	2.39	*"Trochammina ochracea"*	1.50	Indeterminate agglutinated	0.69	*Ammonia* aff. *A aoteana*	0.20	*Trochammina* sp.	0.21
Asterorotalia pulchella	1.18	*Amphistegina lessonii*	2.26	*Ammotium directum*	1.33	*Reussella pulchra*	0.66			*Quinqueloculina* sp.	0.17
Reussella pulchra	0.92	*Cavarotalia annectens*	2.23	Indeterminate rotaliid	1.29	*Bolivina* sp.	0.49			*Bolivina* sp.	0.05
Elphidium indicum	0.53	*Ammonia tepida*	1.68	Indeterminate agglutinated	1.13	*Rosalina globularis*	0.47			*Elphidium hyalocostatum*	0.03
Elphidium singaporense	0.53	*Elphidium singaporense*	1.65	*Amphistegina lessonii*	1.03	Indeterminate rotaliid	0.36			*Haplophragmoides wilberti*	0.03
Planorbulina acervalis	0.53	*Elphidium* sp.	1.40	*Gavelinopsis praegeri*	0.56	*Miliammina fusca*	0.35			*"Trochammina ochracea"*	0.03
Sagrinella lobata	0.53	*Pararotalia nipponica*	1.28	*Sagrina zanzibarica*	0.55	*Quinqueloculina* sp.	0.30				
Bolivina sp.	0.39	*Ammotium morenoi*	1.19	*Ammonia tepida*	0.54	*Amphistegina lessonii*	0.24				
Cibicides sp. B	0.39	*Cibicides* sp.	1.12	*Miliammina fusca*	0.46	*Caronia exilis*	0.20				
Ammonia tepida	0.26	*Cibicides* sp. B	0.96	*Cavarotalia annectens*	0.43	*Trochammina inflata*	0.20				
Cellanthus biperforatus	0.26	*Rosalina* sp. B	0.90	*Reussella* sp. C	0.32	*Bruneica clypea*	0.17				
Elphidium hyalocostatum	0.26	*Planorbulina acervalis*	0.87	*Rosalina globularis*	0.26	*Sagrinella lobata*	0.17				
Indeterminate agglutinated	0.26	*Elphidium* cf. *E. neosimplex*	0.85	*“Glomospira” fijiensis*	0.21	*Elphidium* aff. *E. simulatum*	0.16				

Table 5 continued.

Indeterminate rotaliid	0.26	*Asterorotalia pulchella*	0.63	*Quinqueloculina* sp.	0.21	*Cellanthus craticulus*	0.15
Pararotalia sp. A	0.26	*Schackoinella globosa*	0.60	*Cellanthus craticulus*	0.20	*"Glomospira" fijiensis*	0.15
Reussella sp. C	0.26	*Murrayinella murrayi*	0.58	*Haplophragmoides wilberti*	0.18	*Siphotrochammina lobata*	0.13
Cancris carinatus	0.13	*Reussella spinulosa*	0.56	*Pararotalia nipponica*	0.18	*Cellanthus* sp.	0.12
Caronia exilis	0.13	*Caronia exilis*	0.44	*Ammodiscus* sp. A	0.17	*Elphidium* sp.	0.12
Cibicides cf. *C. fletcheri*	0.13	*Reussella* sp. C	0.44	*Caronia exilis*	0.17	*Ammonia tepida*	0.09
Cibicides sp.	0.13	*Trochammina amnicola*	0.44	*Elphidium* cf. *E. neosimplex*	0.17	*Arenoparrella mexicana*	0.09
Elphidium cf. *E. neosimplex*	0.13	*Peneroplis pertusus*	0.41	*Elphidium* sp.	0.17	*Globocassidulina bisecta*	0.09
Elphidium aff. *E. simulatum*	0.13	*Paratrochammina stoeni*	0.37	*Murrayinella murrayi*	0.17	*Rosalina* sp. B	0.09
Murrayinella murrayi	0.13	*Miliammina fusca*	0.33	*Siphotrochammina lobata*	0.14	*Sagrina zanzibarica*	0.09
Pararotalia nipponica	0.13	*Elphidium* aff. *E. simulatum*	0.31	*Cibicides* cf. *C. fletcheri*	0.13	*Asterorotalia pulchella*	0.07
		Eponides sp.	0.28	*Elphidium simplex*	0.13	*Ammodiscus* sp. A	0.04
		Elphidium hyalocostatum	0.27	*Elphidium* aff. *E. simulatum*	0.13	*Cancris carinatus*	0.04
		Elphidium simplex	0.27	*Nonion* sp.	0.13	*Cellanthus biperforatus*	0.04
		Indeterminate agglutinated	0.27	*Pseudorotalia* cf. *P. schroeteriana*	0.13	*Elphidium indicum*	0.04
		Pararotalia sp.	0.26	*Cellanthus* sp.	0.12	*Elphidium* cf. *E. neosimplex*	0.04
		Globocassidulina bisecta	0.25	Indeterminate miliolid	0.12	*Elphidium* aff. *E. poeyanum*	0.04
		Elphidium aff. *E. poeyanum*	0.23	*Pararotalia* sp.	0.12	*Elphidium simplex*	0.04
		Trochammina sp. E	0.23	*Asterigerinata* sp. A	0.09	*Gavelinopsis praegeri*	0.04
		Trochammina sp.	0.23	*Cibicides* sp. B	0.09	*Guttulina* sp.	0.04
		Cancris carinatus	0.21	*Elphidium* aff. *E. poeyanum*	0.09	*Planorbulina acervalis*	0.04
		Brizalina subtenuis	0.20	*Asterorotalia pulchella*	0.08	*Pseudorotalia* cf. *P. schroeteriana*	0.04
		Elphidium advenum	0.16	*Bruneica clypea*	0.08		
		Pararotalia venusta	0.16	*Elphidium hyalocostatum*	0.05		
		Spiroloculina manifesta	0.16	*Eponides* sp.	0.05		
		Buliminoides williamsoni	0.13	*Trochammina laevigata*	0.05		
		Cellanthus craticulus	0.12	*Arenoparrella mexicana*	0.04		
		Pararotalia calcariformata	0.12	*Cibicides* sp.	0.04		
		Elphidium crispum s.l.	0.11	*Planorbulina acervalis*	0.04		

Table 5 continued.

Indeterminate miliolid	0.11	*Rosalina* sp. B	0.04
Pseudorotalia cf. *P. schroeteriana*	0.11	*Schackoinella globosa*	0.04
Elphidium indicum	0.10		
Haplophragmoides wilberti	0.09		
Ammonia sp.	0.08		
Ammotium directum	0.08		
Arenoparrella mexicana	0.08		
Guttulina sp.	0.08		
Pararotalia sp.	0.08		
"Trochammina ochracea"	0.08		
Cellanthus biperforatus	0.04		
Haplophragmoides cf. *H. manilaensis*	0.04		
Siphotrochammina lobata	0.04		

Table 6: Averages for eight cluster groups (CG). nT, total number of specimens picked; nL, number of live specimens picked; nD, number of dead specimens picked; NT, total number of foraminifera/20mL of sediment; NL, number of live foraminifera/20mL of sediment; ND, number of dead foraminifera/20mL of sediment; %L, percent live specimens; %D, percent dead specimens; ST, total number of species; SL, number of live species; SD, number of dead species; %SL, percent live species; %SD, percent dead species; α, Fisher's alpha for total assemblages; 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; %Lt, percent of live textulariid species; %Lc, percent of live calcareous species; T%t, percent of textulariid specimens in total assemblage; T%c, percent calcareous specimens in total assemblage; T%Lt, percent of live textulariid specimens of all live specimens; T%Lc, percent live calcareous specimens of all live specimens; T%Dt, percent dead textulariid specimens of all dead specimens; T%Dc, percent of dead calcareous specimens of all dead specimens.

CG	nT	nL	nD	NT	NL	ND	%L	%D	ST	SL	SD	%SL	%SD	α	STt	STc	SDt	SDc	SLt	SLc	%Lt	%Lc	T%t	T%c	T%Lt	T%Lc	T%Dt	T%Dc
TA1	57	5	52	326	15	311	28	72	13	3	11	35	76	6.7	3	10	2	9	2	2	78	22	20	80	69	64	13	90
TA2	187	9	178	44837	2364	42473	5	95	34	4	33	12	96	12.3	5	29	4	29	2	3	42	9	12	88	25	82	12	88
TB1	182	42	140	2480	443	2037	26	74	20	8	18	41	89	6.1	9	11	7	11	5	3	61	23	54	46	49	50	55	45
TB2	165	26	139	2696	432	2264	16	84	14	6	13	41	93	4.0	8	6	7	6	4	2	59	26	83	17	85	19	83	17
TC1	126	63	95	602	366	354	64	54	7	5	9	79	67	1.7	6	1	8	1	5		81		100	1	100		100	1
TC2	191	84	108	2277	801	1477	43	57	7	5	6	73	94	1.4	6	1	6	1	4	1	75	90	99	1	99	3	100	1
DA1	52		52	311		311		100	11		11		100	6.8	2	9	2	9					20	80			13	90
DA2	178		178	42473		42473		100	33		33		100	11.7	4	29	4	29					12	88			12	88
DB1	159		159	3657		3657		100	18		18		100	5.6	7	12	7	12					60	40			61	39
DB2	115		115	370		370		100	13		13		100	3.9	8	5	8	5					78	22			78	22
DC1	112		112	639		639		100	8		8		100	1.9	7	1	7	1					99	1			99	1
DC2	102		102	1958		1958		100	6		6		100	1.3	5	1	5	1					100	1			100	1

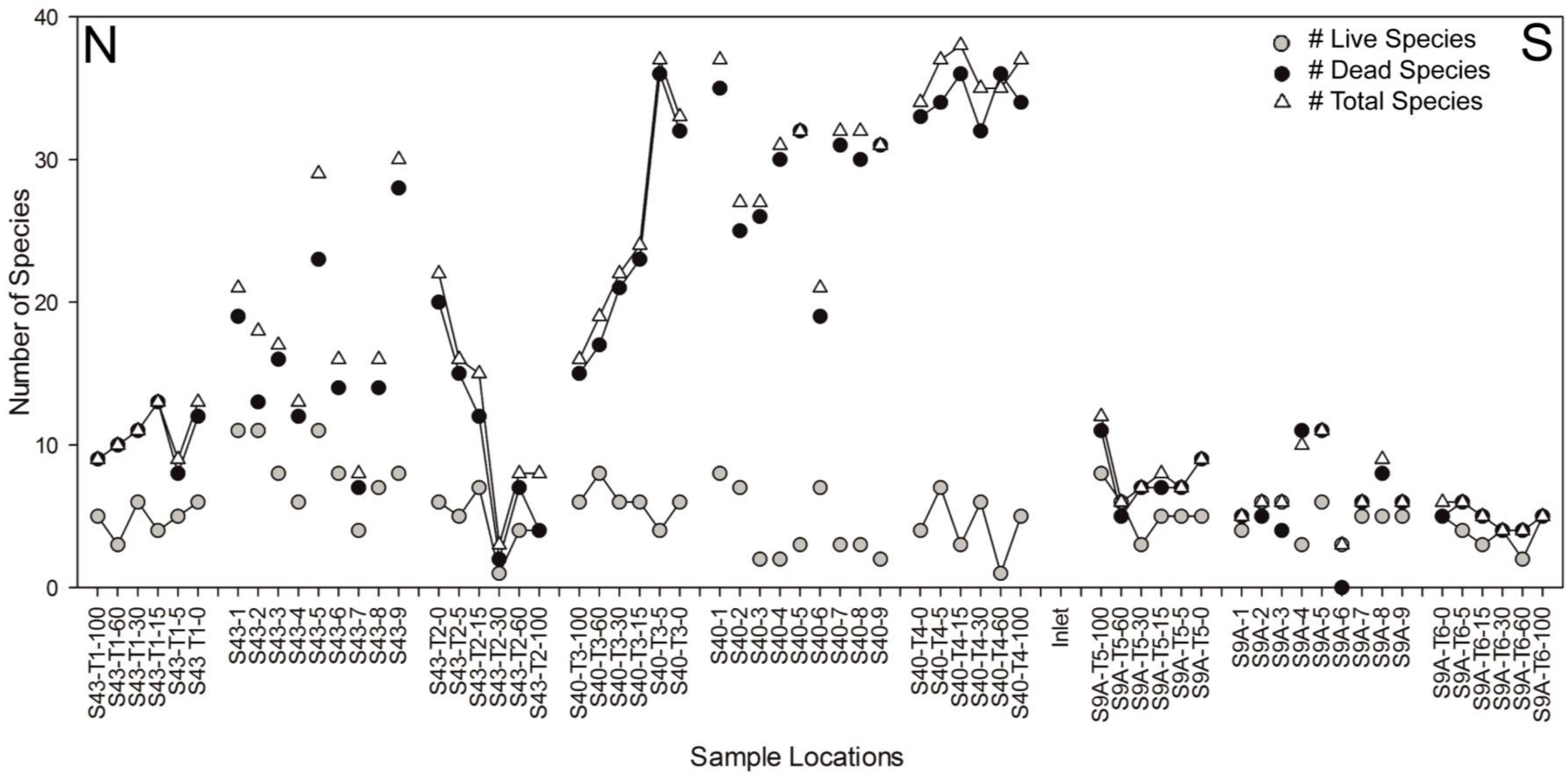


Figure 17: Species Richness: Live, dead, and total species richness for all sample locations. Transects indicated by connected symbols.

Table 7: Mean percent abundance of all species included in and defined by the dead cluster analysis of all dead assemblage data.

Group DA1	**Mean**	**Group DA2**	**Mean**	**Group DB1**	**Mean**	**Group DB2**	**Mean**	**Group DC1**	**Mean**	**Group DC2**	**Mean**
4 Samples, 34 Taxa	**%**	**14 Samples, 65 Taxa**	**%**	**13 Samples, 55 Taxa**	**%**	**11 Samples, 34 Taxa**	**%**	**9 Samples, 16 Taxa**	**%**	**11 Samples, 15 Taxa**	**%**
Amphistegina lessonii	49.31	*Ammonia* aff. *A. aoteana*	12.10	*Ammobaculites exiguus*	45.64	*Ammobaculites exiguus*	42.05	*Miliammina fusca*	50.97	*Miliammina fusca*	77.61
Pararotalia sp.	11.25	*Sagrinella lobata*	9.12	*Ammonia* aff. *A. aoteana*	19.01	*Ammonia* aff. *A. aoteana*	15.50	*Ammotium directum*	18.48	*Ammotium directum*	11.77
Quinqueloculina sp.	8.43	*Ammobaculites exiguus*	8.80	*Ammotium morenoi*	4.63	*Paratrochammina stoeni*	12.11	*Trochammina amnicola*	13.73	*Trochammina amnicola*	4.79
Ammonia aff. *A. aoteana*	7.81	*Quinqueloculina* sp.	7.41	*Bolivina* sp.	3.33	*Trochammina* sp.	6.58	*Ammobaculites exiguus*	7.89	*Ammobaculites exiguus*	3.23
Ammotium directum	5.00	*Reussella pulchra*	6.98	*Reussella pulchra*	3.02	*Trochammina amnicola*	4.53	Indeterminate agglutinated	3.61	*Siphotrochammina lobata*	0.69
Indeterminate calcareous	3.43	*Bolivina* sp.	6.95	*Trochammina amnicola*	2.64	*Trochammina* sp. E	4.41	*Trochammina* sp.	1.42	Indeterminate agglutinated	0.50
Ammotium morenoi	1.92	Indeterminate calcareous	6.56	*Paratrochammina stoeni*	1.93	*"Trochammina ochracea"*	3.05	*Haplophragmoides* cf. *H. manilaensis*	1.03	*Haplophragmoides* cf. *H. manilaensis*	0.34
Cellanthus sp.	1.92	*Sagrina zanzibarica*	3.89	Indeterminate calcareous	1.89	*Cavarotalia annectens*	2.20	*Ammotium morenoi*	0.65	*Trochammina laevigata*	0.29
Trochammina sp.	1.79	*Cibicides* cf. *C. fletcheri*	3.86	*Trochammina* sp. E	1.88	Indeterminate agglutinated	1.90	*Arenoparrella mexicana*	0.53	*Ammotium morenoi*	0.20
Asterorotalia pulchella	1.23	*Gavelinopsis praegeri*	2.87	*Sagrinella lobata*	1.74	*Ammotium morenoi*	1.62	*Trochammina laevigata*	0.44	*"Glomospira" fijiensis*	0.15
Reussella pulchra	0.96	Indeterminate rotaliid	2.63	*Amphistegina lessonii*	1.68	Indeterminate calcareous	0.95	*Siphotrochammina lobata*	0.40	*Bolivina* sp.	0.13
Ammobaculites exiguus	0.55	*Rosalina globularis*	2.41	Indeterminate rotaliid	1.47	*Ammotium directum*	0.92	*Quinqueloculina* sp.	0.30	*Arenoparrella mexicana*	0.12
Elphidium indicum	0.55	*Amphistegina lessonii*	2.30	*Ammotium directum*	1.24	Indeterminate rotaliid	0.75	*"Trochammina ochracea"*	0.19	*"Trochammina ochracea"*	0.07
Elphidium singaporense	0.55	*Cavarotalia annectens*	2.29	*Ammonia tepida*	0.72	*Reussella pulchra*	0.57	*"Glomospira" fijiensis*	0.18	*Haplophragmoides wilberti*	0.06
Planorbulina acervalis	0.55	*Elphidium singaporense*	1.73	Indeterminate agglutinated	0.68	*Bruneica clypea*	0.29	*Elphidium hyalocostatum*	0.10	*Trochammina* sp.	0.06
Sagrinella lobata	0.55	*Ammonia tepida*	1.71	*Gavelinopsis praegeri*	0.62	*Siphotrochammina lobata*	0.29	*Ammonia* aff. *A. aoteana*	0.09		
Bolivina sp.	0.41	*Elphidium* sp.	1.46	*“Trochammina ochracea”*	0.61	*Caronia exilis*	0.26				
Cavarotalia annectens	0.41	*Pararotalia nipponica*	1.33	*Trochammina* sp.	0.57	*Trochammina laevigata*	0.20				
Cibicides sp. B	0.41	*Cibicides sp.*	1.17	*Quinqueloculina* sp.	0.45	*"Glomospira" fijiensis*	0.18				
Ammonia tepida	0.27	*Ammotium morenoi*	1.15	*Miliammina fusca*	0.43	*Amphistegina lessonii*	0.17				
Cellanthus biperforatus	0.27	*Cibicides* sp. B	1.01	*Reussella* sp. C	0.42	*Miliammina fusca*	0.17				
Elphidium hyalocostatum	0.27	*Rosalina* sp. B	0.93	*Sagrina zanzibarica*	0.39	*Cellanthus craticulus*	0.15				
Indeterminate agglutinated	0.27	*Planorbulina acervalis*	0.91	*Rosalina globularis*	0.37	*Sagrinella lobata*	0.14				
Indeterminate rotaliid	0.27	*Elphidium* cf. *E. neosimplex*	0.72	*Cavarotalia annectens*	0.36	*Elphidium hyalocostatum*	0.12				
Pararotalia sp. A	0.27	*Asterorotalia pulchella*	0.66	*Cellanthus* sp.	0.32	*Elphidium simplex*	0.12				

Table 7 continued.

Reussella sp. C	0.27	*Schackoinella globosa*	0.64	*Cellanthus craticulus*	0.29	*Elphidium* aff. *E. simulatum*	0.11
Cancris carinatus	0.14	*Murrayinella murrayi*	0.61	*Elphidium* sp.	0.29	*Bolivina* sp.	0.11
Caronia exilis	0.14	*Reussella spinulosa*	0.58	Indeterminate miliolid	0.24	*Eponides* sp.	0.09
Cibicides cf. *C. fletcheri*	0.14	*Reussella* sp. C	0.46	*Pararotalia* sp.	0.24	*Cellanthus* sp.	0.06
Cibicides sp.	0.14	*Peneroplis pertusus*	0.43	*Elphidium* aff. *E. simulatum*	0.22	*Arenoparrella mexicana*	0.05
Elphidium cf. *E. neosimplex*	0.14	*Caronia exilis*	0.41	*Murrayinella murrayi*	0.20	*Cellanthus biperforatus*	0.05
Elphidium aff. *E. simulatum*	0.14	*Miliammina fusca*	0.31	*Ammodiscus* sp. A	0.19	*Elphidium* aff. *E. poeyanum*	0.05
Murrayinella murrayi	0.14	*Paratrochammina stoeni*	0.31	*Asterorotalia pulchella*	0.17	*Reussella* sp. C	0.05
Pararotalia nipponica	0.14	*Elphidium* aff. *E. simulatum*	0.29	*Haplophragmoides wilberti*	0.15	*Pseudorotalia* cf. *P. schroeteriana*	0.05
		Elphidium simplex	0.29	*Pararotalia nipponica*	0.14		
		Elphidium hyalocostatum	0.28	*"Glomospira" fijiensis*	0.14		
		Globocassidulina bisecta	0.27	*Cibicides* cf. *C. fletcheri*	0.14		
		Trochammina amnicola	0.26	*Caronia exilis*	0.14		
		Eponides sp.	0.25	*Pseudorotalia* cf. *P. schroteriana*	0.13		
		Elphidium aff. *E. poeyanum*	0.24	*Asterigerinata* sp. A	0.11		
		Pararotalia sp.	0.22	*Arenoparrella mexicana*	0.10		
		Cancris carinatus	0.22	*Globocassidulina bisecta*	0.09		
		Brizalina subtenuis	0.21	*Rosalina* sp. B	0.09		
		Indeterminate agglutinated	0.21	*Cibicides* sp. B	0.09		
		Trochammina sp. E	0.20	*Elphidium* aff. *E. poeyanum*	0.09		
		Trochammina sp.	0.20	*Elphidium simplex*	0.09		
		Elphidium advenum	0.18	*Elphidium* cf. *E. neosimplex*	0.09		
		Pararotalia venusta	0.18	*Planorbulina acervalis*	0.09		
		Spiroloculina manifesta	0.16	*Bruneica clypea*	0.05		
		Buliminoides williamsoni	0.13	*Cancris carinatus*	0.05		
		Pararotalia calcariformata	0.13	*Schackoinella globosa*	0.05		
		Indeterminate miliolid	0.12	*Cibicides* sp.	0.04		

Table 7 continued.

Elphidium crispum s.l.	0.11	*Elphidium indicum*	0.04
Pseudorotalia cf. *P. schroeteriana*	0.11	*Siphotrochammina lobata*	0.04
Elphidium indicum	0.10	*Guttulina* sp.	0.04
Haplophragmoides wilberti	0.09		
Guttulina sp.	0.08		
"Trochammina ochracea"	0.08		
Ammotium directum	0.08		
Cellanthus craticulus	0.08		
Pararotalia sp. A	0.08		
Siphotrochammina lobata	0.04		
Cellanthus biperforatus	0.04		
Haplophragmoides cf. *H. manilaensis*	0.04		
Arenoparrella mexicana	0.04		

DENSITY/ ABUNDANCE DATA

Twenty six of the 63 20 mL samples contained fewer than 1,000 specimens, 22 contained between 1,001–10,000 specimens, four contained between 10,001–20,000 specimens, and 11 contained more than 20,001 specimens (Table 4). All 11 samples containing >20,001 total specimens are part of group TA2, located closest to the inlet along transect 4, and within the nine samples of the SET11-S40 fish cage complex system (Table 4; Figure 18). Transect 4 had the greatest average total density with 54,477 total specimens per 20mL (Table 4). Transect 3 which is characterized by groups TA2, TB1, and TB2 has an average total density of 5,976, most similar to groups TB1, and TB2 (Table 6). The total density in samples T3-0 and T3-5 is over 10,001; these samples cluster in group TA2 (Table 4). All samples associated with the SET11-S43 fish cage complex and SET11-S9A abandoned fish cage complex, including samples along transects 1, 2, 5, and 6, contained fewer than 10,001 total specimens per 20mL except for SET11-S43-4 and SET11-S9A-8 (Table 4). Transect 1 had the lowest total average density of 123 specimens per 20mL (Table 4).

The number of dead foraminifera in a 20 mL sample (ND) very closely mimics the total foraminiferal density (NT) patterns in the Setiu lagoon due to the paucity of live foraminifera (Table 4). Live foraminiferal species (%SL) and specimens (%L) are more abundant in the Setiu estuary than in the lagoon (Table 4). All samples with greater than 10,001 total foraminifera also contain more than 10,001 dead foraminifera except for sample SET11-S9A-8 which had a density of 10,080 total foraminifera and 7,200 dead foraminifera (Table 4). Similarly, all samples with between 1,001-10,000 total foraminifera also contained between 1,001-10,000 dead foraminifera except samples T3-60, SET11-S9A-7, SET11-S9A-9, T6-60, and T6-100 (Table 4). Transect 4 had the greatest average density of dead specimens and transect 1 had the lowest average density of dead specimens with 51,476 and 100 dead specimens per 20mL, respectively (Table 4).

SPECIES DIVERSITY

Species Richness (S)

A plot of the number of dead species per sample closely mimics a plot of total number of species per sample (Figure 17). The number of dead and total species per sample exhibits an overall increase from north to south within the Setiu lagoon (Figure 17). The number of dead species (SD) averages 11 in transect 1 and 34 in transect 4 (Table 4). Similarly, groups TB2 and DB2 furthest to the north, have averages of 14 and 13 total species (ST), respectively, and 13 dead species while groups TA2 and DA2, closest to the lagoon, averages 34 and 33 total species, respectively, and 33 and 33 dead species, respectively (Table 6). Transect 2, partially characterized by groups TA1 and DA1, is the exception in that the average number of total (ST) and dead (SD) species decreases rather than increases along the north to south gradient (Table 4). The number of live species per sample exhibits little fluctuation with the greatest average occurring in the lagoon at the SET11-S43 floating fish cage complex and the lowest average within the SET11-S40 floating fish cage complex (Table 4), although both percent live specimens and percent live species per sample location generally decrease from north to south (Figure 19).

In the Setiu estuary, the number of dead (SD) and total (ST) species per sample is lower than all lagoonal samples except for those of transect 1 and three samples in transect 2 (Figures 4, 15). The number of live species per sample (SL) is uniformly low (less than 8) and similar to the number of dead species per sample; at station SET11-S9A-6, no dead species were recorded (Table 4). Percent live species (%SL) and specimens (%L) is generally greater in the estuary than in the lagoon (Figure 24). Groups TC1 and TC2 have the same average (7) for total number of species (ST) while groups DC1 and DC2 average 8 and 6 species, respectively (Table 6).

Fisher's Alpha Index (α)

In the Setiu lagoon, alpha values for total assemblages generally increase with increasing salinity from transect 1 to transect 4 (Figure 20; Table 4) and range between 14.7 at T4-15 and 1.6 at SET11-S43-5 to the east of the fish cage complex (Table 4). Samples T1-0, T3-0, T3-5, T4-0, T4-5, and T4-15 all represent the greatest alpha values for their corresponding transects with values generally decreasing with distance from the cages (Figure 20; Appendix E). The greatest alpha values at the SET11-S40 fish cage complex (SET11-S40-1, SET11-S40-4, and SET11-S40-7) are located to the west of the cages (Figure 20).

Total assemblage alpha values in the Setiu estuary are much lower than in the lagoon and range between 0.7 and 2.8 (Table 4). Samples T6-0 and T6-5, closest to the fish cage complex, have the greatest alpha values of all samples along transect 6 (Figure 20; Appendix E). The greatest alpha values at the SET11-S9A fish cage complex (SET11-S9A-4, SET11-S9A-5) are located to the east of the cages, close to the barrier island (Appendix E).

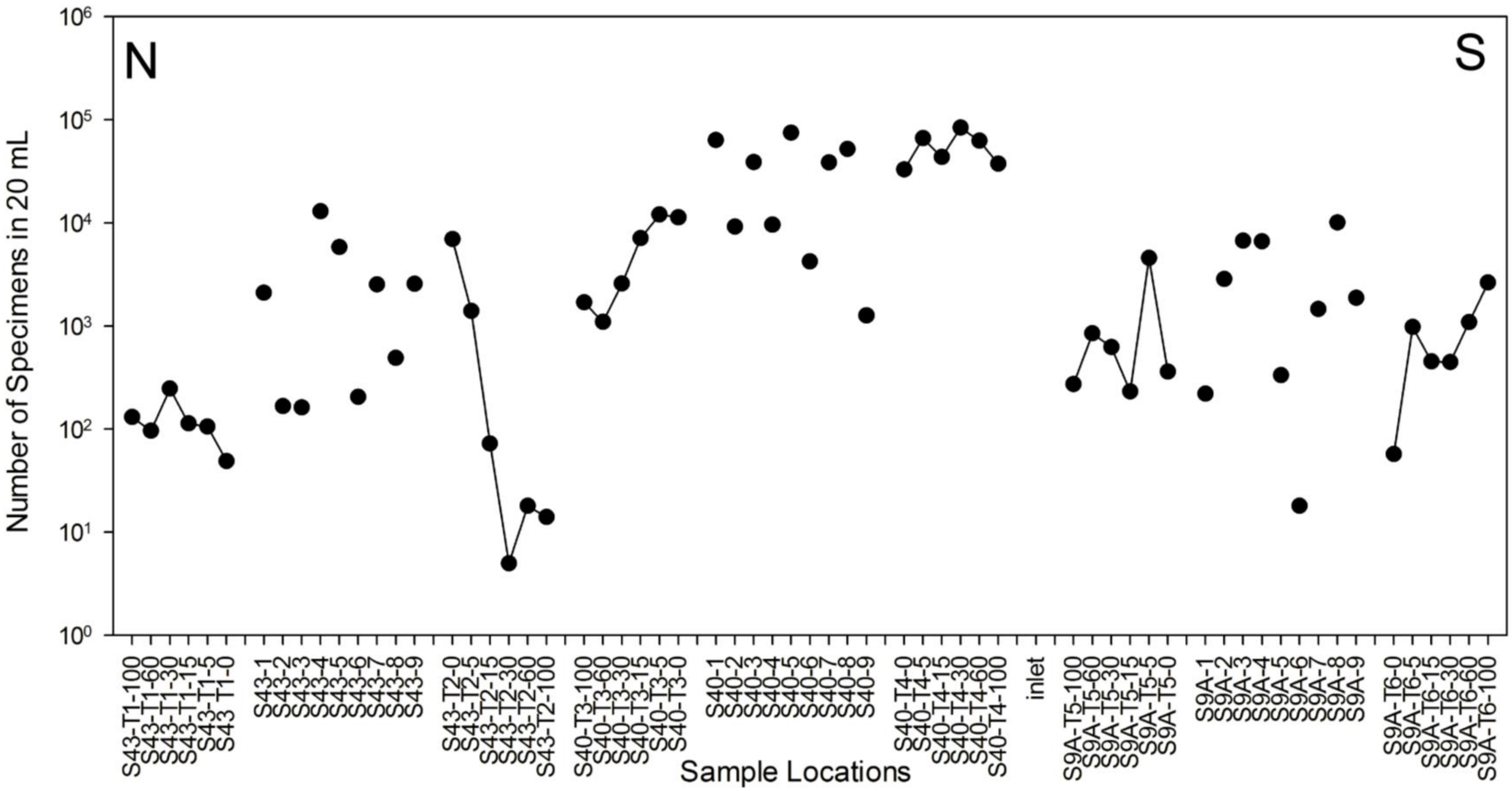


Figure 18: Relative density of the total number of specimens in 20 mL of sediment. Transects indicated by connected symbols.

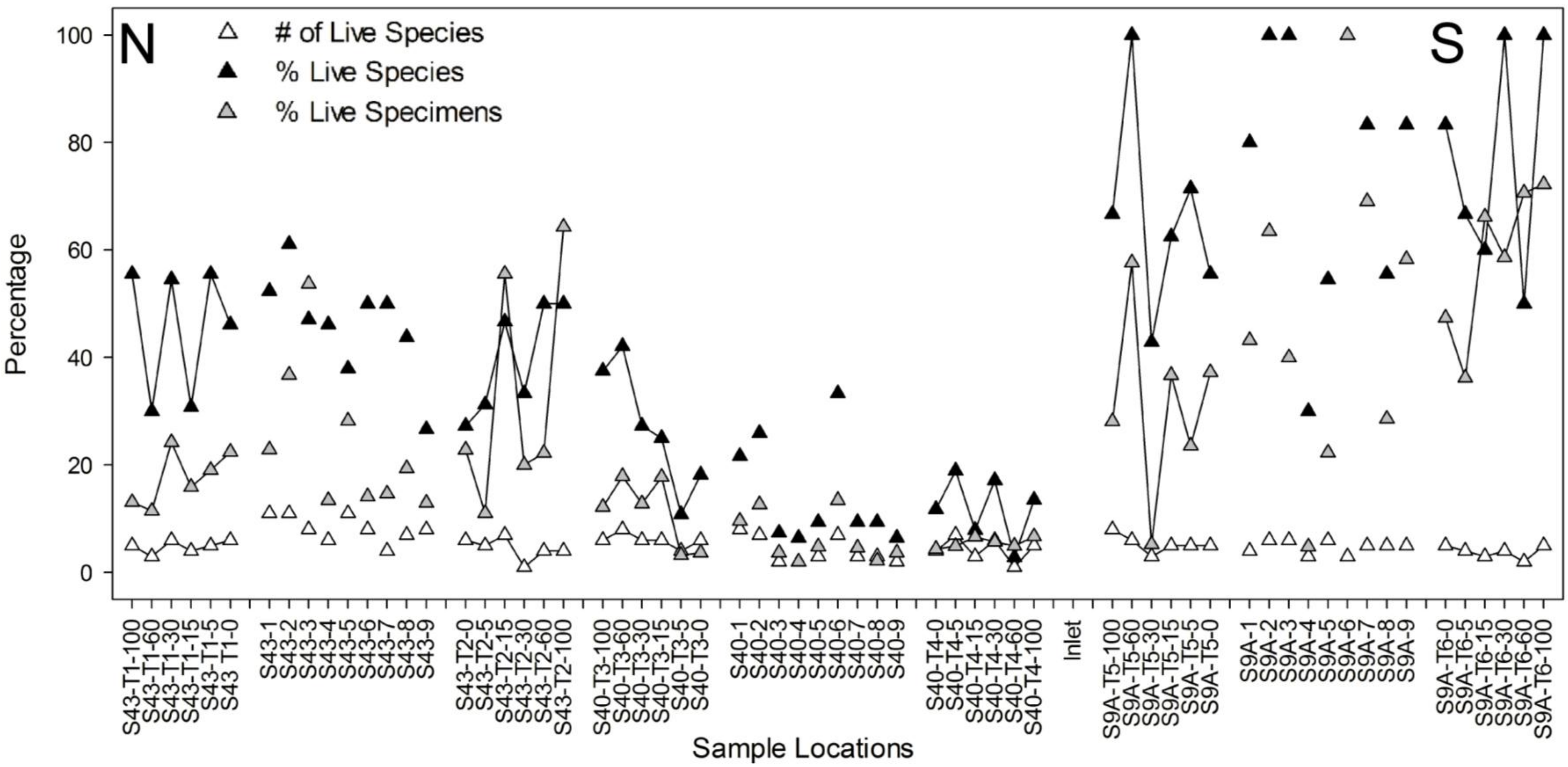


Figure 19: Comparison of percent live species and percentage of live specimens as well as the number of live species at each sample location. Transects indicated by connected symbols.

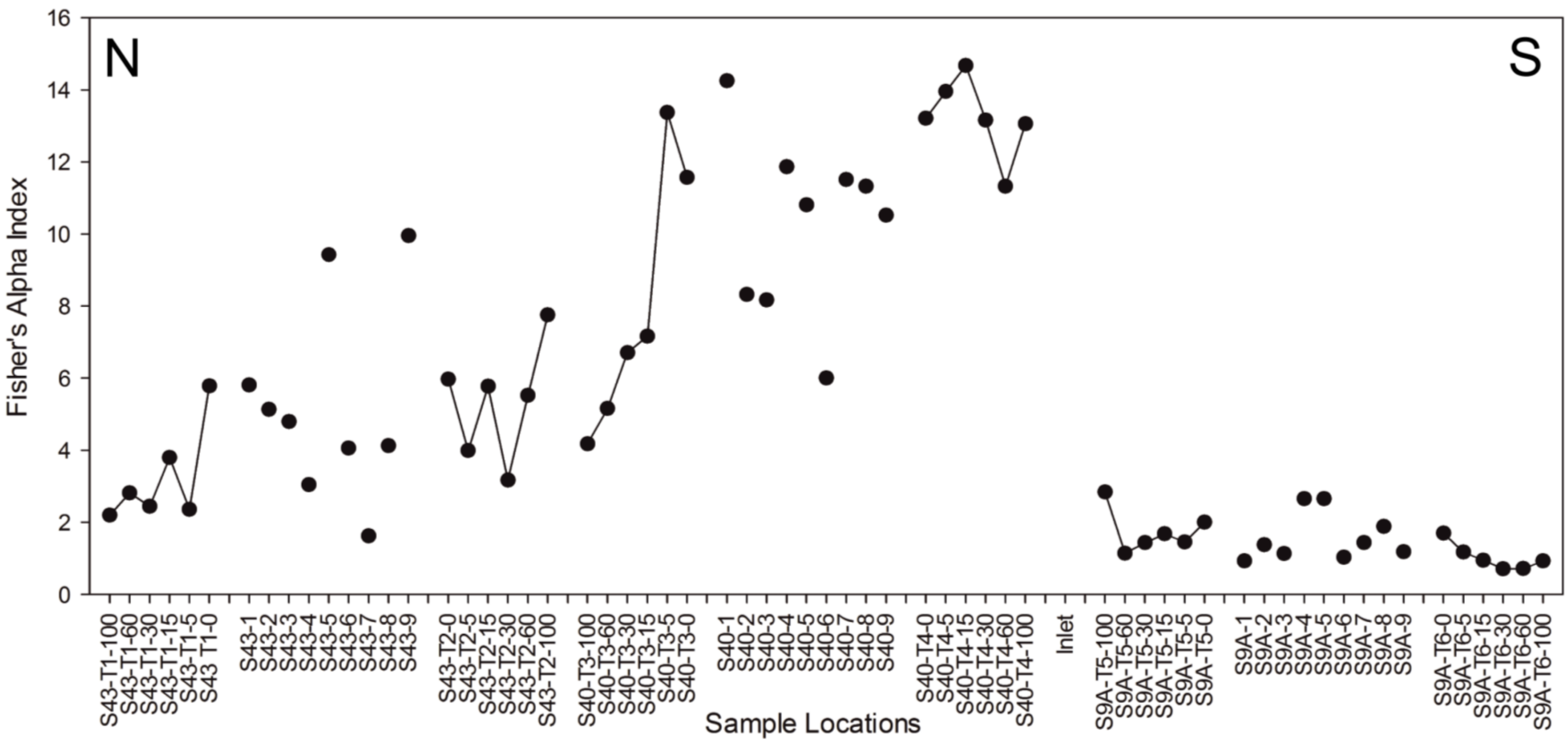


Figure 20: Fisher's alpha diversity index (total assemblage) for all sample locations. Transects indicated by connected symbols.

FORAMINIFERAL SHELL TYPE

In the Setiu lagoon, agglutinated shell types in total assemblages decrease gradually from the north towards the inlet as salinity increases (Figure 21). Calcareous *Ammonia* aff. *A. aoteana* along with agglutinated *Ammobaculites exiguus* are dominant in most groups, both live and dead (TA2, DA2, TB1, DB1, TB2, DB2) (Tables 5, 7). *Ammonia* and *Ammobaculites* species are cosmopolitan in restricted paralic tropical environments (e.g., Debenay, 2000; Culver et al., 2012). Groups TB1, DB1, TB2, and DB2, around the SET11-S43 fish cage complex, where the salinity averages 22 (Table 1), are dominated by agglutinated taxa (Tables 5, 7; Figure 21) including *Paratrochammina stoeni*, *Trochammina amnicola*, and *Ammotium morenoi*. These are intertidal, brackish water species associated with mangrove swamps (e.g., Brönnimann and Keij, 1986; Brönnimann et al., 1992; Horton et al., 2003; Culver et al., 2012). Groups TA1, DA1, TA2, and DA2, where the salinity ranges from 21.5 to 29.2 (Table 1), are composed primarily of calcareous taxa such as *Amphistegina lessonii*, *Sagrinella lobata*, *Quinqueloculina* sp., *Pararotalia* sp. and *Reussella pulchra* (Tables 5, 7).

The samples collected around site SET11-S9A where salinity ranges between 0.4–2.1 (Table 1) were dominated strongly by agglutinated species (Figure 17) such as *Miliammina fusca*, *Ammobaculites exiguus*, *Ammotium directum*, and *Trochammina amnicola* (Tables 5, 7). These species are known to characterize very low salinity marsh, mangrove swamp, and estuarine environments (Ellison, 1972; Brönnimann et al., 1992; Hayward et al., 1999b; Culver et al., 2012). These four taxa comprise 90.3% and 96.2% of groups TC1 and TC2, respectively and 91.1% and 97.4% of groups DC1 and DC2, respectively (Tables 5, 7).

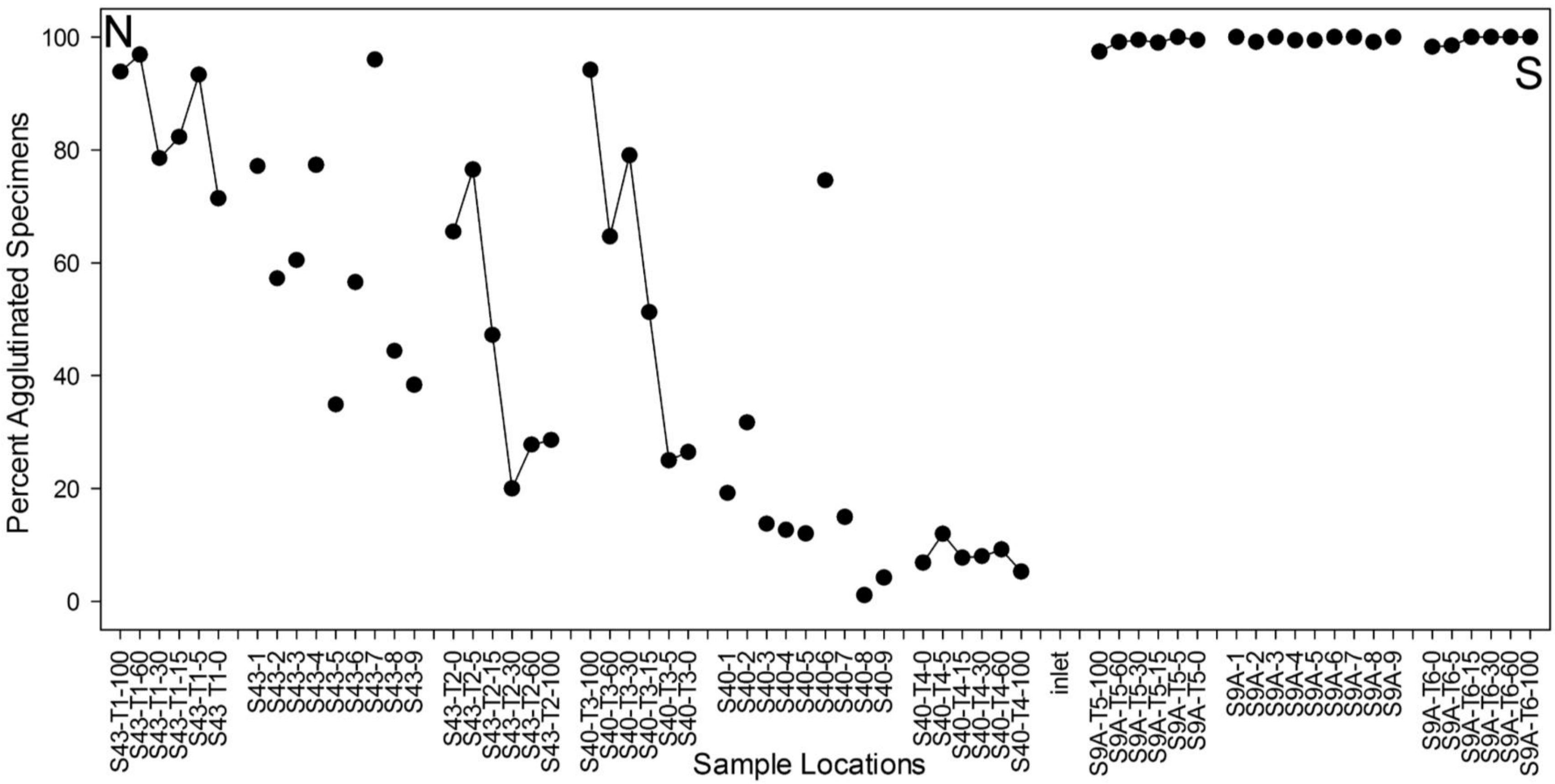


Figure 21: Percent agglutinated specimens of total specimens per sample. Transects indicated by connected symbols.

DCA and DCCA ANALYSES

DCA of the total foraminiferal data set shows that axes 1 to 3 are significant (eigenvalue >0.1; Sejrup et al., 2004); they account for 32.1%, 7.4%, and 4.2% of the total variance (Figure 22; Table 8). DCCA provides a graph which indicates the strength of relationships between variables (Birks, 1995; Korsman and Birks, 1996) based on the lengths and orientation of the environmental arrows as well as the distribution of foraminifera (Figure 23). A gradient length greater than two standard deviation units indicates a unimodal trend of foraminiferal abundance data with respect to environmental variables (Sejrup et al., 2004; Leorri and Cearreta, 2009; Culver et al., 2012). The DCCA of the total foraminiferal data set with selected environmental variables, including salinity, pH, dissolved oxygen (mg/L), depth (m), $\delta^{13}C$, $\delta^{15}N$, C:N, and percent mud, resulted in a gradient length of 3.694 with only the first axis significant (eingenvalue of 0.592; Table 8). DCCA Axis 1 captures 25.7% of the total variance of the species abundance data and 49% of the total variance of species-environment relationship (Table 8). Salinity seems to be the most relevant of all environmental variables (Figure 23).

The DCCA correlation matrix provides values which represent the correlation among the different environmental variables. The greatest correlation values are between salinity and pH (0.79), $\delta^{15}N$ and C:N (0.73), and salinity and $\delta^{13}C$ (0.67) (Table 9).

Table 8: Summary of detrended correspondence analysis (DCA) and detrended canonical correspondence analysis (DCCA) results for total foraminiferal data from the Setiu estuary and lagoon.

	Axes	1	2	3	4
DCA	Eigenvalues	0.765	0.176	0.101	0.056
	Lengths of gradient	4.408	3.088	1.575	1.277
	Cumulative % variance of species data	32.1	39.5	43.7	46.1
DCCA	Eigenvalues	0.592	0.075	0.044	0.024
	Lengths of gradient	3.694	1.694	1.38	0.939
	Species-environment correlations	0.966	0.914	0.898	0.898
	Cumulative % variance of species data	25.7	29	30.9	32
	Cumulative % variance of species-environment relation	49	53.7	0	0

Table 9: Detrended canonical correspondence analysis (DCCA) correlation matrix results of all environmental variables which represent the correlation among the different environmental variables.

	Depth	Salinity	pH	DO	$\delta^{13}C$	$\delta^{15}N$	C:N	%Mud
Depth	1							
Salinity	-0.35	1						
pH	-0.08	0.79	1					
DO	-0.17	0.29	0.21	1				
$\delta^{13}C$	-0.50	0.67	0.53	0.37	1			
$\delta^{15}N$	0.07	0.28	0.24	0.30	0.38	1		
C:N	0.01	0.43	0.31	0.37	0.26	0.73	1	
%Mud	-0.41	0.15	-0.02	0.23	0.05	0.19	0.45	1

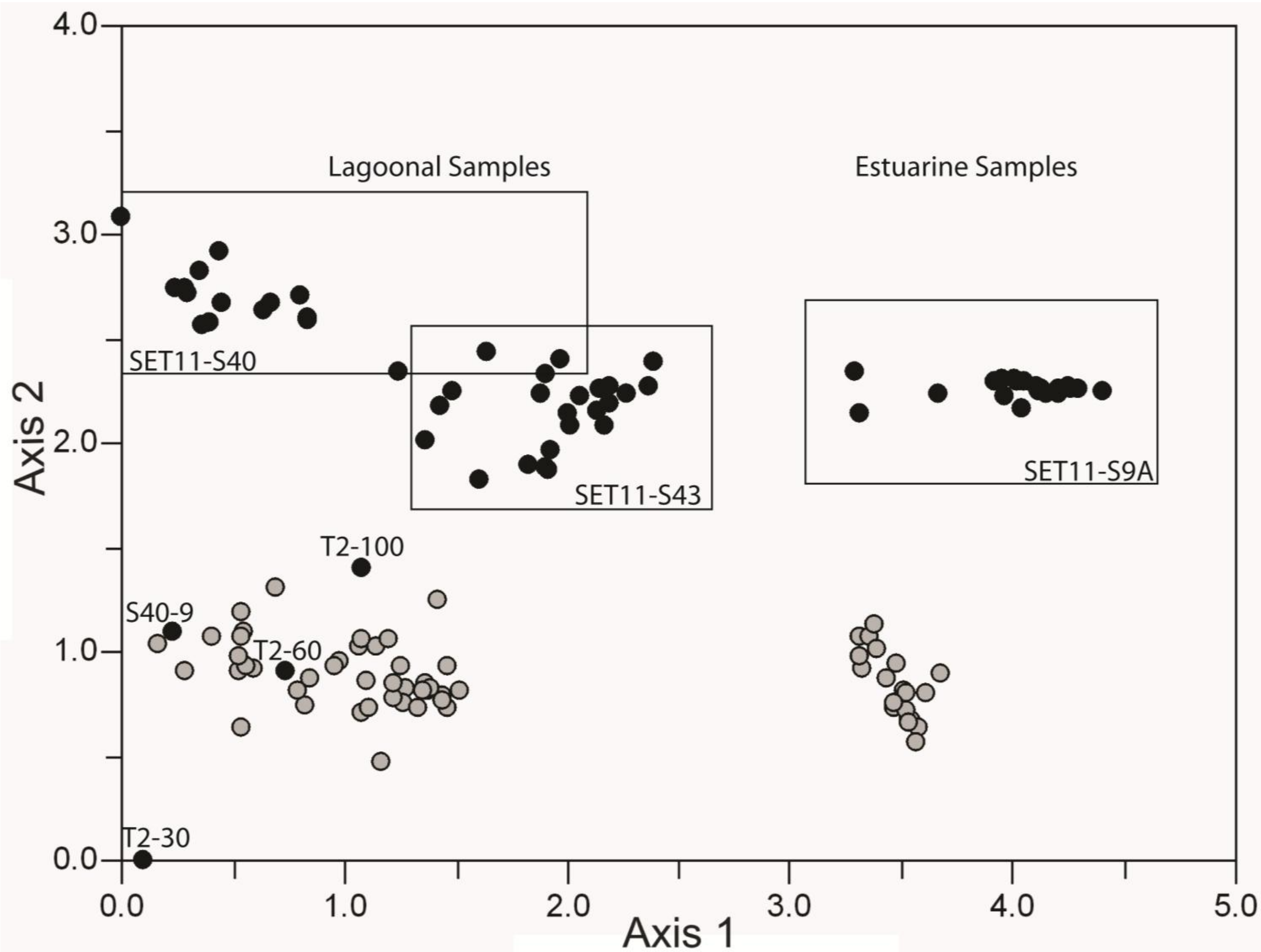


Figure 22: Plot of detrended correspondence analysis (DCA) and detrended canonical correspondence analysis (DCCA) results of total foraminiferal data from the Setiu estuary and lagoon. DCA results are indicated by the black circles while DCCA results are indicated by the gray circles. All circles plotted between 3.0 and 5.0 on Axis 1 are from the SET11-S9A abandoned fish cage complex in the estuary while all others are from Setiu lagoon.

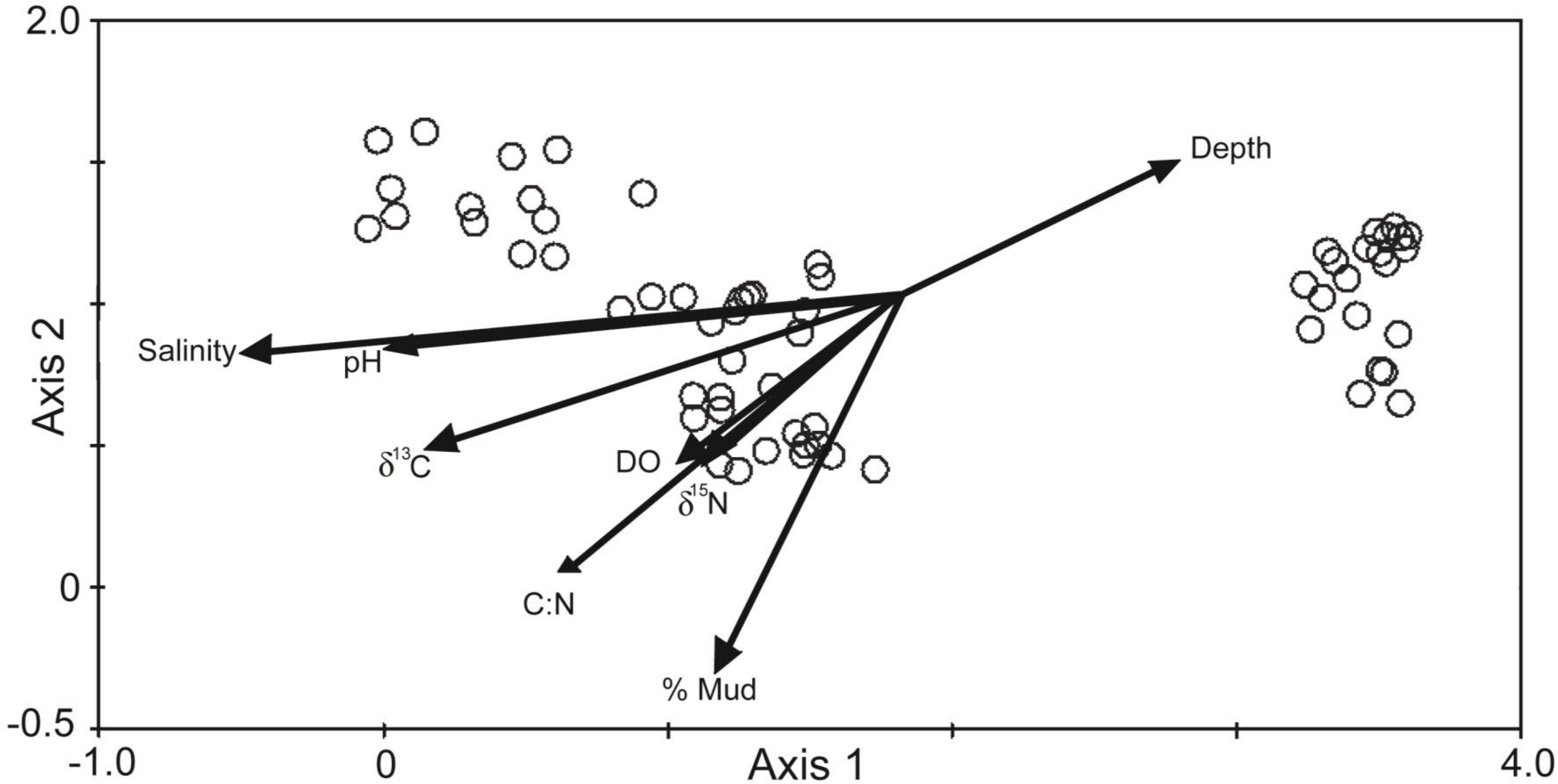


Figure 23: Detrended canonical correspondence analysis (DCCA) results of all foraminiferal data showing the relationship between different environmental variables as indicated by the length of the axes. DO= dissolved oxygen.

DISCUSSION

THE DISTRIBUTION OF SEDIMENT CHARACTERISTICS, $\delta^{13}C$ AND $\delta^{15}N$ VALUES IN THE SETIU LAGOON AND ESTUARY

Setiu Lagoon

Culver et al. (2012), Yaacob, (1988), Yaacob et al. (1995), Yaacob and Husain (2005), and Yaacob and Mustapa (2010) described the sediments of the Setiu lagoon as gravelly coarse sand to fine sand and sandy mud. Only seven of the 22 lagoonal samples in Culver et al. (2012) had a mean grain-size below 63 µm (mud). In contrast, 21 of 42 samples collected in the Setiu lagoon for this study have a mean grain-size below 63 µm, 19 of which agree with the Farrell/Folk classification and are deemed primarily mud (Figure 3). Thirteen of the 19 were collected under and around the SET11-S43 fish cage complex and the remaining six were from transect 3, to the north of SET11-S40 (Figure 3; Appendix J). Sediments with a high percent mud have a high mean percent LOI, high mean percent carbon, and high mean $\delta^{15}N$ value (Figure 4; Table 10).

Samples for this study were collected in June 2011, in the middle of the southwest monsoon season (May-August), when nearshore surface currents flow to the north. With the rapid flooding (six to eight hours) and slow ebb (up to 18 hours) of spring tides in this region (Phillips, 1985), tidal currents in the lagoon are considered responsible for the transport of organic-rich mud northwards from under the fish cages (Figures 3–7; Appendix J). In contrast, the slow ebb tide results in less active transport of organic-rich mud southwards from the fish cage complexes.

Table 10: Mean environmental variable data according to cluster group (CG). Abbreviation key: DO, dissolved oxygen (mg/L); %LOI, percent loss on ignition; %N, percent nitrogen; %C, percent organic carbon.

CG	Mean Dist. Inlet	Mean Depth	Mean Salinity	Mean pH	Mean DO	Mean %Mud	Mean %LOI	Mean %C	Mean %N	Mean $\delta^{13}C$	Mean $\delta^{15}N$
TA1	2.38	1.2	24.1	8.0	6.1	0.6	0.6	0.1	0.0	-22.00	1.94
TA2	1.40	1.8	26.4	8.0	5.2	30.1	4.3	0.8	0.2	-25.91	1.90
TB1	2.78	1.4	22.9	7.9	5.9	80.5	11.7	2.1	0.3	-25.04	2.63
TB2	3.08	1.5	22.1	7.7	6.0	55.6	8.2	2.0	0.2	-24.79	3.23
TC1	8.70	1.7	0.5	6.9	4.3	58.1	6.7	1.7	0.4	-28.36	1.31
TC2	8.71	2.3	1.1	7.3	4.5	16.8	2.4	0.5	0.1	-27.77	1.57
DA1	2.38	1.2	24.1	8.0	6.1	0.6	0.6	0.1	0.0	-22.00	1.94
DA2	1.40	1.8	26.4	8.0	5.2	30.1	4.3	0.8	0.2	-25.91	1.90
DB1	2.56	1.4	23.2	7.9	5.8	52.4	8.0	1.6	0.3	-24.69	2.85
DB2	3.37	1.4	21.8	7.7	6.0	86.6	12.2	2.6	0.3	-25.18	3.02
DC1	8.64	2.6	1.3	7.5	4.3	30.6	3.9	0.8	0.3	-27.96	1.61
DC2	8.76	2.0	0.8	7.0	4.6	12.6	1.9	0.4	0.1	-27.73	1.53

Terrestrial C_3 plants are strongly depleted in ^{13}C and have values that typically range between -23‰ and -30‰ (Fry and Sherr, 1984; Peterson and Fry, 1987, Sampaio et al., 2010), similar to values for mangrove plants which have averages ranging between -25.6‰ and -27.6‰ (Kuramoto and Minagawa, 2003). In the marine influenced Setiu lagoon, $\delta^{13}C$ values are less negative than in the Setiu estuary (Figures 9, 11, 13) and range between -26.73‰ and -20.31‰ (Table 3). A less negative $\delta^{13}C$ signature would be expected around the SET11-S40 fish cage complex due to its proximity (1 to 2 km) to the inlet, in comparison to fish cage complex SET11-S43. However, no trends in $\delta^{13}C$ values are evident in the lagoon except along transect 2, which is affected by a marine overwash deposit (Figure 9). The lack of marine influence on the $\delta^{13}C$ values of the Setiu lagoon is likely the result of high sediment flux from the surrounding, carbon-rich, mangrove forest, as indicated by a high (~ 40:1) C:N ratio and $\delta^{13}C$ values (~ -26.6‰) similar to that of lagoonal sediment (mean $\delta^{13}C$ of -24.92‰; Figure 13). The current study has very limited data on fish food compared to Holmer et al. (2002, 2003), who discriminated four fish food types (Frymesh, Starter, Grower, and Finisher). Nevertheless, the smaller (3.5:1) C:N ratio and lighter $\delta^{13}C$ values (-20.33‰) of the fish food in comparison to muddy, lagoonal sediments indicates minimal influence on the $\delta^{13}C$ from fish food and aquaculture, contrary to findings by Holmer et al. (2002, 2003) and Yokoyama et al. (2006) in the Philippines and Japan.

In a study by Alongi et al. (2003), it was noted that sediments under and around fish cages were finer than those of the surrounding estuary and that loading of organic matter under and around the aquacultural site resulted in nitrification of NH_4^+ to NO_2^- and NO_3^- with concentrations ranging from 0.5 to 20.5 µM in two estuaries in northwest Malaysia. In contrast, Nixon et al. (1984) did not detect any NO_3^- in the two estuaries, where salinity was greater than 18, approximately 20 years earlier, prior to the presence of aquaculture. In comparison, where $\delta^{15}N$ values are highest in the Setiu lagoon around the SET11-S43 fish cage complex and under the SET11-S40 fish cage complex there is an increase in percent mud and percent carbon (Figures 4, 10) which may result in greater rates of denitrification at those locations..

Marine $\delta^{15}N$ values typically range between 4‰ and 9‰ (Fry and Sherr, 1984; Tucker et al., 1999; Sampaio et al., 2010) whereas $\delta^{15}N$ values of terrestrial mangrove plants are generally lighter (~2‰ to 5‰) (Sweeney and Kaplan, 1980; Owens, 1987; Maksymowska et al., 2000). Alterations of nitrogen isotope values of mangrove plant matter can occur due to denitrification and reduction of NO_2^- and NO_3^- to atmospheric N_2 or N_2O by decomposition, resulting in the surrounding soils and sediments to have an enriched $\delta^{15}N$ value since ^{14}N denitrifies faster than ^{15}N (Cline and Kaplan, 1975; Faure, 1977; Peterson and Fry, 1987). Anthropogenic inputs of nitrate via fertilizers and some industrial plants (e.g., paper mills) into a water body can also alter the nitrogen isotope value of the surrounding organic matter and sediments (Heaton, 1986; Thornton and McManus, 1994; Harrington et al., 1998; Kuramoto and Minagawa, 2001; Corbett et al., 2007). The $\delta^{15}N$ value for *Nypa fruticans* that is used for comparison was obtained down-river from a densely populated area in Thailand where many shrimp ponds and fish paste factories exist. As a result, the $\delta^{15}N$ value for *Nypa fruticans* that is used for comparison may be enriched in ^{15}N (Kuramoto and Minagawa, 2001) in comparison to the values for *Rhizophora apiculata* and *Avicennia alba* (Table 4). The $\delta^{15}N$ values of the mangrove plants suggest that the $\delta^{15}N$ signature of lagoonal sediments is heavily influenced by sediment flux from the surrounding mangrove forests.

The high C:N ratio of the mangrove plants (~40:1; Kuramoto and Minagawa, 2001) agree with terrestrial C:N ratio values (~10:1 and greater; Thornton and McManus, 1994; Maksymowska et al., 2000; Yamamuro, 2000) though the lagoonal sediments reflect a more marine C:N ratio value (average 7.65:1). Whereas C:N ratios of particulate organic matter generally increase with depth and degradation since nitrogen is lost more quickly than carbon (Faure, 1977) vascular plant detritus C:N ratios decrease as total percent nitrogen increases with time (Odum and de la Cruz, 1967; Heald, 1971; Fell, 1975) due to increased protein content from microbial biomass (Odum and de la Cruz, 1967; Heald, 1971; Cifuentes et al., 1996). Fell et al. (1975) noticed an increase in total nitrogen content in *Rhizophora mangle* leaves during decay, over a span of 15 to 50 days, after being submerged in brackish waters. Cifuentes et al. (1996) attributed unusually low C:N ratios of sediment, which have $\delta^{13}C$ and $\delta^{15}N$ values indicative of a terrestrial source, to nitrogen immobilization by bacteria in an estuary in Ecuador. The C:N ratios of the lagoonal sediment of this study may also be a result of bacterial immobilization of nitrogen on mangrove detritus.

Setiu Estuary

Culver et al., (2012) described the Setiu estuarine sediments as generally coarser than the lagoonal sediments. In this study, 17 samples were classified as dominantly sand (Table 2;

Figures 3, 5–7; Appendices F, J, K). Mud samples were collected from between the fish cage complex and the barrier island shore. The distribution of mud at SET11-S9A may be due to reduction of Setiu and Caluk river currents by the structures of the abandoned fish cage complex.

In the Setiu estuary, which is strongly influenced by seasonally variable fluvial input, $\delta^{13}C$ values at the SET11-S9A fish cage complex, 8 km south of the inlet, range between -28.67‰ and -26.35‰ (Figure 9; Table 3), indicating the influence of terrestrial organic matter from the surrounding mangrove forest. The C:N ratio of mangrove plants is so high (~40:1) in comparison to that of sandy estuarine sediment (~ 3.5:1; Figures 13, 14) that its influence on the sediment values dominates the carbon signature. The C:N ratios of the two kinds of fish food (~ 3.5:1) are similar to those for the sandy estuarine sediment although $\delta^{13}C$ values of the sediment (-27.84‰) are much more enriched and similar to values for mangrove plants (-26.6‰) than to values of fish foods (-20.33‰; Figures 11, 13; Table 3). The low C:N ratios of the estuarine sediment may be a result of bacterial immobilization of nitrogen related to decaying mangrove leaves as has been seen in many other tropical intertidal environments (Odum and de la Cruz, 1967; Heald, 1971; Gotto and Taylor, 1976; Cifuentes et al., 1996). The $\delta^{13}C$ values and C:N signatures of the sediment samples indicate negligible effects from the now abandoned SET11-S9A fish cage complex.

$\delta^{15}N$ values for the sediment samples around the SET11-S9A fish farm complex range between 0.71‰ and 2.16‰, and are generally lighter than samples from the Setiu lagoon, where $\delta^{15}N$ values range between 0.87‰ and 4.15‰ (Figures 11, 14; Table 3). The $\delta^{15}N$ values in the Setiu estuary are consistent with the surrounding vegetation, minimal marine influence, and minimal population of the surrounding area.

ENVIRONMENTAL EFFECTS OF FISH CAGE COMPLEXES

Estuarine benthic foraminifera have been used as a proxy for salinity since the early 1970s (e.g., Nichols, 1974) as foraminiferal assemblages are often strongly correlated with salinity and pH (Parker, 1952; Hayward and Hollis, 1994; de Rijk, 1995; de Rijk and Troelstra, 1997; Hayward et al., 1997, 1999a, 1999b, 2004; Goldstein and Watkins, 1998; Debenay and Guiral, 2006; Tarasova, 2006; Culver et al., 2012). Many authors have worked to quantify the relationship between foraminiferal assemblage composition and salinity (e.g., Debenay et al., 1993; de Rijk, 1995; de Rijk and Troelstra, 1997; Debenay et al., 1997; Goldstein and Watkins, 1998; Debenay and Guillou, 2002; Hayward et al., 2004) and the relative distance from the source of marine or freshwater input (e.g., Leorri and Cearreta, 2009).

The cluster analyses, DCA, and DCCA all indicate that the mixture of marine and fresh water, represented by salinity, is the primary environmental variable responsible for the distribution of foraminifera in the this study (Figures 15, 16, 22, 23; Table 8), confirming the findings of Culver et al. (2012). The DCCA weighted correlation matrix of environmental variables indicates that pH (which correlates very closely with salinity), $\delta^{15}N$, C:N, and $\delta^{13}C$ are the other variables controlling foraminiferal distribution along axis 1 (Table 9; Figure 23). The DCA plot (Figure 22), and to a lesser extent the DCCA plots, (Figures 22, 23) show similar foraminiferal distributions as the cluster analysis dendrograms (Figures 15, 16) with estuarine samples discriminated from the two lagoonal groups that cluster together (Figure 22).

SET11-S40 Fish Cage Complex

Aquacultural practices in the Setiu lagoon began at the SET11-S40 fish cage complex in the 1970s. The SET11-S43 fish cage complex is several years younger (communication from local fishermen). Indications of environmental impact of the SET11-S40 fish farm complex include relatively enriched $\delta^{15}N$ values at sites SET11-S40-2, SET11-S40-5, SET11-S40-8, directly below the cages, and slight increases in percent mud, percent organic matter, percent live specimens (%L), and a decrease Fisher's alpha diversity index (α) values away from the cages along transect 3 (Table 3; Figures 4, 20; Appendix E). The nine samples collected from beneath and around the SET11-S40 fish cage complex exhibit no trends in percent live specimens (%L), density (NT), Fisher's alpha diversity index (α), or percent agglutinated specimens (T%t) (Table 4; Figures 18–21; Appendix E) that can be attributed to effects of fish farming. The generally high total density (NT), low percent live specimens (%L), and high Fisher's alpha diversity index (α) (Table 4; Figures 18–20; Appendix E) are likely a result of tidal mixing in very shallow water (~1.5 m) at the southern end of the SET11-S40 fish cage complex including transect 4 (Figure 2). The decrease in percent agglutinated specimens (T%t) and increase in total number of species (ST) compared with SET11-S43 (average salinity 22.0; Figures 17, 21; Tables 1, 4), reflect a stronger marine influence at the SET11-S40 fish cage complex (average salinity 27.7; Table 1). *Quinqueloculina* species in the southernmost samples from the SET11-S40 complex, and transect 4 to its immediate south, further reflect marine influence closer to the inlet (Culver et al., 2012; Tables 5, 7; Appendix B).

Three samples in Culver et al. (2012) were collected from within 2–3 m of the SET11-S40 fish cage complex. Similar to all of the samples from beneath and around the fish cage complexes in this study, very few miliolids were present in these three samples (Culver et al., 2012). The three samples also had a high average density (37,980 dead specimens per 20 mL of sediment), low mean percentage of live specimens (1.3%), high species richness (37 dead species), and a high mean species diversity values (α = 13.5) in contrast with all other foraminiferal samples from the Setiu lagoon (Culver et al., 2012). Samples from around the SET11-S40 fish cage complex in this study have a similar high mean density (32,463 dead specimens per 20 mL of sediment), relatively low mean percentage of live specimens (6%), high species richness (29 dead species), and a high mean species diversity ($\alpha = 10.3$) (Tables 4, 6; Appendix E). A 56 cm core collected from within a couple of meters of SET11-S40-5 shows patterns of changing density of foraminifera downcore (H. Thornberg, personal communication, February 2013). The top and middle of the core are dominated by *Ammonia* aff. *A. aoteana* and *Ammobaculites exiguus*, similar to most surface samples collected from the SET11-S40 fish cage complex. In comparison, the bottom of the core is dominated by *Ammonia* aff. *A. aoteana* and *Quinqueloculina* spp. (H. Thornberg, personal communication, February 2013). While many of these characteristics (density, diversity, percent live specimens, and species richness) may be related to aquaculture, it is more likely a result of salinity patterns and influence of tidal currents.

SET11-S43 Fish Cage Complex

The foraminiferal samples collected from the SET11-S43 fish cage complex exhibit distributional patterns that are similar to those described by Brown et al. (1987), Alve (1995), Angel et al. (2000), Luan and Debenay (2005), Hayek and Buzas (2006), and Tarasova and Preobrazhenskaya (2007) in response to organic enrichment. These patterns include increases in diversity, density, number of live specimens, and number of eurytopic agglutinated taxa increasing in dominance (Clark, 1971; Alve, 1995; Schafer et al., 1995; Scott et al., 1995; Angel et al., 2000; Luan and Debenay, 2005; Hayek and Buzas (2006); Tarasova, 2006; Tarasova and Preobrazhenskaya, 2007). At SET11-S43, characterized by organic-rich mud, these patterns include an increased dominance of agglutinated *Ammobaculites exiguus*, decreasing Fisher's alpha diversity index (α) and decreasing percent live specimens (%L) along transect 1, away from the fish cages (Figures 3–7, 19, 20; Tables 2, 4; Appendices E, F, J). Overall, samples collected from the SET11-S43 fish farm complex have greater percent live specimens (%L) than the SET11-S40 fish cage complex probably as the result of increased organic matter (cf., Alve, 1995); values are greatest towards the north of the complex (Figure 19; Table 4).

To the south of the SET11-S43 fish cage complex, three samples (T2-30, T2-60, T2-100) were collected from a marine barrier island overwash deposit of medium to coarse-grained sand (Figures 3, 5–7; Table 2; Appendix K). These samples clustered together in group TA1 and were composed of 80% calcareous taxa (T%c) (Table 6), primarily *Amphistegina lessonii* (Tables 5, 7), and exhibit a sharp decrease in density (NT) and total number of species (ST) (Figures 17, 18; Tables 4, 6). The sediment characteristics reflect a marine influence in a brackish to marine lagoon as does the foraminiferal assemblage; *Amphistegina lessonii* and *Ammonia* aff. *A. aoteana* dominate Setiu inlet assemblages (Culver et al., 2012) and *Pararotalia* sp. has been identified as an indicator of a strong marine influence in other lagoons around the world (Debenay et al., 1998).

In a core collected near sample station SET11-S43-5, a general decrease in diversity is obvious from the bottom to the top of the core (H. Thornberg, personal communication, February 2013). The bottom of the core is dominated by calcareous *Ammonia* aff. *A. aoteana* and *Rosalina globularis*, comprising nearly 55% of all specimens, whereas the middle and top of the core are dominated by *Ammonia* aff. *A. aoteana* and *Ammobaculites exiguus*, comprising nearly 58% and 66% of all specimens, respectively in these two core segments (H. Thornberg, personal communication, February 2013). Increased proportions of agglutinated foraminifera up-core indicate either increased environmental perturbation through time as a result of fish farming or decreasing salinity through time at this location.

SET11-S9A Fish Cage Complex

Sediment characteristics and foraminiferal assemblages in the Setiu estuary (Yaacob, 1988; Yaacob et al., 1995; Yaacob and Husain, 2005; Yaacob and Mustapa, 2010; Culver et al., 2012) indicate no lasting effects from the SET11-S9A fish farm. Foraminiferal assemblages at SET11-S9A are indistinguishable from assemblages in the surrounding estuary. The SET11-S9A abandoned fish cage complex and its corresponding transects (5 and 6), where the average salinity is 1.0 (Table 1), is characterized by entirely agglutinated assemblages (Tables 4, 6) dominated by *Ammobaculites exiguus* and *Miliammina fusca* (Tables 5, 7).

Coarse sand occurs directly under the SET11-S9A fish cages (Appendix J). Organic-rich mud, whose $\delta^{13}C$ and $\delta^{15}N$ values are similar to those of the surrounding mangrove forest vegetation, is located between the cage complex and the barrier island (Appendix J). It is not well documented how long the SET11-S9A fish cage complex has been abandoned though it is possible it was abandoned shortly after an inlet, just 4 km north of the SET11-S9A complex, closed in 2003. A 30 cm core, collected within a couple meters of sample station SET11-S9A-8, is composed of coarse-grained sand above and below a black muddy unit. Agglutinated foraminifera occur throughout the core but *Miliammina fusca* is more dominant in the upper sand unit (H. Thornberg, personal communication, February 2013). The black mud unit and the varying proportions of agglutinated species indicate that fish farm actives did impact the local estuarine environment although this is no longer evident in surficial sediment and surficial foraminiferal samples.

Data from abandoned fish farm complex SET11-S9A illustrates a recovery from any effects of fish farming activities following fish farm abandonment. Periodic abandonment of fish farm sites has been suggested by Holmer et al. (2002) and Carroll (2003) to aid in the recovery of the sedimentary environment directly below and surrounding fish farming operations. Length of the abandonment period should vary based on temperature, water depth, feeding rates, the length of time the fish farm has been operating, and whether the farm is located in a restricted flow or open water environment (Carroll, 2003). Carroll et al. (2003) concluded that organic loading from salmon farming is the most apparent environmental impact in colder waters, such as those around Norway and Scotland. Increased feeding rates as water temperatures increase in the spring and summer cause an increase in biological oxygen demand (BOD) which results in a decrease in bottom water oxygen content (Brown et al., 1987). Holmer et al. (2002) noticed that milkfish pens in the Bolinao area of the Philippines significantly affected the organic matter content of the underlying and surrounding sediments compared with net cages at greater depths (Hall et al., 1990, 1992; Holmer and Kristensen, 1992; Karakassis et al., 2000), and that sedimentation rates generally increased with the input of fish food. Tarasova and Preobrazhenskaya (2007) analyzed foraminiferal distribution around an active, 30 year old, scallop aquaculture site in Minonosok Bay in the Sea of Japan and found that numerous years of aquaculture significantly affected the foraminiferal assemblage in the Bay. Alongi et al. (2003) concluded that fish cage farming may result in some nutrient enrichment but impacts on water chemistry in two mangrove estuaries in northwest peninsular Malaysia were reduced with adequate tidal exchange and flushing.

CONCLUSIONS

Sediment grain-size distribution, which is likely a function of hydrodynamics, and the presence of fish cage complexes, has a strong correlation with the distribution of organic material in the Setiu lagoon and estuary. Mud accumulation and percent organic matter are greatest under and surrounding the northernmost fish cage complex (SET11-S43) where tidal currents are weakest as a result of the greater distance from the inlet and the presence of the fish farm complexes. The high $\delta^{15}N$ values in the Setiu lagoon are likely a result of denitrified mangrove forest material. $\delta^{13}C$ values in the lagoon indicate a strong terrestrial mangrove forest influence except where a marine overwash exists. $\delta^{13}C$ and $\delta^{15}N$ values in the Setiu estuary are primarily related to the fluvial input from the Setiu and Caluk rivers, lack of marine influence, the surrounding vegetation, and a small, local human population.

The distribution of foraminifera in the Setiu estuary and lagoon in this study exhibits a strong correlation with salinity, and pH. Generally, calcareous shell type, density, and diversity all increase in the Setiu lagoon from north to south, approaching the inlet. However, foraminiferal samples collected beneath and around the active SET11-S43 fish cage complex and to a lesser extent transect 3, to the north of the active SET11-S40 fish cage complex, exhibit distributional patterns associated with aquaculture including changes in diversity, mean percent of live specimens, the presence of a single dominant taxa, and an increase in the mean percent live species. The foraminiferal assemblage of the inactive SET11-S9A fish cage complex are indistinguishable from those of the surrounding estuary, indicating that during a period of abandonment, the influence of the fish farm complex has disappeared.

References

ACKEFORS, H., and ENNELL, M., 1994, The release of nutrients and organic matter from aquaculture systems in Nordic countries: Journal of Applied Ichthyology, v. 10, p. 225–241.

ACOSTA, J. T., 1940, Nuevos Foraminiferos de la Costa Sur de Cuba: Memorias de la Sociedad Cubana de Historia Natural, no. 14, p. 269–275.

ALONGI, D. M., CHONG, V. C., DIXON, P., SASEKUMAR, A., and TIRENDI, F., 2003, The influence of fish cage aquaculture on pelagic carbon flow and water chemistry in tidally dominated mangrove estuaries of peninsular Malaysia: Marine Environmental Research, v. 55, p. 313–333.

ALVE, E., 1991, Benthic foraminifera reflecting heavy metal pollution in Sorfjord, western Norway: Journal of Foraminiferal Research, v. 21, p. 1–19.

————, 1995, Benthic foraminiferal responses to estuarine pollution: a review: Journal of Foraminiferal Research, v. 25, p. 190–203.

————, LEPLAND, A., MAGNUSSON, J., and BACKER-OWE, K., 2009, Monitoring strategies for establishment of ecologic reference conditions: possibilities and limitations: Marine Pollution Bulletin, v. 59, p. 297–310.

ANDERSEN, H. V., 1953, Two new species of *Haplophragmoides* from the Louisiana coast: Contributions from the Cushman Foundation for Foraminiferal Research, v. 4, p. 20–22.

ANDERSON, J. U., 1963, An improved pretreatment for mineralogical analysis of samples containing organic matter: Clays and Clay Minerals, v. 10, p. 380–388.

ANGEL, D. L., KROST, P., and GORDIN, H., 1995, Benthic Implications of net cage aquaculture in the oligotrophic Gulf of Aqaba: European Aquaculture Society, Special Publication, v. 25, p. 129–173.

————, VERGHESE, S., LEE, J. J., SALEH, A. M., ZUBER, D., LINDELL, D., and SYMONS, A., 2000, Impact of a net cage fish farm on the distribution of benthic foraminifera in the northern Gulf of Eilat (Aqaba, Red Sea): Journal of Foraminiferal Research, v. 30, p. 54–65.

ASANO, K., 1936, Studies in the fossil foraminifera from the Neogene of Japan. Part 1. Foraminifera from Muraoka-mura, Kamakuragori, Kanagawa Prefecture: Journal of the Geological Society of Japan, v. 43, p. 606–614.

————, 1944, *Hanzawaia*, a new genus of foraminifera from the Pliocene of Japan: Journal of the Geological Society of Japan, v. 51, p. 97–99.

AXLER, R., LARSEN, C., TIKKANEN, C., MCDONALD, M., YOKOM, S., and AAS, P., 1996, Water quality issues associated with aquaculture: a case study in mine pit lakes: Water Environmental Resources, v. 68, p. 995–1011.

BANDY, O. L., INGLE, J. C., and RESIG, J. M., 1964a, Foraminiferal trends, Laguna Beach outfall area, California: Limnology and Oceanography, v. 9, p. 112–123.

————, ————, and ————, 1964b, Foraminifera, Los Angeles County outfall area, California: Limnology and Oceanography, v. 9, p. 124–137.

————, ————, and ————, 1965, Modification of foraminiferal distribution by the Orange County outfall, California: Ocean Sciences and Ocean Engineering, Marine Technology Society, Transactions, p. 54–76.

BARTLETT, M. S., 1947, The use of transformations: International Biometric Society, v. 3, p. 39–52.

BATES, J. M., and SPENCER, R. S., 1979, Modification of foraminiferal trends by the Chesapeake-Elisabeth sewage outfall, Virginia Beach, Virginia: Journal of Foraminiferal Research, v. 9, p. 125–140.

BENDER, M., 1971, Variations in the $^{13}C/^{12}C$ ratios of plants in relation to the pathway of photosynthetic carbon dioxide fixation: Phytochemistry, v. 10, p. 1239–1244.

BERNHARD, J. M., 1988, Postmortem vital staining in benthic foraminifera: duration and importance in population and distributional studies: Journal of Foraminiferal Research, v. 18, p. 143–146.

————, 2000, Distinguishing live from dead foraminifera: Methods review and proper applications: Micropaleontology, v. 46, p. 38–46.

BIRKS, H. J. B., 1995, Quantitative paleoenvironmental reconstructions, in Maddy, D., and Brew, J. S. (eds.), Statistical Modelling of Quaternary Science Data, Technical Guide 5: Quaternary Research Association, Cambridge, p. 161–254.

BRADY, H. B., 1884, Notes on the foraminifera dredged by H.M.S. Challenger during the years 1873–1876: Report of the Scientific Results of the Voyage of H.M.S. Challenger, London, (Zoology), v. 9, 814 p.

————, and ROBERTSON, D., 1870, The ostracoda and foraminifera of tidal rivers with an analysis and description of the Foraminifera: Annals and Magazine of Natural History, v. 6, p. 273–309.

BRATTON, J. F., COLMAN, S. M., and SEAL II, R. R., 2003, Eutrophication and carbon sources in Chesapeake Bay Over the last 2700 yr: human impacts in context: Geochimica et Cosmochimica Acta, v. 67, p. 3385–3402.

BRESLER, V., and YANKO, V., 1995, Acute toxicity of heavy metals for benthic epiphytic foraminifera *Pararotalia spinigera* (Le Calvez) and influence of seaweed-derived DOC: Environmental Toxicology, v. 14, p. 1687–1695.

BRÖNNIMANN, P., and KEIJ, A.J., 1986, Agglutinated Foraminifera (Litoulacea and Trochamminacea) from brackish waters of the State of Brunei and of Sabah, Malaysia, northwest Borneo: Revue de Paléobiologie, v. 5, p. 11–31.

————, and WHITTAKER, J. E., 1993, Taxonomic revision of some recent agglutinated foraminifera from the Malay Archipelago, in the Millett Collection, The Natural History Museum, London: Bulletin of the Natural History Museum London (Zoology), v. 59, p. 107–124.

————, and ZANINETTI, L., 1979, *Paratrochammina stoeni*, n. sp., a new trochamminid (Foraminifera) from recent mangrove swamp sediments of Viti Levu, Fiji, with remarks on S. Atlantic and S. Pacific mangrove foraminifera: Notes du Laboratoire de Paléontologie de l'Université de Genève, v. 4, p. 51–54.

————, KEIJ, A. J., and ZANINETTI, L., 1983, *Bruneica clypea* n. gen., n. sp., a Recent remaneicid (Foraminiferida: Trochamminacea) from the brackish waters of Brunei, northwest Borneo: Revue de Paléobiologie, v. 2, p. 35–41.

————, WHITTAKER, J. E., and ZANINETTI, L., 1992, Brackish water foraminifera from mangrove sediments of southwestern Viti Levu, Fiji Islands, southwest Pacific: Revue de Paléobiologie, v. 2, p. 35–41.

BROWN, J. R., GOWEN, R. J., and MCLUSKY, D. S., 1987, The effect of salmon farming on the benthos of a Scottish sea loch: Journal of Exploratory Marine Biology and Ecology, v. 109, p. 39–51.

BUCKLEY, D. E., OWENS, E. H., SCHAFER, C. T., VILKS, G., CRANSTON, R. E., RASHID, M. A., WAGNER, F. J. E., and WALKER, D. A., 1974, Canso Strait and Chedabucto Bay: a multidisciplinary study of the impact of man on the marine environment: Geological Survey of Canada, Paper 74-30, v. 1, p. 133–160.

CARPENTER, W. B., PARKER, W. K., and JONES, J. R., 1862, Introduction to the Study of the Foraminifera: The Ray Society, London, 319 p.

CARROLL, M. L., COCHRANE, S., FIELER, R., VELVIN, R., and WHITE, P., 2003, Organic enrichment of sediments from salmon farming in Norway: environmental factors, management practices, and monitoring techniques: Aquaculture, v. 226, p. 165–180.

CEARRETA, A., IRABIEN, M. J., ULIBARRI, I., YUSTA, I., CROUDACE, I.W., and CUNDY, A. B., 2002, Recent salt marsh development and natural regeneration of reclaimed areas in the Plentzia Estuary, N. Spain: Estuarine, Coastal and Shelf Science, v. 54, p. 863–886.

CIFUENTES, L. A., COFFIN, R. B., SOLORZANO, L., CARDENAS, W., ESPINOZA, J., and TWILLEY, R. R., 1996, Isotopic and elemental variations of carbon and nitrogen in a mangrove estuary: Estuarine, Coastal and Shelf Science, v. 43, 781–800.

CLARK, D. F., 1971, Effects of aquaculture outfall on benthonic foraminifera in Clam Bay, Nova Scotia: Maritime Sediments, v. 7, p. 76–84.

CLINE, J. D., and KAPLAN, I. R., 1975, Isotopic fractionation of dissolved nitrate during denitrification in the eastern tropical North Pacific Ocean: Marine Chemistry, v. 3, p. 271–299.

CORBETT, D. R., MCKEE, B., and ALLISON, M., 2006, Nature of decadal-scale sediment accumulation in the Mississippi River deltaic region: Continental Shelf Research, v. 26, p. 2125–2140.

————, VANCE, D., LETRICK, E., MALLINSON, D., and CULVER, S., 2007, Decadal-scale sediment dynamics and environmental change in the Albemarle estuarine system, North Carolina: Estuarine, Coastal, and Shelf Science, v. 71, p. 717–729.

CULVER, S. J., and BUZAS, M. A., 1995, The effects of anthropogenic habitat disturbance, habitat destruction, and global warming on shallow marine benthic foraminifera: Journal of Foraminiferal Research, v. 25, p. 204–211.

————, MALLINSON, D. J., CORBETT, D. R., ROUF, A. A., SHAZILI, N. A. M., YAACOB, R., WHITTAKER, J. E., BUZAS, M. A., and PARHAM, P. R., 2012, Distribution of foraminifera in the Setiu estuary and lagoon, Terengganu, Malaysia: Journal of Foraminiferal Research, v. 42, p. 109–133.

CUSHMAN, J. A., 1922, Results of the Hudson Bay Expedition, 1920. 1. The Foraminifera: Contributions to Canadian Biology, v. 9, p. 135–147.

————, 1926, Recent foraminifera from Porto Rico: Publications of the Carnegie Institution of Washington, v. 342, p. 73–84.

————, 1933, Some new Recent Foraminifera from the tropical Pacific: Contributions from the Cushman Laboratory for Foraminiferal Research, v. 9, p. 77–95.

————, 1936, New genera and species of the families Verneuilinidae and Valvulinidae and of the subfamily Virgulininae: Cushman Laboratory for Foraminiferal Research, Special Publication, no. 6, p. 1–71.

————, 1945, The species of the subfamily Reussellinae of the foraminiferal family Buliminidae: Contributions from the Cushman Laboratory for Foraminiferal Research, v. 21, p. 23–54.

————, and BRÖNNIMANN, P., 1948, Additional new species of arenaceous foraminifera from the shallow waters of Trinidad: Contributions from the Cushman Laboratory for Foraminiferal Research, v. 24, p. 37–42.

————, and TODD, R., 1944, The genus *Spiroloculina* and its species: Cushman Laboratory for Foraminiferal Research, Special Publication, no. 11, p. 1–82.

DEAN, W. E., 1974, Determination of carbonate and organic matter in calcareous sediments and sediment rocks by loss on ignition: Comparison with other methods: Journal of Sedimentary Petrology, v. 44, p. 242–248.

DEBENAY, J. P., 2000, Foraminifers of paralic tropical environments: Micropaleontology, v. 46, p. 153–160.

————, BENETEAU, E., ZHANG, J., STOUFF, V., GESLIN, E., REDOIS, F., and FERNANDEZ-GONZALEZ, M. 1998, *Ammonia beccarii* and *Ammonia tepida* (Foraminifera): morphofunctional arguments for their distinction, v. 34, p. 235–244.

————, DELLA PATRONA, L., and GOGUENHEIM, H., 2009a, Colonization of coastal environments by foraminifera: insights from shrimp ponds in New Caledonia (SW Pacific): Journal of Foraminiferal Research, v. 39, p. 249–266.

————, ————, HERBLAND, A., and GOGUENHEIM, H., 2009b. The impact of easily oxidized material (EOM) on the meiobenthos: foraminiferal abnormalities in shrimp ponds of New Caledonia; implications for environment and paleoenvironment survey: Marine Pollution Bulletin, v. 59, p. 323–335.

————, EICHLER, B. B., GUILLOU, J.-J., EICHLER-COELHO, P., COELHO, C., and PORTO-FILHO, E., 1997, Behaviour of foraminiferal populations and comparison with the avifauna in a highly stratified lagoon: the Lagoa da Conceicao (SC, Brazil): Revue de Paléobiologie, v. 16, p. 55–75.

————, and FERNANDEZ, J. M., 2009, Benthic foraminifera records of complex anthropogenic environmental changes combined with geochemical data in a tropical bay of New Caledonia (SW Pacific): Marine Pollution Bulletin, v. 59, p. 311–322.

————, and GUILLOU, 2002, Ecological transitions indicated by foraminiferal assemblages in paralic environments: Estuaries, v. 25, p. 1107–1120.

————, and GUIRAL, D., 2006, Mangrove swamp foraminifera, indicators of sea level or paleoclimate?: Revue de Paléobiologie, v. 25, p. 567-574.

————, ————, and PARRA, M., 2002, Ecological factors acting on the microfauna in mangrove swamps. The case of foraminiferal assemblages in French Guiana: Estuarine, Coastal, and Shelf Science, v. 55, p. 509–533.

————, PERTHUISOT, J. P., and COLLEUIL, B., 1993, Expression numérique du confinement par les peuplements de foraminifères. Applications aux domaines paraliques d'Afrique de l'Ouest: Compte Rendus de l'Académie des Sciences, v. 12, p. 1823–1830.

DELGADO, O., GRAU, A., POU, S., RIERA, F., MASSUTI, C., ZABALA, M., and BALLESTEROS, E., 1997, Seagrass regression caused by fish cultures in Fornells Bay (Menorca, Western Mediterranean): Oceanologica Acta, v. 20, p. 557–563.

DE RIJK, S., 1995, Salinity control on the distribution of salt marsh foraminifera (Great Marshes, Massachusetts): Journal of Foraminiferal Research, v. 25, p. 156–166.

————, and Troelstra, S. R., 1997, Salt marsh foraminifera from the Great Marshes, Massachusetts: environmental controls: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 130, p. 81–112.

D'ORBIGNY, A. D., 1826, Tableau méthodique de la classe Céphalopodes: Annales des Sciences Naturelles, Paris, no. (1), 7, p. 245–314.

————, 1839a, Foraminifères, Part 2 of natural history in de la Sagra, R., Histoire physique, politique et naturelle de l'île de Cuba: Arthus Bertrand, Paris, 224 p.

ELLISON, R. L., 1972, *Ammobaculites*, foraminiferal proprietor of Chesapeake Bay estuaries: Geological Society of America, Memoir 133, p. 247–262.

FARRELL, K. M., HARRIS, W. B., MALLINSON, D. J., CULVER, S. J., RIGGS, S. R., PIERSON, J., SELF-TRAIL, J. M., and LAUTIER, J. C., 2012, Standardizing texture and facies codes for process-based classification of clastic sediment and rock: Journal of Sedimentary Research, v. 82, p. 364–378.

FAURE, G., 1977, Principles of Isotope Geology: John Wiley & Sons: New York, 589 p.

————, 1991, Principles and Applications of Geochemistry: A Comprehensive Textbook for Geology Students: Prentice Hall Inc: Upper Saddle River, New Jersey, 600 p.

FELL, J. W., CEFALU, R. C, MATER, I. M., and TALLMAN, A. S., 1975, Microbial activities in the mangrove (*Rhizophora mangle*) leaf detrital system: Proceedings of the International Symposium on the Biology and Management of Mangroves, Florida, p. 661–679.

FINLAY, H. J., 1940, New Zealand foraminifera: key species in stratigraphy, No. 4: Transactions of the Royal Society of New Zealand, v. 69, p. 448–472.

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

FOLK, R. L., 1954, The distinction between grain size and mineral composition in sedimentary rock nomenclature: Journal of Geology, v. 62, p. 344–359.

FORSKÅL, P., 1775, Descriptiones animalium: Hauniae, Copenhagen, Carsten Niebuhr, 164 p.

FRY, B., and SHERR, E. B., 1984, $\delta^{13}C$ measurements as indicators of carbon flow in marine and freshwater ecosystems: Contributions in Marine Science, v.27, p. 13–47.

GACIA, E., DUARTE, C. M., and MIDDELBURG, J. J., 2002, Carbon and nutrient deposition in a Mediterranean seagrass (*Posidonia oceanica*) meadow: American Association of Limnology and Oceanography, v. 47, p. 23–32.

GALLOWAY, J. J., and WISSLER, S. G., 1927, Pleistocene Foraminifera from the Lomita Quarry, Palos Verdes Hills, California: Journal of Paleontology, v.1, p. 35–87.

GOLDSTEIN, S. T., and WATKINS, G. T., 1998, Elevation and the distribution of salt-marsh foraminifera, St. Catherines Island, Georgia: a taphonomic approach: palaois, v. 16, p. 570–580.

————, and ————, 1999, Taphonomy of salt marsh foraminifera: an example from coastal Georgia: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 149, p. 103–114.

————, ————, and KUHN, R. M., 1995, Microhabitats of salt marsh foraminifera: St. Catherines Island, Georgia, USA: Marine Micropaleontology, v. 26, p. 17–29.

GOTTO, J. W., and TAYLOR, B. F., 1976, N2 fixation associated with decaying leaves of the red mangrove (*Rhizophora mangle*): Applied and Environmental Microbiology, v. 31, p. 781–783.

GOWEN, R. J., and BRADBURY, N. B., 1987, The ecological impact of salmonid farming in coastal waters: a review: Oceanographic Marine Biology Annual Review, v. 25, p. 563–575.

GRANT, J., HATCHER, A., SCOTT, D. B., POCKLINGTON, P., SCHAFER, C. T., and WINTERS, G. V., 1995, A multidisciplinary approach to evaluating impacts of shellfish aquaculture on benthic communities: Estuaries, v. 18, p. 124–144.

HALL, P. O. J., ANDERSON, L. G., HOLBY, O., KOLLBERG, S., and SAMUELSSON, M., 1990, Chemical fluxes and mass balances in a marine fish cage farm. I. Carbon: Marine Ecology Progress Series, v. 61, p. 61–73.

HALLOCK, P., LIDZ, B. H., COCKEY-BURKHARD, E. M., and DONNELLY, K. B., 2003, Foraminifera as bioindicators in coral reef assessment and monitoring: the foram index: Environmental Monitoring and Assessment, v. 81, p. 221–238.

HARGRAVE, B. T., PHILLIPS, G. A., DOUCETTE, L. I., WHITE, M. J., MILLIGAN, T. G., WILDISH, D. J., and CRANSTON, R. E., 1997, Assessing benthic impacts of organic enrichment from marine aquaculture: Water, Air and Soil Pollution, v. 99, p. 641–650.

HARRINGTON, R. R., KENNEDY, B. P., CHAMBERLAIN, C. P., BLUM, J. D., and FOLT, C. L., 1998, ^{15}N enrichment in agricultural catchments: field patterns and applications to tracking Atlantic salmon (*Salmo salar*): Chemical Geology including Isotope Geoscience, v. 147, p. 281–294.

HARRIS, D., HORWATH, W. R., and VAN KESSEL, C., 2001, Acid fumigation of soils to remove carbonates prior to total organic carbon or carbon-13 isotopic analysis: Soil Science Society of America Journal, v. 65, p. 1853–1856.

HATTA, A., and UJIIE, H., 1992, Benthic foraminifera from Coral Seas between Ishigaki and Iriomote Islands, southern Ryukyu Island Arc, northwestern Pacific, Part I, Systematic descriptions of Textulariina and Miliolina: Bulletin of the College of Science, University of the Ryukyus, v. 53, p. 49–119.

HAYEK, L. C., and BUZAS, M. A., 2006, The martyrdom of St. Lucie: decimation of a meiofauna: Bulletin of Marine Science, v. 72, p. 341–352.

————, ————, 2010, Surveying Natural Populations: Columbia University Press, New York, 590 p.

HAYWARD, B. W., GRENFELL, H. R., PULLIN, A. D., REID, C., and HOLLIS, C. J., 1997, Foraminiferal associations in the upper Waitemata Harbour, Auckland, New Zealand: Journal of the Royal Society of New Zealand, v. 27, p. 21–51.

————, ————, REID, C. M., and HAYWARD, K. A., 1999a, Recent New Zealand shallow-water benthic foraminifera: taxonomy, ecologic distribution, biogeography and use in paleoenvironmental assessment: Institute of Geological and Nuclear Sciences Monograph No. 21, 264 p.

————, ————, and SCOTT, D. B., 1999b, Tidal range of marsh foraminifera for determining former sea-level heights in New Zealand: New Zealand Journal of Geology and Geophysics, v. 42, p. 395–413.

————, and HOLLIS, C. J., 1994, Brackish Foraminifera in New Zealand: a taxonomic and ecologic review: Micropaleontology, v. 40, p. 185–222.

————, SCOTT, G. H., GRENFELL, H .R., CARTER, R., and LIPPS, J. H., 2004, Estimation of tidal elevation and salinity histories of sheltered harbours and estuaries using benthic foraminifera: The Holocene, v. 14, p. 218–232.

HEALD, E. J., 1971, The production of organic detritus in a south Florida estuary: University of Miami Sea Grant Technical Bulletin, v. 6, 110 p.

HEATON, T. H. E., 1986, Isotopic studies of nitrogen pollution in the hydrosphere and atmosphere: a review: Chemical Geology (Isotope Geosciences Section), v., 59, p. 87–102.

HERON-ALLEN, E., and EARLAND, A., 1913, Clare Island Survey: Part 64. Foraminifera: Proceedings of the Royal Irish Academy, v. 31, p. 1–188.

————, and ————, 1915, XVIII. The Foraminifera of the Kerimba Archipelago (Portuguese East Africa): The Transactions of the Zoological Society of London, v. 20, p. 543–794.

HEVIA, M., ROSENTHAL, H., and GOWEN, R. J., 1996, Modelling benthic deposition under fish cages: Journal of Applied Ichthyology, v. 12, p. 71–74.

HOLMER, M., DUARTE, C. M., HEILSKOV, A., OLESEN, B., and TERRADOS, J., 2003, Biogeochemical conditions in sediments enriched by organic matter from net-pen fish farms in the Bolinao area, Philippines: Marine Pollution Bulletin, v. 46, p. 1470–1479.

————, and KRISTENSEN, E., 1992, Impact of marine fish cage farming on metabolism and sulfate reduction of underlying sediments: Marine Ecology Progress Series, v. 80, p. 191–201.

————, and ————, 1996, Seasonality of sulfate reduction and pore water solutes in a marine fish farm sediment: the importance of temperature and sedimentary organic matter: Biogeochemistry, v. 32, p. 15–39.

————, MARBÁ, N., DIAZ-ALMELA, E., DUARTE, C.M., TSAPAKIS, M., and DANOVARO, R., 2007, Sedimentation of organic matter from fish farms in oligotrophic Mediterranean assessed through bulk and stable isotope ($\delta^{13}C$ and $\delta^{15}N$) analyses: Aquaculture, v. 262, p. 268–280.

————, ————, TERRADOS, J., DUARTE, C. M., and FORTES, M. D., 2002, Impacts of milkfish (*Chanos chanos*) aquaculture on carbon and nutrient fluxes in the Bolinao area, Philippines: Marine Pollution Bulletin, v. 44, p. 685–696.

HOOD, D. W., 1970, Introduction in Symposium on Organic Matter in Natural Waters: Institute of Marine Science Occasional Publication, v. 1, 613 p.

HORTON, B. P., LARCOMBE, P., WOODROFFE, S. A., WHITTAKER, J. E., WRIGHT, M. R., and WYNN, C., 2003, Contemporary foraminiferal distributions of a mangrove environment, Great Barrier Reef coastline, Australia: implications for sea-level reconstructions: Marine Geology, v. 198, p. 225–243.

————, WHITTAKER, J. E., THOMSON, K. H., HARDBATTLE, M. I. J., KEMP, A., WOODROFFE, S. A., and WRIGHT, M. R., 2005, The development of a modern foraminiferal data set for sea-level reconstructions, Wakatobi Marine National Park, southeast Salwesi, Indonesia: Journal of Foraminiferal Research, v. 35, p. 1–14.

JONES, R. W., 1994, The Challenger Foraminifera: Oxford University Press, Oxford, 149 p.

KARAKASSIS, I., TSAPAKIS, M., and HATZIYANNI, E., 1998, Seasonal variability in sediment profiles beneath fish farm cages in the Mediterranean: Marine Ecology Progress Series, v. 162, p. 243–252.

KELLY, L. A., STELLWAGEN, J., and BERGHEIM, A., 1996, Waste loadings from a fresh-water Atlantic salmon farm in Scotland: Water Resources Bulletin, v. 32, p. 1017–1025.

KORNFELD, M. M., 1931, Recent littoral foraminifera from Texas and Louisiana: Contributions from the Department of Geology of Stanford University, v. 1, p. 77–101.

KORSMAN, T., and BIRKS, H. J. B., 1996, Diatom-based water chemistry reconstructions from northern Sweden: a comparison of reconstruction techniques: Journal of Paleolimnology, v. 15, p. 65–77.

KURAMOTO, T., and MINAGAWA, M., 2001, Stable carbon and nitrogen isotopic characterization of organic matter in a mangrove ecosystem on the southwestern coast of Thailand: Journal of Oceanography, v. 57, p. 421–431.

LAMARCK, J. B. P. A. DE M., 1804, Suites des mémoires sur les fossils des environs de Paris. Explication des planches relatives aux coquilles fossils des environs de Paris: Annales du Muséum National d'Histoire Naturelle, Paris, vol. 5. 1778 p.

LEORRI, E., and CEARRETA, A., 2009, Quantitative assessment of the salinity gradient within the estuarine systems in the southern Bay of Biscay using benthic foraminifera: Continental Shelf Research, v. 29, p. 1226–1239.

LINNÉ, C., 1758, Systema Naturae, Ed. 10, Holmiae, suecia, impensis L. Salvii, tomus 1, 709 p.

LOEBLICH JR., A. R., and TAPPAN, H., 1994, Foraminifera of the Sahul Shelf and Timor Sea: Cushman Foundation for Foraminiferal Research, Special Publication no. 31, 661 p.

LUAN, B. T., and DEBENAY, J. P., 2005, Foraminifera, environmental indicators in the highly impacted environments of the Mekong Delta: Hydrobiologia, v. 548, p. 75–83.

MARBÁ, N., SANTIAGO, R., DÍAZ-ALMELA, E., ÁLVAREZ, E., and DUARTE, C. M., 2006, Seagrass (*Posidonia oceanica*) vertical growth as an early indicator of fish farm-derived stress: Estuarine Coastal and Shelf Science, v. 67, p. 475–483.

MAKSYMOWSKA, D., RICHARD, P., PIEKAREK-JANKOWSKA, H., and RIERA, P., 2000, Chemical and isotope composition of the organic matter sources in the Gulf of Gdansk (southern Baltic Sea): Estuarine, Coastal and Shelf Science, v. 51, p. 585–598.

MARTIN, R. E., 2000, Environmental Micropaleontology: The Application of Microfossils to Environmental Geology: Kluwer Academic/Plenum Publishers, New York, p. 481.

————, and STEINKER, D. C., 1973, Evaluation of techniques for recognition of living foraminifera: Compass, v. 50, p. 26–30.

MATSON, E. A., BRINSON, M. M., CAHOON, D. D., and DAVIS, G. J., 1983, Biogeochemistry of the sediments of the Pamlico and Neuse River estuaries, North Carolina: University of North Carolina Water Resources Research Institute, Report No. 191, 103 p.

————, and ————, 1990, Stable carbon isotopes and the C: N ratio in the estuaries of the Pamlico and Neuse Rivers, North Carolina: Journal of Limnography and Oceanography, v. 35, p. 1290–1300.

MCCULLOCH, I. A., 1977, Qualitative observations on recent foraminiferal tests with emphasis on the Eastern Pacific, v. 3: University of Southern California, Los Angeles, 1078 p.

MELLO, J. F., and BUZAS, M. A., 1968, An application of cluster analysis as a method of determining biofacies: Journal of Paleontology, v. 42, p. 747–758.

MIDLEN, A., and REDDING, T., 1998, Environmental Management for Aquaculture: Chapman & Hall, London, UK, 223 p.

MILLETT, F. W., 1903, Report on the Recent Foraminifera of the Malay Archipelago collected by Mr. A. Durrand, F.M.R.S., Part XV: Journal of the Royal Microscopical Society, London, v. 23.6, p. 685–704.

————, 1904, X., Report on the Recent Foraminifera of the Malay Archipelago collected by Mr. A. Durrand, F.M.R.S., Part XVI: Journal of the Royal Microscopical Society, v. 24.5, p. 489–506.

MUNSTERMAN, D., and KERSTHOLT, S., 1996, Sodium polytungstate, a new non-toxic alternative to bromoform in heavy liquid separation: Review of Paleobotany and Palynology, v. 91, p. 417–422.

MURRAY, J. W., 1973, Distribution and Ecology of Living Benthic Foraminiferids: Heinemann Educational Books Limited, London, 274 p.

————, and BOWSER, S. S., 2000, Mortality, protoplasm decay rate, and reliability of staining techniques to recognize ‘living’ foraminifera: a review: Journal of Foraminiferal Research, v. 30, p. 66–70.

NICHOLS, M. M., 1974, Foraminifera in estuarine classification, in Odum, H.T., and others (eds.), Coastal Ecological Systems in the United States, Volume 1: The Conservation Foundation, Washington, D.C., p. 325–441.

NIXON, S. W., FURNAS, B. N., LEE, V., and MARSHALL, N., 1984, The role of mangroves in the carbon and nutrient dynamics of Malaysia estuaries: Proceedings of the Asian Symposium on Mangrove Environmen- Research and Management, p. 534–544.

NOMURA, R., 1983, Cassidulinid foraminiferal provinces around Japan during the latest Cenozoic: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 46, p. 185–202.

ODUM, E. P., and DE LA CRUZ, A. A., 1967, Particulate organic detritus in a Georgia salt marsh-estuarine ecosystem: Estuaries, American Association for the Advancement of Science, Washington, p. 383–388.

OWENS, N. J. P., 1987, Natural variations in ^{15}N in the marine environment: Advances in Marine Biology, v. 24, p. 390–451.

PARKER, W. K., 1952, Foraminiferal distribution in the Long Island Sound- Buzzards Bay area: Bulletin of the Museum of Comparative Zoology, Harvard College, v. 106, p.428–473.

————, and JONES, T. R., 1865, On some foraminifera from the North Atlantic and Arctic Oceans, including Davis Straits and Baffin’s Bay: Philosophical Transactions Royal Society, London, v. 155, p. 325–441.

PEARSON, T. H., and ROSENBERG, R., 1978, Macrobenthos succession in relation to organic enrichment and pollution of the marine environment: Oceanography and Marine Biology, Annual Review, v. 16, p. 229–311.

PETERSON, B. J., and FRY, B., 1987, Stable isotopes in ecosystem studies: annual review of ecology and systematics, v. 18, p. 293–320.

PHILLIPS, R. P., 1985, Long-shore transport of sediment during August and September of the Terengganu coast: Pertanika, v. 8, p. 273–279.

RESIG, J. M., 1960, Foraminiferal ecology around ocean outfalls off southern California: Waste Disposal in the Marine Environment, Pergamon Press, London, p. 104–121.

REUSS, A. E., 1850, Neues Foraminiferen aus den Schichten des österreichischen Tertiärbeckens: denkschriften der kaiserlichen akademie der wissenschaften, mathematisch-Naturwissen-schaftliche Classe 1, p. 365–390.

RIMMER, M. A., and RUSSELL, D. J., 1998, Aspects of biology and culture of *Lates calcarifer*: Tropical Mariculture, Academic Press, San Diego, 173–224.

SACKETT, W. M., 1964, The depositional history and isotopic organic carbon composition of marine sediments: Marine Geology, v. 2, p. 173–185.

SAMPAIO, L., FREITAS, R., MAGUAS, C., and QUINTINO, V., 2010, Coastal sediments under the influence of multiple organic enrichment sources: an evaluation using carbon and nitrogen stable isotopes: Marine Pollution Bulletin, v. 60, p. 272–282.

SAUNDERS, J. B., 1957, Trochamminidae and certain Lituolidae (Foraminifera) from the recent brackish-water sediments of Trinidad, British West Indies: Smithsonian Miscellaneous Collection, v. 134, p. 1–16.

SCHAFER, C. T., 1973, Distribution of foraminifera near pollution sources in Chaleur Bay: Water, Air and Soil Pollution, v. 2, p. 1–14.

————, and COLE, F. E., 1974, Distribution of benthic foraminifera: their use in delimiting local near shore environment: Offshore Geology of Canada, Eastern Canada, Geological Survey of Canada, v. 1, p. 103–108.

————, WINTERS, G. V., SCOTT, D. B., POCKLINGTON, P., COLE, F. E., and HONIG, C., 1995, Survey of living foraminifera and polychaete populations at some Canadian aquaculture sites: potential for impact mapping and monitoring: Journal of Foraminiferal Research, v. 25, p. 236–259.

SCOTT, D. B., MEDIOLI, F., and SCHAFER, C., 2001, Monitoring in Coastal Environments Using Foraminifera and Thecamoebian Indicators: Cambridge University Press, Cambridge, 177 p.

————, SCHAFER, C. T., HONIG, C., and YOUNGER, D. C., 1995, Temporal variations of benthic foraminiferal assemblages under or near aquaculture operations: documentation of impact history: Journal of Foraminiferal Research, v. 25, p. 224–235.

————, TOBIN, R., WILLIAMSON, M., MEDIOLI, F. S., LATIMER, J. S., BOOTHMAN, W. A., ASIOLI, A., and HAURY, V., 2005, Pollution monitoring in two North American estuaries: historical reconstructions using benthic foraminifera: Journal of Foraminiferal Research, v. 35, p. 65–82.

SEJRUP, H. P., BIRKS, H. J. B., KRISTENSEN, D. K., and MADSEN, H., 2004, Benthonic foraminiferal distributions and quantitative transfer functions for the northwest European continental margin: Marine Micropaleontology, v. 53, p. 197–226.

SHERR, E. B., 1982, Carbon isotope composition of organic seston and sediments in a Georgia salt marsh estuary: Geochimica et Cosmochimica Acta, v. 46, p. 1227–1232.

SHULTZ, D. J., and CALDER, J. A., 1976, Organic carbon $^{13}C/^{12}C$ variations in estuarine sediments: Geochemica et Cosmochimica Acta, v. 40, p. 381–385.

SOKAL, R. R., and SNEATH, P. H. A., 1963, Principles of Numerical Taxonomy: San Francisco, W.H. Freeman & Co., 359 p.

STARKEY, H. C., BLACKMON, P. D., and HAUFF, P. L., 1984, The routine mineralogical analysis of clay-bearing samples: U.S.G.S. Bulletin 1563, 26 p.

SWEENEY, R. E., and KAPLAN, I.R., 1980, Natural abundances of ^{15}N as a source indicator for near-shore marine sedimentary and dissolved nitrogen: Marine Chemistry, v. 9, p. 81–94.

TARASOVA, T. S., 2006, Environmental impacts on the benthic foraminiferal fauna in nearshore ecosystems: Russian Journal of Marine Biology, v. 32, p. 11–20.

————, and PREOBRAZHENSKAYA, T. V., 2007, Benthic foraminifera at a scallop aquaculture site in Minonosok Bay, the Sea of Japan: Russian Journal of Marine Biology, v. 33, p. 17–29.

TER BRAAK, C. J. F., and SMILAUER, P., 1998, CANOCO Reference Manual and User's Guide to Canoco for Windows: Software for Canonical Community Ordination (version 4): Microcomputer Power, Ithaca, New York, USA, 352 p.

————, and ————, 2002, CANOCO Reference Manual and CanoDraw for Windows User's Guide: Software for Canonical Community Ordination (version 4.5). Section on permutation methods: Microcomputer Power, Ithaca, New York, USA, 500 p.

THORNTON, S.F., and MCMANUS, J., 1994, Application of organic carbon and nitrogen stable isotope and C/N ratios as source indicators of organic matter provenance in estuarine systems: evidence from the Tay Estuary, Scotland: Estuarine, Coastal and Shelf Science, v. 38, p. 219–233.

TODD, R., 1957, Smaller foraminifera: geology of Saipan, Mariana Islands, Part III, Paleontology: USGS Professional Papers, 280-H, p. 265–320.

TUCKER, J., SHEATS, N., GIBLIN, A. E., HOPKINSON, C. S., and MONTOYA, J. P., 1999, Using stable isotopes to trace sewage-derived material through Boston Harbor and Massachusetts Bay: Marine Environmental Research, v. 48, p. 353–375.

VAN MARLE, L. J., 1991, Eastern Indonesian, late Cenozoic smaller benthic foraminifera: Verhandelingen der Koninklijke Nederlandse Akademie van Wetenschappen, v. 34, p. 1–328.

VON FICHTEL, L., and VON MOLL, J. P. C., 1798, Testacea microscopica, aliaque minuta ex generibus Argonauta et Nautilus, ad naturam picta et descripta (Microscopische und andere klein Schalthiere aus den geschlechtern Argonaute und Schiffer: Camesina, Vienna, 123 p.

WALKER, D. A., LINTON, A. E., and SCHAFER, C. T., 1974, Sudan Black B: a superior stain to rose Bengal for distinguishing living from non-living foraminifera: Journal of Foraminiferal Research, v. 4, p. 205–215.

WALLER, S. S., and LEWIS, J. K., 1979, Occurrence of C_3 and C_4 Photosynthetic Pathways in North American Grasses: Journal of Range Management, v. 32, p. 12–28.

WALTON, W. R., 1952, Techniques for recognition of living foraminifera: Contributions from the Cushman Foundation for Foraminiferal Research, v. 3, p. 56–60.

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

WHITTAKER, J. E., and HODGKINSON, R. L.,1979, Foraminifera of the Togopi Formation, eastern Sabah, Malaysia: Bulletin of the British Museum (Natural History) Geology Series, v. 31, p. 1–120.

WOODROFFE, S. A., and HORTON, B. P., 2005, Holocene sea-level changes in the Indo-Pacific: Journal of Asian Earth Sciences, v. 25, p. 29–43.

World Wildlife Fund for Nature- Malaysia. *Project: Sustainable Management of Setiu Wetlands*. Retrieved January 21, 2013. http://www.wwf.org.my/about_wwf/what_we_do/freshwater_main/freshwater_conserving_freshwater_habitats/projects_sustainable_management_of_setiu_wetlands/

WU, R. S. S., 1995, The environmental impact of marine fish culture: towards a sustainable future: Marine Pollution Bulletin, v. 31, p. 169–166.

YAACOB, R., 1988. Geophysical Studies in Setiu Lagoon-Estuary System. M.S. thesis: Universiti Pertanian Malaysia.

————, HUSAIN, M. L., and SHAZILI, N. A. M., 1995, Grain-size distribution of sediment in the vicinity of Setiu Lagoon-estuary system: Pertanika Journal of Tropical Agricultural Sciences, v. 18, p. 71–76.

————, and ————, 2005, The relationship of sediment texture with coastal environments along the Kuala Terengganu coast, Malaysia: Environmental Geology, v. 48, p. 639–645.

————, and MUSTAPA, M. Z., 2010, Grain-size distribution and subsurface mapping at the Setiu wetlands, Setiu, Terengganu: Environmental and Earth Sciences, v. 60, p. 975–984.

YAMAMURO, M., 2000, Chemical tracers of sediment organic matter origins in two coastal lagoons: Journal of Marine Systems, v. 26, p. 127–134.

YANKO, V., ARNOLD, A. J., and PARKER, W. C., 1999, Effects of marine pollution on benthic Foraminifera, *in* Sen Gupta, B. K. (ed.), Modern Foraminifera: Kluwer Academic Publishers, MA, p. 217–235.

YOKOYAMA, H., ABO, K., and ISHIHI, Y., 2006, Quantifying aquaculture-derived organic matter in the sediment in and around a coastal fish farm using stable carbon and nitrogen isotope ratios: Aquaculture, v. 254, p. 411–425.

APPENDIX A

Taxonomic reference list.

Ammobaculites exiguus Cushman and Brönnimann, 1948, p.38, pl. 7, figs. 7, 8.

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

Ammonia tepida (Cushman) = *Rotalia beccari* (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.

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

Amphistegina lessonii d'Orbigny, 1826, p. 304, no. 3.

Arenoparrella mexicana (Kornfeld) = *Trochammina inflata* (Montagu) var. *mexicana* Kornfeld, 1931, p. 86, pl. 13, fig. 5a, b, c.

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

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

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

Buliminella elegantissima d'Orbigny, 1839a, 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.

Cavarotalia annectens (Parker and Jones) = *Rotalia beccarii* (Linné) var. *annectens* Parker and Jones, 1865, p. 422, pl. 19, figs. 11a, b, c.

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

Cellanthus craticulus von Fichtel and von Moll, 1798, p. 51, pl. 5, figs. h–k.

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

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

Elphidium crispum s.l. Linné = *Nautilus crispus* Linné, 1758, p.709, pl. 5, figs. 12a, 12b.

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. 97, fig. 1.

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

Elphidium simplex Cushman, 1933, p.52, pl. 12, figs. 8, 9.

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

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

Globocassidulina bisecta Nomura, 1983, p. 73, pl. 2, figs. 2,3, pl. 14, figs 8-12, pl. 15, figs. 1-5.

''Glomospira'' fijiensis Brönnimann, Whittaker and Zaninetti, 1992, p. 23, pl. 3, figs. 1–4; pl. 13, figs. 1–4.

Hanzawaia nipponica Asano, 1944, p. 99, pl. 4, figs. 1, 2.

Haplophragmoides 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.

Murrayinella murrayi Heron-Allen and Earland, 1915, p. 720, pl. 53, figs. 27-34.

Pararotalia calcariformata McCulloch = *Pararotalia* (?) *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.

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

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

Pseudorotalia schroeteriana (Parker and Jones) = *Rotalia 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.

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.

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

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

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

Siphotrochammina lobata Saunders, 1957, p. 9, 10, pl. 3, figs. 1, 2.

Spirolina cylindracea (Lamarck) = *Spirolinites cylindracea* Lamarck 1804, p. 245; 1806, pl. 62 (14), fig. 15.

Spiroloculina manifesta Cushman and Todd, 1944, p. 62, pl. 8, figs. 26–28.

Trochammina amnicola Brönnimann and Keij, 1986, p. 22, pl. 2, figs. 1, 2, pl. 4, figs. 1–13.

Wiesnerella ujiiei Hatta in Hatta and Ujiie, 1992, p. 62, pl. 4, fig. 8.

APPENDIX B

Foraminiferal census data. L, live; D, dead. Samples ordered from north to south.

Taxon↓ Sample Location→		T1-100	T1-60	T1-30	T1-15	T1-5	T1-0	S43-1	S43-2	S43-3	S43-4	S43-5	S43-6	S43-7	S43-8	S43-9	T2-0	T2-5	T2-15	T2-30	T2-60	T2-100	Total
Ammobaculites exiguus	L	7	6	8	10	6	3	12	4	2	10	11	3	28	8	2	25	15	16		2		178
	D	50	54	41	43	44	17	82	37	15	125	35	37	163	58	48	100	121	7				1077
Ammodiscus sp. A	L																						0
	D														2		1						3
Ammonia aff. *A. aoteana*	L			3		1		6	34	40	4	27	12		22	14	21	5	18		1	5	213
	D	7	3	42	10	2	7	21	31	15	35	48	68	6	42	58	32	28	9		2		466
Ammonia tepida	L																						0
	D											4			4								8
Ammonia sp.	L																						0
	D																						0
Ammotium directum	L								1	1	4		1			1							8
	D		1	2				6	3		2		1	9			1	8				1	34
Ammotium morenoi	L	2			6			3		15	5	2	2	2	1			1	1		1	2	43
	D	1	1	5	1		1	4	1	2	11	2		9		2	6	15	5		1		67
Amphistegina lessonii	L																						0
	D							3			1	10			5			1	3	3	7	2	35
Arenoparrella mexicana	L																						0
	D											1											1
Asterigerinata sp. A	L																						0
	D											2											2
Asterorotalia pulchella	L																						0
	D																2						2
Bolivina sp.	L											1											1
	D			1				1			2	1			10	6	8						29
Brizalina subtenuis	L																						0
	D																						0
Bruneica clypea	L																						0
	D						1					1	1										3
Buliminella elegantissima	L																						0
	D																						0
Buliminoides williamsoni	L																						0
	D																						0
Cancris carinatus	L																						0
	D																						0
Caronia exilis	L																						0
	D				1			1															2
Cavarotalia annectens	L							2														1	3
	D				8	3	3	4	2			1											21
Cellanthus biperforatus	L																						0
	D																						0
Cellanthus craticulus	L							1							1								2
	D				1			1								1			1				4
Cellanthus sp.	L																						0
	D							1										2	1		1		5
Cheilochanus sp.	L																						0
	D																						0

Cibicides cf. *C. fletcheri*	L																						0
	D															1							1
Cibicides sp. B	L																						0
	D															2							2
Cibicides sp.	L																						0
	D																						0
Elphidium advenum	L																						0
	D																						0
Elphidium crispum s.l.	L																						0
	D																						0
Elphidium hyalocostatum	L																						0
	D									1													1
Elphidium indicum	L																						0
	D																1						1
Elphidium cf. *E. neosimplex*	L											1				1							2
	D																	1					1
Elphidium aff. *E. poeyanum*	L																						0
	D															2							2
Elphidium simplex	L																						0
	D									1													1
Elphidium aff. *E. simulatum*	L																						0
	D							2								2	1						5
Elphidium singaporense	L																						0
	D																						0
Elphidium sp.	L											1											1
	D										1	2											3
Eponides sp.	L																						0
	D								1														1
Gavelinopsis praegeri	L														1								1
	D														8	1	1						10
Globocassidulina bisecta	L																						0
	D																						0
"*Glomospira*" *fijiensis*	L							1															1
	D	1											2										3
Guttulina sp.	L																						0
	D										1												1
Hanzawaia nipponica	L																						0
	D															1							1
Haplophragmoides cf. *H. manilaensis*	L																						0
	D																						0
Haplophragmoides wilberti	L								1														1
	D																						0
Indeterminate agglutinated	L								1							1							2
	D	5			4			1	8	3		2				3	1		1				28
Indeterminate calcareous	L						1									1	1		1				4
	D					1	1	2	1	2		1	1			4	3	6	1		1		24
Indeterminate miliolid	L																						0
	D																		1				1
Indeterminate rotaliid	L																						0
	D				1		1			3		5	1			5	1	2	1				20
?*Jadammina* sp.	L																						0
	D									1													1
Miliammina fusca	L										2												2
	D	1							1		1					1	1						5

Murrayinella murrayi	L																						0
	D											2			1	1							4
Neoconorbina sp.	L																						0
	D																						0
? *Neoconorbina*	L																						0
	D																						0
Nodosariid	L																						0
	D																						0
Nonion sp.	L											3											3
	D																						0
Pararotalia calcariformata	L																						0
	D																						0
Pararotalia nipponica	L											1											1
	D															1							1
Pararotalia venusta	L																						0
	D																						0
Pararotalia sp. A	L																						0
	D																						0
Pararotalia sp.	L																						0
	D																		1	1		1	3
Paratrochammina stoeni	L	2	3	17	1	4	1	9	4	12		1			2	3		1					60
	D	25	11	41	11	14	1	8	7	14	2		4		6	2	7	2					155
Peneroplis pertusus	L																						0
	D																						0
Planodiscorbis sp.	L																						0
	D											1											1
Planorbulina acervalis	L																						0
	D															1		1					2
Pseudorotalia cf. *P. schroeteriana*	L																						0
	D												1					1					2
Quinqueloculina sp.	L							1						2									3
	D											1				1	4	1			1	1	9
Reussella pulchra	L																						0
	D						1	1		1	5	8	3	1	6	7	3	3					39
Reussella spinulosa	L																						0
	D																						0
Reussella sp. C	L																						0
	D			1															1				2
Rosalina globularis	L												1			1							2
	D															1	1						2
Rosalina sp. B	L											1											1
	D																						0
Sagrina zanzibarica	L																						0
	D											1											1
Sagrinella lobata	L																						0
	D							1	1			5			7	6							20
Schackoinella globosa	L																						0
	D															1							1
Siphotrochammina lobata	L								1														1
	D									1													1
Spirolina cylindracea	L																						0
	D																						0
Spiroloculina manifesta	L																						0
	D																						0

Trochammina amnicola	L			5		4	4	4	2	10	4	2	7		3	1			2				48
	D		2	5	7	5	2	1		5		5	17	1	2	1	3						56
Trochammina laevigata	L								1								1						2
	D		1		1																		2
"Trochammina ochracea"	L												1						1	1		1	4
	D		3	3		7	2		2	4		1	10			4							36
Trochammina sp. E	L	3		12	1	3	1	4	4	3		4	2	1			3	1	1				43
	D	9	7	8	2	9		9		3	1		4	3	3	2	2	1					63
Trochammina sp.	L	3	2	8		2	1	5	8	4							2	1					36
	D	14	2	17	5		1	13	10	4		1	26		4	3					1		101
Wiesnerella sp.	L																						0
	D																						0
Number of live specimens	L	17	11	53	18	20	11	48	61	87	29	55	29	33	38	25	53	24	40	1	4	9	666
Number of dead specimens	D	113	85	166	95	85	38	162	105	75	187	140	176	192	158	168	179	193	32	4	14	5	2372
Total Foraminifera (live+dead)	T	130	96	219	113	105	49	210	166	162	216	195	205	225	196	193	232	217	72	5	18	14	3038
Taxon↓ Sample Location→		**T3-100**	**T3-60**	**T3-30**	**T3-15**	**T3-5**	**T3-0**	**S40-1**	**S40-2**	**S40-3**	**S40-4**	**S40-5**	**S40-6**	**S40-7**	**S40-8**	**S40-9**	**T4-0**	**T4-5**	**T4-15**	**T4-30**	**T4-60**	**T4-100**	**Total**
Ammobaculites exiguus	L	10	7	1	4		1	2	1	1		2	2	1									32
	D	102	63	68	58	31	36	24	47	19	15	15	109	16		4	6	10	10	12	18	6	669
Ammodiscus sp. A	L		1																				1
	D		1																				1
Ammonia aff. *A. aoteana*	L	1	5	9	24	1	2	8	12	6	2	7	4	6	1	6	3	2	10	5	13	10	137
	D	5	21	12	21	16	18	39	50	40	1	21	13	24	12	31	20	20	20	18	30	24	456
Ammonia tepida	L														1								1
	D					4	3	3	5	1	5	5	2	4		2	5	1	1	4	1	4	50
Ammonia sp.	L							1															1
	D									1													1
Ammotium directum	L		6	4	1																		11
	D	1	6	3		1												1					12
Ammotium morenoi	L	1	10					2					5										18
	D	5	7	7	6	5	1	1	2	2		4	11	3		1	3	5	1		2	2	68
Amphistegina lessonii	L															1				1			2
	D					2	4		1	1	8	7	1	4	5	59	3	4	3	6	1	8	117
Arenoparrella mexicana	L																	1					1
	D	1				1							1										3
Asterigerinata sp. A	L																						0
	D																						0
Asterorotalia pulchella	L																						0
	D							2	2		1	3				9	2	3	1	1		3	27
Bolivina sp.	L																						0
	D		15	4	14	14	10	9	10	14	11	11	2	16	7	3	11	12	13	10	21	15	222
Brizalina subtenuis	L																						0
	D														2		1	1	1				5
Bruneica clypea	L																						0
	D																						0
Buliminella elegantissima	L																						0
	D							1															1
Buliminoides williamsoni	L																						0
	D					1					1				1								3
Cancris carinatus	L																						0
	D											1	1			1	1	1	1		2		8
Caronia exilis	L		1																1				2
	D	2			2	1	1		1		2	4				1	1			1			16
Cavarotalia annectens	L						1																1

	D					8	9	4	7	11	3	2		4	3	3		3	2	1	6	2	68
Cellanthus biperforatus	L																						0
	D	1												1		2							4
Cellanthus craticulus	L										1												1
	D											1						1					2
Cellanthus sp.	L																						0
	D															1							1
Cheilochanus sp.	L																						0
	D																			1			1
Cibicides cf. *C. fletcheri*	L																					1	1
	D			1		4	4	3	1	5	6	8		4	16	1	5	11	6	8	7	9	99
Cibicides sp. B	L																						0
	D					1		2		3	4			1		3	1	3	1	5	1	2	27
Cibicides sp.	L																						0
	D					1	2	1	1	2	5	2		2	1	1	5		6				29
Elphidium advenum	L																						0
	D							2									1		1				4
Elphidium crispum s.l.	L																						0
	D														1							2	3
Elphidium hyalocostatum	L																						0
	D					2	1					1				2	1	1				1	9
Elphidium indicum	L																						0
	D										2					4							6
Elphidium cf. *E. neosimplex*	L		1			2		1									1						5
	D				1	3		1		1		1			2	1		1	2	2	4	2	21
Elphidium aff. *E. poeyanum*	L																						0
	D	1										2						1	1	1		1	7
Elphidium simplex	L	1																					1
	D				1	2	2		1										3				9
Elphidium aff. *E. simulatum*	L																	1					1
	D						2	2	1		1		1	1		1					1		10
Elphidium singaporense	L																						0
	D					2	2	2			3	5		3	2	4	2	4	5	3	3	7	47
Elphidium sp.	L																						0
	D					3	2	3	1	1		7	2	2	3		1	6		1	5	4	41
Eponides sp.	L					1																	1
	D					3	1								1		1						6
Gavelinopsis praegeri	L																						0
	D			1	2	6	8	2		5	6				7		9	3	9	6	7	2	73
Globocassidulina bisecta	L																						0
	D							1			1		2	1						1	3		9
"Glomospira" fijiensis	L												1										1
	D			1	1				1														3
Guttulina sp.	L																						0
	D							1		1													2
Hanzawaia nipponica	L																						0
	D																						0
Haplophragmoides cf. *H. manilaensis*	L																						0
	D																		1				1
Haplophragmoides wilberti	L																						0
	D		1	1	1	1					1												5
Indeterminate agglutinated	L																			1		1	2
	D			3			3								1	2	1						10
Indeterminate calcareous	L					2			2						1					1			6

	D	2	10		2	11	17	5	8	15	17	11	3	12	13	12	12	16	10	6	9	6	197
Indeterminate miliolid	L																						0
	D							1											1			1	3
Indeterminate rotaliid	L						1																1
	D			1	7	9	4	6	5		5	1		3	6	2	5	5	8	2	9	2	80
?*Jadammina* sp.	L																						0
	D																						0
Miliammina fusca	L				2								3					1					6
	D			4	2			1						3				2			2		14
Murrayinella murrayi	L																						0
	D					5	2				1			1		1	1	2	1		1	1	16
Neoconorbina sp.	L																						0
	D																					1	1
? *Neoconorbina*	L																						0
	D											1											1
Nodosariid	L																						0
	D																			1			1
Nonion sp.	L																						0
	D																						0
Pararotalia calcariformata	L																						0
	D																	1	1	1			3
Pararotalia nipponica	L																						0
	D			1	1	5	4	2		1		6		1	4	1	1	2	2	1	2	3	37
Pararotalia venusta	L																						0
	D																				1	4	5
Pararotalia sp. A	L																						0
	D											1			1	2							4
Pararotalia sp.	L																			1			1
	D									1		1			1				1		1	1	6
Paratrochammina stoeni	L			3			1															1	5
	D	17		13	4	4			1		1		4						1		2		47
Peneroplis pertusus	L																						0
	D							1							1		2	1	2		2	2	11
Planodiscorbis sp.	L																						0
	D																						0
Planorbulina acervalis	L																						0
	D							1							3	4	4	4	1	3	4	3	27
Pseudorotalia cf. *P. schroeteriana*	L																						0
	D				2		1													1	1		5
Quinqueloculina sp.	L											1					2	1	1				5
	D		1			2	2	7	2	2	14	25		13	18	12	13	17	14	19	20	19	200
Reussella pulchra	L							1															1
	D		4	1	8	7	7	6	20	16	14	17		14	19	7	7	4	4	15	22	25	217
Reussella spinulosa	L																						0
	D							2		1	1	4			5						2		15
Reussella sp. C	L																						0
	D		3			1	2		1		1	3		1		2	2			1			17
Rosalina globularis	L												7		1		1						9
	D			1	2	2	1	5			14	2	3	1			8	6	8	3	4	2	62
Rosalina sp. B	L																						0
	D					2		1			1	4	2	5	3		1			3	1	2	25
Sagrina zanzibarica	L								7									1					8
	D		1	2	2	8	5	6		2		5	2	4	12		5	11	7	9	17	9	107
Sagrinella lobata	L								2														2

	D		7	1	7	7	21	9		29		17	3	16	24	4	12	11	18	18	33	19	256
Schackoinella globosa	L																						0
	D						1	2		4				3				1	1	1	2	1	16
Siphotrochammina lobata	L																						0
	D	3						1	1														5
Spirolina cylindracea	L																						0
	D														1								1
Spiroloculina manifesta	L																						0
	D										1			1					1		1		4
Trochammina amnicola	L	6	5		1			2	1				4					2				1	22
	D	15	11	13	9	2		1	6	1	1		4	1									64
Trochammina laevigata	L																						0
	D																						0
"Trochammina ochracea"	L																						0
	D	3	1	2	2		1		2				1	1									13
Trochammina sp. E	L	4		2	3				1					1									11
	D	5	9	10	7	1			2	3					1								38
Trochammina sp.	L			3			1																4
	D	3	4				5																12
Wiesnerella sp.	L																			1			1
	D																						0
Number of live specimens	L	23	36	22	35	6	7	17	26	7	3	10	26	8	4	7	7	9	12	10	13	14	302
Number of dead specimens	D	166	165	150	162	178	182	160	179	182	147	198	167	166	176	183	153	175	169	165	248	195	3666
Total Foraminifera (live+dead)	T	189	201	172	197	184	189	177	205	189	150	208	193	174	180	190	160	184	181	175	261	209	3968

Taxon↓	**Sample Location→**	**T5-100**	**T5-60**	**T5-30**	**T5-15**	**T5-5**	**T5-0**	**S9A-1**	**S9A-2**	**S9A-3**	**S9A-4**	**S9A-5**	**S9A-6**	**S9A-7**	**S9A-8**	**S9A-9**	**T6-0**	**T6-5**	**T6-15**	**T6-30**	**T6-60**	**T6-100**	**Total**
Ammobaculites exiguus	L	6	16	2	18	4	16	12	17	5	1	13	6	27	20	43	4	13	39	38	48	52	400
	D	9	3	9	5	14	2	2		1	9	39		4	4	3	1	4	2	5	2	3	121
Ammodiscus sp. A	L																						0
	D																						0
Ammonia aff. *A. aoteana*	L																						0
	D											1											1
Ammonia tepida	L																						0
	D																						0
Ammonia sp.	L																						0
	D																						0
Ammotium directum	L	8	18	2	10	6	14	12	8	11		5		12		4	4	7	9	8		16	154
	D	33	27	26	17	22	25	24	11	15	18	18		8	16	8	6	18	10	14	2	2	320
Ammotium morenoi	L																						0
	D	1		5							1	3							1				11
Amphistegina lessonii	L																						0
	D																						0
Arenoparrella mexicana	L																						0
	D	2									2						1						5
Asterigerinata sp. A	L																						0
	D																						0
Asterorotalia pulchella	L																						0
	D																						0
Bolivina sp.	L																						0
	D														1			1					2
Brizalina subtenuis	L																						0
	D																						0
Bruneica clypea	L																						0
	D																						0

Buliminella elegantissima	L				0
	D				0
Buliminoides williamsoni	L				0
	D				0
Cancris carinatus	L				0
	D				0
Caronia exilis	L				0
	D				0
Cavarotalia annectens	L				0
	D				0
Cellanthus biperforatus	L				0
	D				0
Cellanthus craticulus	L				0
	D				0
Cellanthus sp.	L				0
	D				0
Cheilochanus sp.	L				0
	D				0
Cibicides cf. *C. fletcheri*	L				0
	D				0
Cibicides sp. B	L				0
	D				0
Cibicides sp.	L				0
	D				0
Elphidium advenum	L				0
	D				0
Elphidium crispum s.l.	L				0
	D				0
Elphidium hyalocostatum	L				0
	D	1			1
Elphidium indicum	L				0
	D				0
Elphidium cf. *E. neosimplex*	L				0
	D				0
Elphidium aff. *E. poeyanum*	L				0
	D				0
Elphidium simplex	L				0
	D				0
Elphidium aff. *E. simulatum*	L				0
	D				0
Elphidium singaporense	L				0
	D				0
Elphidium sp.	L				0
	D				0
Eponides sp.	L				0
	D				0
Gavelinopsis praegeri	L				0
	D				0
Globocassidulina bisecta	L				0
	D				0
"*Glomospira*" *fijiensis*	L	2	2 1	1	6
	D	2		2	4
Guttulina sp.	L				0
	D				0
Hanzawaia nipponica	L				0

	D																						0
Haplophragmoides cf. *H. manilaensis*	L	1							1														2
	D	4				2	2		1		3	4			1								17
Haplophragmoides wilberti	L																						0
	D										1												1
Indeterminate agglutinated	L	3	2				6			1		2		1	3							2	20
	D	6	3		1	5	6		2		1	11		4	1							1	41
Indeterminate calcareous	L																						0
	D																						0
Indeterminate miliolid	L																						0
	D																						0
Indeterminate rotaliid	L																						0
	D																						0
?*Jadammina* sp.	L																						0
	D																						0
Miliammina fusca	L	27	79	6	39	29	26	56	106	68	4	8	1	93	32	57	14	47	75	71	89	74	1001
	D	58	53	104	80	75	61	88	62	110	109	14		41	131	57	15	93	46	63	52	50	1362
Murrayinella murrayi	L																						0
	D																						0
Neoconorbina sp.	L																						0
	D																						0
? *Neoconorbina*	L																						0
	D																						0
Nodosariid	L																						0
	D																						0
Nonion sp.	L																						0
	D																						0
Pararotalia calcariformata	L																						0
	D																						0
Pararotalia nipponica	L																						0
	D																						0
Pararotalia venusta	L																						0
	D																						0
Pararotalia sp. A	L																						0
	D																						0
Pararotalia sp.	L																						0
	D																						0
Paratrochammina stoeni	L																						0
	D																						0
Peneroplis pertusus	L																						0
	D																						0
Planodiscorbis sp.	L																						0
	D																						0
Planorbulina acervalis	L																						0
	D																						0
Pseudorotalia cf. *P. schroeteriana*	L																						0
	D																						0
Quinqueloculina sp.	L	2																					2
	D	3		1																			4
Reussella pulchra	L																						0
	D																						0
Reussella spinulosa	L																						0
	D																						0
Reussella sp. C	L																						0

	D																						0
Rosalina globularis	L																						0
	D																						0
Rosalina sp. B	L																						0
	D																						0
Sagrina zanzibarica	L																						0
	D																						0
Sagrinella lobata	L																						0
	D																						0
Schackoinella globosa	L																						0
	D																						0
Siphotrochammina lobata	L	1				1				1	3					2							8
	D			1		1					8	3				2							15
Spirolina cylindracea	L																						0
	D																						0
Spiroloculina manifesta	L																						0
	D																						0
Trochammina amnicola	L	6	11		4	2	5	15	7	4		8	11	1	8	3	4	4		2		4	99
	D	20	8	35	18	17	11	10	5	9	3	23		2	5	7	7	7	4	2	1	1	195
Trochammina laevigata	L				1																		1
	D	1					1				3	3				1							9
"Trochammina ochracea"	L																						0
	D							1						1									2
Trochammina sp. E	L																						0
	D																						0
Trochammina sp.	L											1											1
	D	1			1		4					10			1								17
Wiesnerella sp.	L																						0
	D																						0
Number of live specimens	L	54	128	10	72	42	67	95	141	90	8	37	18	134	64	109	27	71	123	119	137	148	1694
Number of dead specimens	D	138	94	181	124	136	113	125	81	135	158	129	0	60	160	78	30	125	63	84	57	57	2128
Total Foraminifera (live+dead)	T	192	222	191	196	178	180	220	222	225	166	166	18	194	224	187	57	196	186	203	194	205	3822

APPENDIX C

Transformed data for the total cluster analysis not including species which only had one specimen. Samples ordered from north to south.

Species	Sample No. Species Code	T1-100	T1-60	T1-30	T1-15	T1-5	T1-0	S43-1	S43-2	S43-3	S43-4	S43-5	S43-6	S43-7	S43-8	S43-9	T2-0	T2-5	T2-15	T2-30	T2-60	T2-100
Ammobaculites exiguus	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	0.00	0.00	0.00	0.00	0.00	0.00
Ammodiscus sp. A	2	1.45	1.82	0.99	1.51	1.52	1.39	1.47	1.04	0.66	1.82	1.01	0.92	2.34	1.24	1.07	1.65	1.83	1.20	0.00	0.68	0.00
Ammonia aff. *A aoteana*	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	0.20	0.00	0.13	0.00	0.00	0.00	0.00	0.00
Ammonia tepida	4	0.47	0.36	0.94	0.60	0.34	0.78	0.73	1.35	1.24	0.88	1.34	1.35	0.33	1.22	1.31	1.00	0.80	1.32	0.00	0.84	1.28
Ammonia sp.	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammotium directum	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	7	0.00	0.20	0.19	0.00	0.00	0.00	0.34	0.31	0.16	0.33	0.00	0.20	0.40	0.00	0.14	0.13	0.39	0.00	0.00	0.00	0.54
Amphistegina lessonii	8	0.31	0.20	0.30	0.50	0.00	0.29	0.37	0.16	0.66	0.55	0.29	0.20	0.45	0.14	0.20	0.32	0.55	0.59	0.00	0.68	0.78
Arenoparrella mexicana	9	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.14	0.46	0.00	0.00	0.32	0.00	0.00	0.14	0.41	1.77	1.35	0.78
Asterigerinata sp. A	10	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
Asterorotalia pulchella	11	0.00	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bolivina sp.	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	0.19	0.00	0.00	0.00	0.00	0.00
Brizalina subtenuis	13	0.00	0.00	0.14	0.00	0.00	0.00	0.14	0.00	0.00	0.19	0.20	0.00	0.00	0.46	0.35	0.37	0.00	0.00	0.00	0.00	0.00
Bruneica clypea	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
Buliminoides williamsoni	16	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.14	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cancris carinatus	17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cavarotalia annectens	19	0.00	0.00	0.00	0.19	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
Cellanthus biperforatus	20	0.00	0.00	0.00	0.54	0.34	0.50	0.34	0.22	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54
Cellanthus craticulus	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	0.00
Cellanthus sp.	22	0.00	0.00	0.00	0.19	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.00	0.00	0.24	0.00	0.00	0.00
Cibicides cf. *C. fletcheri*	24	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	0.19	0.24	0.00	0.48	0.00
Cibicides sp. B	25	0.00	0.00	0.00	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
Cibicides sp.	26	0.00	0.00	0.00	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	0.00	0.00	0.00	0.00	0.00
Elphidium advenum	27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 crispum s.l.	28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	30	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
Elphidium cf. *E. neosimplex*	31	0.00	0.00	0.00	0.00	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
Elphidium aff. *E. poeyanum*	32	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	0.14	0.00	0.00	0.00	0.00
Elphidium simplex	33	0.00	0.00	0.00	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	0.00	0.00	0.00	0.00	0.00
Elphidium aff. *E. simulatum*	34	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
Elphidium singaporense	35	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	0.20	0.13	0.00	0.00	0.00	0.00	0.00
Elphidium sp.	36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eponides sp.	37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gavelinopsis praegeri	38	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
Globocassidulina bisecta	39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.14	0.13	0.00	0.00	0.00	0.00	0.00
"Glomospira" fijiensis	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	0.00
Guttulina sp.	41	0.18	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Haplophragmoides cf. *H. manilaensis*	43	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
Haplophragmoides wilberti	44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 agglutinated	45	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
Indeterminate calcareous	46	0.39	0.00	0.00	0.38	0.00	0.00	0.14	0.47	0.27	0.00	0.20	0.00	0.00	0.00	0.29	0.13	0.00	0.24	0.00	0.00	0.00
Indeterminate miliolid	47	0.00	0.00	0.00	0.00	0.20	0.41	0.20	0.16	0.22	0.00	0.14	0.14	0.00	0.00	0.32	0.26	0.33	0.33	0.00	0.48	0.00
Indeterminate rotaliid	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	0.00	0.00	0.00	0.24	0.00	0.00	0.00
Miliammina fusca	50	0.00	0.00	0.00	0.19	0.00	0.29	0.00	0.00	0.27	0.00	0.32	0.14	0.00	0.00	0.32	0.13	0.19	0.24	0.00	0.00	0.00
Murrayinella murrayi	51	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.24	0.00	0.00	0.00	0.00	0.14	0.13	0.00	0.00	0.00	0.00	0.00
Nonion sp.	55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.14	0.14	0.00	0.00	0.00	0.00	0.00	0.00
Pararotalia calcariformata	56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pararotalia nipponica	57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 venusta	58	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	0.00	0.00	0.00	0.00	0.00
Pararotalia sp. A	59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 sp.	60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	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	0.24	0.93	0.00	0.54
Peneroplis pertusus	62	0.95	0.78	1.08	0.66	0.85	0.41	0.58	0.52	0.82	0.19	0.14	0.28	0.00	0.41	0.32	0.35	0.24	0.00	0.00	0.00	0.00
Planorbulina acervalis	64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 cf. *P. schroeteriana*	65	0.00	0.00	0.00	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	0.00	0.00	0.00	0.00
Quinqueloculina sp.	66	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	0.14	0.00	0.00	0.00	0.00
Reussella pulchra	67	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.14	0.00	0.19	0.00	0.14	0.26	0.14	0.00	0.00	0.48	0.54
Reussella spinulosa	68	0.00	0.00	0.00	0.00	0.00	0.29	0.14	0.00	0.16	0.31	0.41	0.24	0.13	0.35	0.38	0.23	0.24	0.00	0.00	0.00	0.00
Reussella sp. C	69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	70	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	0.24	0.00	0.00	0.00
Rosalina sp. B	71	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	0.20	0.13	0.00	0.00	0.00	0.00	0.00
Sagrina zanzibarica	72	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
Sagrinella lobata	73	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
Schackoinella globosa	74	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.16	0.00	0.00	0.32	0.00	0.00	0.38	0.35	0.00	0.00	0.00	0.00	0.00	0.00
Siphotrochammina lobata	75	0.00	0.00	0.00	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
Spiroloculina manifesta	77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	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

Trochammina amnicola	78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 laevigata	79	0.00	0.29	0.43	0.50	0.59	0.71	0.31	0.22	0.62	0.27	0.38	0.70	0.13	0.32	0.20	0.23	0.00	0.33	0.00	0.00	0.00
"Trochammina ochracea"	80	0.00	0.20	0.00	0.19	0.00	0.00	0.00	0.16	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
Trochammina sp. E	82	0.00	0.36	0.23	0.00	0.52	0.41	0.00	0.22	0.32	0.00	0.14	0.47	0.00	0.00	0.29	0.00	0.00	0.24	0.93	0.00	0.54
Trochammina sp.	83	0.62	0.55	0.61	0.33	0.69	0.29	0.50	0.31	0.39	0.14	0.29	0.34	0.27	0.25	0.20	0.29	0.19	0.24	0.00	0.00	0.00

Species	**Sample No.** **Species Code**	**T3-100**	**T3-60**	**T3-30**	**T3-15**	**T3-5**	**T3-0**	**S40-1**	**S40-2**	**S40-3**	**S40-4**	**S40-5**	**S40-6**	**S40-7**	**S40-8**	**S40-9**	**T4-0**	**T4-5**	**T4-15**	**T4-30**	**T4-60**	**T4-100**
Ammobaculites exiguus	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	0.00	0.00	0.00	0.00	0.00	0.00
Ammodiscus sp. A	2	1.76	1.26	1.37	1.19	0.85	0.92	0.79	1.01	0.66	0.64	0.59	1.72	0.64	0.00	0.29	0.39	0.47	0.47	0.53	0.53	0.34
Ammonia aff. *A aoteana*	3	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammonia tepida	4	0.36	0.74	0.71	1.00	0.62	0.66	1.08	1.16	1.03	0.28	0.77	0.60	0.86	0.54	0.91	0.78	0.71	0.84	0.74	0.84	0.83
Ammonia sp.	5	0.00	0.00	0.00	0.00	0.30	0.25	0.26	0.31	0.15	0.37	0.32	0.20	0.30	0.15	0.21	0.36	0.15	0.15	0.30	0.12	0.28
Ammotium directum	6	0.00	0.00	0.00	0.00	0.00	0.00	0.15	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
Ammotium morenoi	7	0.15	0.49	0.41	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	0.15	0.00	0.00	0.00	0.00
Amphistegina lessonii	8	0.36	0.59	0.41	0.35	0.33	0.15	0.26	0.20	0.21	0.00	0.29	0.58	0.26	0.00	0.15	0.27	0.33	0.15	0.00	0.18	0.20
Arenoparrella mexicana	9	0.00	0.00	0.00	0.00	0.21	0.29	0.00	0.14	0.15	0.47	0.38	0.14	0.30	0.33	1.19	0.27	0.30	0.26	0.40	0.12	0.39
Asterigerinata sp. A	10	0.15	0.00	0.00	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	0.15	0.00	0.00	0.00	0.00
Asterorotalia pulchella	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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.	12	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.20	0.00	0.16	0.25	0.00	0.00	0.00	0.44	0.22	0.26	0.15	0.15	0.00	0.24
Brizalina subtenuis	13	0.00	0.55	0.31	0.54	0.56	0.46	0.45	0.45	0.55	0.55	0.48	0.20	0.62	0.40	0.25	0.53	0.52	0.54	0.48	0.58	0.54
Bruneica clypea	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	0.21	0.00	0.16	0.15	0.15	0.00	0.00	0.00
Buliminoides williamsoni	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
Cancris carinatus	17	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Caronia exilis	18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.00	0.00	0.15	0.16	0.15	0.15	0.00	0.18	0.00
Cavarotalia annectens	19	0.21	0.14	0.00	0.20	0.15	0.15	0.00	0.14	0.00	0.23	0.29	0.00	0.00	0.00	0.15	0.16	0.00	0.15	0.15	0.00	0.00
Cellanthus biperforatus	20	0.00	0.00	0.00	0.00	0.42	0.46	0.30	0.37	0.49	0.28	0.20	0.00	0.30	0.26	0.25	0.00	0.26	0.21	0.15	0.30	0.20
Cellanthus craticulus	21	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Cellanthus sp.	22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.14	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00
Cibicides cf. *C. fletcheri*	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	0.15	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides sp. B	25	0.00	0.00	0.15	0.00	0.30	0.29	0.26	0.14	0.33	0.40	0.40	0.00	0.30	0.61	0.15	0.36	0.49	0.37	0.43	0.33	0.44
Cibicides sp.	26	0.00	0.00	0.00	0.00	0.15	0.00	0.21	0.00	0.25	0.33	0.00	0.00	0.15	0.00	0.25	0.16	0.26	0.15	0.34	0.12	0.20
Elphidium advenum	27	0.00	0.00	0.00	0.00	0.15	0.21	0.15	0.14	0.21	0.37	0.20	0.00	0.21	0.15	0.15	0.36	0.00	0.37	0.00	0.00	0.00
Elphidium crispum s.l.	28	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.15	0.00	0.00	0.00
Elphidium hyalocostatum	29	0.00	0.00	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	0.00	0.00	0.00	0.20
Elphidium indicum	30	0.00	0.00	0.00	0.00	0.21	0.15	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.21	0.16	0.15	0.00	0.00	0.00	0.14
Elphidium cf. *E. neosimplex*	31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium aff. *E. poeyanum*	32	0.00	0.14	0.00	0.14	0.33	0.00	0.21	0.00	0.15	0.00	0.14	0.00	0.00	0.21	0.15	0.16	0.15	0.21	0.21	0.25	0.20
Elphidium simplex	33	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	0.00	0.00	0.15	0.15	0.15	0.00	0.14
Elphidium aff. *E. simulatum*	34	0.15	0.00	0.00	0.14	0.21	0.21	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.00
Elphidium singaporense	35	0.00	0.00	0.00	0.00	0.00	0.21	0.21	0.14	0.00	0.16	0.00	0.14	0.15	0.00	0.15	0.00	0.15	0.00	0.00	0.12	0.00
Elphidium sp.	36	0.00	0.00	0.00	0.00	0.21	0.21	0.21	0.00	0.00	0.28	0.32	0.00	0.26	0.21	0.29	0.22	0.30	0.33	0.26	0.21	0.37
Eponides sp.	37	0.00	0.00	0.00	0.00	0.26	0.21	0.26	0.14	0.15	0.00	0.38	0.20	0.21	0.26	0.00	0.16	0.36	0.00	0.15	0.28	0.28
Gavelinopsis praegeri	38	0.00	0.00	0.00	0.00	0.30	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.16	0.00	0.00	0.00	0.00	0.00
Globocassidulina bisecta	39	0.00	0.00	0.15	0.20	0.36	0.41	0.21	0.00	0.33	0.40	0.00	0.00	0.00	0.40	0.00	0.48	0.26	0.45	0.37	0.33	0.20
"Glomospira" fijiensis	40	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.16	0.00	0.20	0.15	0.00	0.00	0.00	0.00	0.00	0.15	0.21	0.00
Guttulina sp.	41	0.00	0.00	0.15	0.14	0.00	0.00	0.00	0.14	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
Haplophragmoides cf. *H. manilaensis*	43	0.00	0.00	0.00	0.00	0.00	0.00	0.15	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
Haplophragmoides wilberti	44	0.00	0.00	0.00	0.00	0.00	0.00	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
Indeterminate agglutinated	45	0.00	0.14	0.15	0.14	0.15	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
Indeterminate calcareous	46	0.00	0.00	0.26	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.21	0.16	0.00	0.00	0.15	0.00	0.14
Indeterminate miliolid	47	0.21	0.45	0.00	0.20	0.54	0.61	0.34	0.45	0.57	0.69	0.48	0.25	0.53	0.57	0.51	0.55	0.60	0.47	0.40	0.37	0.34
Indeterminate rotaliid	48	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	0.00	0.15	0.00	0.00	0.14
Miliammina fusca	50	0.00	0.00	0.15	0.38	0.45	0.33	0.37	0.31	0.00	0.37	0.14	0.00	0.26	0.37	0.21	0.36	0.33	0.42	0.21	0.37	0.20
Murrayinella murrayi	51	0.00	0.00	0.31	0.29	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.25	0.26	0.00	0.00	0.00	0.26	0.00	0.00	0.18	0.00
Nonion sp.	55	0.00	0.00	0.00	0.00	0.33	0.21	0.00	0.00	0.00	0.16	0.00	0.00	0.15	0.00	0.15	0.16	0.21	0.15	0.00	0.12	0.14
Pararotalia calcariformata	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
Pararotalia nipponica	57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.15	0.00	0.00
Pararotalia venusta	58	0.00	0.00	0.15	0.14	0.33	0.29	0.21	0.00	0.15	0.00	0.35	0.00	0.15	0.30	0.15	0.16	0.21	0.21	0.15	0.18	0.24
Pararotalia sp. A	59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.28
Pararotalia sp.	60	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	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Paratrochammina stoeni	61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.14	0.00	0.00	0.15	0.00	0.00	0.00	0.15	0.15	0.12	0.14
Peneroplis pertusus	62	0.61	0.00	0.62	0.29	0.30	0.15	0.00	0.14	0.00	0.16	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.18	0.14
Planorbulina acervalis	64	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	0.15	0.00	0.22	0.15	0.21	0.00	0.18	0.20
Pseudorotalia cf. *P. schroeteriana*	65	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	0.26	0.29	0.32	0.30	0.15	0.26	0.25	0.24
Quinqueloculina sp.	66	0.00	0.00	0.00	0.20	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	0.15	0.12	0.00
Reussella pulchra	67	0.00	0.14	0.00	0.00	0.21	0.21	0.40	0.20	0.21	0.62	0.58	0.00	0.55	0.64	0.51	0.62	0.64	0.58	0.67	0.56	0.61
Reussella spinulosa	68	0.00	0.28	0.15	0.41	0.39	0.39	0.40	0.64	0.59	0.62	0.59	0.00	0.58	0.66	0.39	0.42	0.30	0.30	0.59	0.59	0.71
Reussella sp. C	69	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.15	0.16	0.29	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.18	0.00
Rosalina globularis	70	0.00	0.24	0.00	0.00	0.15	0.21	0.00	0.14	0.00	0.16	0.25	0.00	0.15	0.00	0.21	0.22	0.00	0.00	0.15	0.00	0.00
Rosalina sp. B	71	0.00	0.00	0.15	0.20	0.21	0.15	0.34	0.00	0.00	0.62	0.20	0.46	0.15	0.15	0.00	0.48	0.36	0.42	0.26	0.25	0.20
Sagrina zanzibarica	72	0.00	0.00	0.00	0.00	0.21	0.00	0.15	0.00	0.00	0.16	0.29	0.20	0.34	0.26	0.00	0.16	0.00	0.00	0.26	0.12	0.20
Sagrinella lobata	73	0.00	0.14	0.22	0.20	0.42	0.33	0.37	0.37	0.21	0.00	0.32	0.20	0.30	0.52	0.00	0.36	0.52	0.40	0.46	0.52	0.42
Schackoinella globosa	74	0.00	0.38	0.15	0.38	0.39	0.68	0.45	0.20	0.80	0.00	0.59	0.25	0.62	0.75	0.29	0.55	0.49	0.64	0.65	0.73	0.61
Siphotrochammina lobata	75	0.00	0.00	0.00	0.00	0.00	0.15	0.21	0.00	0.29	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.15	0.15	0.15	0.18	0.14
Spiroloculina manifesta	77	0.25	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trochammina amnicola	78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.15	0.00	0.12	0.00
Trochammina laevigata	79	0.68	0.57	0.56	0.45	0.21	0.00	0.26	0.37	0.15	0.16	0.00	0.41	0.15	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.14
"Trochammina ochracea"	80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 sp. E	82	0.25	0.14	0.22	0.20	0.00	0.15	0.00	0.20	0.00	0.00	0.00	0.14	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Trochammina sp.	83	0.44	0.43	0.53	0.45	0.15	0.00	0.00	0.24	0.25	0.00	0.00	0.00	0.15	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Species	Sample No. Species Code	T5-100	T5-60	T5-30	T5-15	T5-5	T5-0	S9A-1	S9A-2	S9A-3	S9A-4	S9A-5	S9A-6	S9A-7	S9A-8	S9A-9	T6-0	T6-5	T6-15	T6-30	T6-60	T6-100
Ammobaculites exiguus	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	0.00	0.00	0.00	0.00	0.00	0.00
Ammodiscus sp. A	2	0.57	0.59	0.48	0.70	0.65	0.64	0.52	0.56	0.33	0.50	1.19	1.23	1.22	0.67	1.04	0.60	0.60	0.98	0.96	1.06	1.09
Ammonia aff. *A aoteana*	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	0.00	0.00	0.00	0.00	0.00	0.00
Ammonia tepida	4	0.00	0.00	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
Ammonia sp.	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	7	0.96	0.93	0.79	0.76	0.82	0.97	0.72	0.59	0.69	0.67	0.76	0.00	0.96	0.54	0.51	0.86	0.73	0.65	0.67	0.20	0.60
Amphistegina lessonii	8	0.14	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00
Arenoparrella mexicana	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	10	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00
Asterorotalia pulchella	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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.	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	0.00
Brizalina subtenuis	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	0.14	0.00	0.00	0.00	0.00
Bruneica clypea	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
Buliminoides williamsoni	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
Cancris carinatus	17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cavarotalia annectens	19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cellanthus biperforatus	20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cellanthus craticulus	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	0.00
Cellanthus sp.	22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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*	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides sp. B	25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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.	26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 crispum s.l.	28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	30	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	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium cf. *E. neosimplex*	31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 aff. *E. poeyanum*	32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 simplex	33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 aff. *E. simulatum*	34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 singaporense	35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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.	36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eponides sp.	37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Globocassidulina bisecta	39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
"Glomospira" fijiensis	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	0.00
Guttulina sp.	41	0.00	0.19	0.00	0.20	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.27	0.20	0.00	0.00	0.00	0.00
Haplophragmoides cf. *H. manilaensis*	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	0.00	0.00	0.00	0.00	0.00
Haplophragmoides wilberti	44	0.32	0.00	0.00	0.00	0.21	0.21	0.00	0.19	0.00	0.27	0.31	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Indeterminate agglutinated	45	0.00	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
Indeterminate calcareous	46	0.44	0.30	0.00	0.14	0.34	0.52	0.00	0.19	0.13	0.16	0.57	0.00	0.47	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.24
Indeterminate miliolid	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	0.00	0.00	0.00	0.00
Indeterminate rotaliid	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miliammina fusca	50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	51	1.46	1.76	1.72	1.79	1.74	1.54	1.95	2.11	2.19	1.94	0.75	0.48	1.29	2.04	1.79	1.59	2.01	1.88	1.90	2.04	1.78
Nonion sp.	55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 calcariformata	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
Pararotalia nipponica	57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 venusta	58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 sp. A	59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 sp.	60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	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
Peneroplis pertusus	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	0.00	0.00
Planorbulina acervalis	64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 cf. *P. schroeteriana*	65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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.	66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	67	0.32	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
Reussella spinulosa	68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 sp. C	69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 sp. B	71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Spiroloculina manifesta	77	0.14	0.00	0.14	0.00	0.21	0.00	0.00	0.00	0.13	0.52	0.27	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00
Trochammina amnicola	78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 laevigata	79	0.75	0.59	0.88	0.68	0.67	0.61	0.70	0.47	0.49	0.27	0.89	1.79	0.36	0.49	0.47	0.91	0.48	0.29	0.28	0.14	0.31
"Trochammina ochracea"	80	0.14	0.00	0.00	0.14	0.00	0.15	0.00	0.00	0.00	0.27	0.27	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00
Trochammina sp. E	82	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trochammina sp.	83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX D

Transformed data for the dead cluster analysis including all species. Samples ordered from north to south.

Species	Sample No. / Species Code	T1-100	T1-60	T1-30	T1-15	T1-5	T1-0	S43-1	S43-2	S43-3	S43-4	S43-5	S43-6	S43-7	S43-8	S43-9	T2-0	T2-5	T2-15	T2-30	T2-60	T2-100
Ammobaculites exiguus	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	0.00	0.00	0.00	0.00	0.00	0.00
Ammodiscus sp. A	2	1.46	1.84	1.04	1.48	1.61	1.47	1.58	1.27	0.93	1.91	1.05	0.95	2.34	1.30	1.13	1.69	1.83	0.97	0.00	0.00	0.00
Ammonia aff. *A aoteana*	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	0.23	0.00	0.15	0.00	0.00	0.00	0.00	0.00
Ammonia tepida	4	0.50	0.38	1.05	0.66	0.31	0.89	0.74	1.15	0.93	0.89	1.25	1.34	0.36	1.08	1.26	0.87	0.78	1.12	0.00	0.78	0.00
Ammonia sp.	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammotium directum	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	7	0.00	0.22	0.22	0.00	0.00	0.00	0.39	0.34	0.00	0.21	0.00	0.15	0.44	0.00	0.00	0.15	0.41	0.00	0.00	0.00	0.93
Amphistegina lessonii	8	0.19	0.22	0.35	0.21	0.00	0.33	0.32	0.20	0.33	0.49	0.24	0.00	0.44	0.00	0.22	0.37	0.57	0.81	0.00	0.54	0.00
Arenoparrella mexicana	9	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.15	0.54	0.00	0.00	0.36	0.00	0.00	0.14	0.62	2.09	1.57	1.37
Asterigerinata sp. A	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asterorotalia pulchella	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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
Bolivina sp.	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	0.21	0.00	0.00	0.00	0.00	0.00
Brizalina subtenuis	13	0.00	0.00	0.16	0.00	0.00	0.00	0.16	0.00	0.00	0.21	0.17	0.00	0.00	0.51	0.38	0.43	0.00	0.00	0.00	0.00	0.00
Bruneica clypea	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
Buliminella elegantissima	15	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.17	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Buliminoides williamsoni	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
Cancris carinatus	17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cavarotalia annectens	19	0.00	0.00	0.00	0.21	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
Cellanthus biperforatus	20	0.00	0.00	0.00	0.59	0.38	0.57	0.32	0.28	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cellanthus craticulus	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	0.00
Cellanthus sp.	22	0.00	0.00	0.00	0.21	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.36	0.00	0.00	0.00
Cheilochanus sp.	23	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	0.20	0.36	0.00	0.54	0.00
Cibicides cf. *C. fletcheri*	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides sp. B	25	0.00	0.00	0.00	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	0.00	0.00	0.00
Cibicides sp.	26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium advenum	27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 crispum s.l.	28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	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*	31	0.00	0.00	0.00	0.00	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	0.00	0.00
Elphidium aff. *E. poeyanum*	32	0.00	0.00	0.00	0.00	0.00	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
Elphidium simplex	33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium aff. *E. simulatum*	34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	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 singaporense	35	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.15	0.00	0.00	0.00	0.00	0.00
Elphidium sp.	36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eponides sp.	37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gavelinopsis praegeri	38	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	0.00	0.00	0.00	0.00	0.00	0.00
Globocassidulina bisecta	39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.15	0.15	0.00	0.00	0.00	0.00	0.00
"Glomospira" fijiensis	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	0.00
Guttulina sp.	41	0.19	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hanzawaia nipponica	42	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Haplophragmoides cf. *H. manilaensis*	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	0.15	0.00	0.00	0.00	0.00	0.00	0.00
Haplophragmoides wilberti	44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 agglutinated	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Indeterminate calcareous	46	0.42	0.00	0.00	0.41	0.00	0.00	0.16	0.56	0.40	0.00	0.24	0.00	0.00	0.00	0.27	0.15	0.00	0.36	0.00	0.00	0.00
Indeterminate miliolid	47	0.00	0.00	0.00	0.00	0.22	0.33	0.22	0.20	0.33	0.00	0.17	0.15	0.00	0.00	0.31	0.26	0.35	0.36	0.00	0.54	0.00
Indeterminate rotaliid	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	0.00	0.00	0.00	0.36	0.00	0.00	0.00
?Jadammina sp.	49	0.00	0.00	0.00	0.21	0.00	0.33	0.00	0.00	0.40	0.00	0.38	0.15	0.00	0.00	0.35	0.15	0.20	0.36	0.00	0.00	0.00
Miliammina fusca	50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	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	51	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.20	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
Neoconorbina sp.	52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.16	0.15	0.00	0.00	0.00	0.00	0.00	0.00
? Neoconorbina	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	0.00	0.00	0.00
Nodosariid	54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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.	55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 calcariformata	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
Pararotalia nipponica	57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 venusta	58	0.00	0.00	0.00	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	0.00	0.00	0.00
Pararotalia sp. A	59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 sp.	60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	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	0.36	1.05	0.00	0.93
Peneroplis pertusus	62	0.98	0.74	1.04	0.69	0.84	0.33	0.45	0.52	0.89	0.21	0.00	0.30	0.00	0.39	0.22	0.40	0.20	0.00	0.00	0.00	0.00
Planodiscorbis sp.	63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudorotalia cf. *P. schroeteriana*	65	0.00	0.00	0.00	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	0.00	0.00	0.00	0.00
Quinqueloculina sp.	66	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	0.00	0.14	0.00	0.00	0.00	0.00
Reussella pulchra	67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.15	0.30	0.14	0.00	0.00	0.54	0.93
Reussella spinulosa	68	0.00	0.00	0.00	0.00	0.00	0.33	0.16	0.00	0.23	0.33	0.48	0.26	0.14	0.39	0.41	0.26	0.25	0.00	0.00	0.00	0.00

Reussella sp. C	69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	70	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	0.36	0.00	0.00	0.00
Rosalina sp. B	71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.00	0.00	0.00	0.00	0.00
Sagrina zanzibarica	72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Schackoinella globosa	74	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.20	0.00	0.00	0.38	0.00	0.00	0.42	0.38	0.00	0.00	0.00	0.00	0.00	0.00
Siphotrochammina lobata	75	0.00	0.00	0.00	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	0.00	0.00	0.00
Spirolina cylindracea	76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Spiroloculina manifesta	77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 laevigata	79	0.00	0.31	0.35	0.55	0.49	0.46	0.16	0.00	0.52	0.00	0.38	0.63	0.14	0.23	0.15	0.26	0.00	0.00	0.00	0.00	0.00
"Trochammina ochracea"	80	0.00	0.22	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
Trochammina sp. E	81	0.00	0.38	0.27	0.00	0.58	0.46	0.00	0.28	0.47	0.00	0.17	0.48	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00
Trochammina sp.	82	0.57	0.58	0.44	0.29	0.66	0.00	0.48	0.00	0.40	0.15	0.00	0.30	0.25	0.28	0.22	0.21	0.14	0.00	0.00	0.00	0.00
Wiesnerella sp.	83	0.72	0.31	0.65	0.46	0.00	0.33	0.57	0.63	0.47	0.00	0.17	0.79	0.00	0.32	0.27	0.00	0.00	0.00	0.00	0.54	0.00

Species	**Sample No. / Species Code**	**T3-100**	**T3-60**	**T3-30**	**T3-15**	**T3-5**	**T3-0**	**S40-1**	**S40-2**	**S40-3**	**S40-4**	**S40-5**	**S40-6**	**S40-7**	**S40-8**	**S40-9**	**T4-0**	**T4-5**	**T4-15**	**T4-30**	**T4-60**	**T4-100**
Ammobaculites exiguus	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	0.00	0.00	0.00	0.00	0.00	0.00
Ammodiscus sp. A	2	1.80	1.33	1.48	1.28	0.86	0.92	0.80	1.08	0.66	0.65	0.56	1.88	0.63	0.00	0.30	0.40	0.48	0.49	0.55	0.55	0.35
Ammonia aff. *A aoteana*	3	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
Ammonia tepida	4	0.35	0.73	0.57	0.74	0.61	0.64	1.03	1.11	0.98	0.17	0.66	0.57	0.78	0.53	0.85	0.74	0.69	0.70	0.67	0.71	0.72
Ammonia sp.	5	0.00	0.00	0.00	0.00	0.30	0.26	0.27	0.34	0.15	0.37	0.32	0.22	0.31	0.00	0.21	0.36	0.15	0.15	0.31	0.13	0.29
Ammotium directum	6	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ammotium morenoi	7	0.16	0.38	0.28	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	0.15	0.00	0.00	0.00	0.00
Amphistegina lessonii	8	0.35	0.41	0.44	0.39	0.34	0.15	0.16	0.21	0.21	0.00	0.29	0.52	0.27	0.00	0.15	0.28	0.34	0.15	0.00	0.18	0.20
Arenoparrella mexicana	9	0.00	0.00	0.00	0.00	0.21	0.30	0.00	0.15	0.15	0.47	0.38	0.15	0.31	0.34	1.21	0.28	0.30	0.27	0.38	0.13	0.41
Asterigerinata sp. A	10	0.16	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asterorotalia pulchella	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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.	12	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.21	0.00	0.17	0.25	0.00	0.00	0.00	0.45	0.23	0.26	0.15	0.16	0.00	0.25
Brizalina subtenuis	13	0.00	0.61	0.33	0.60	0.57	0.47	0.48	0.48	0.56	0.55	0.48	0.22	0.63	0.40	0.26	0.54	0.53	0.56	0.50	0.59	0.56
Bruneica clypea	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	0.21	0.00	0.16	0.15	0.15	0.00	0.00	0.00
Buliminella elegantissima	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
Buliminoides williamsoni	16	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
Cancris carinatus	17	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Caronia exilis	18	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	0.15	0.16	0.15	0.15	0.00	0.18	0.00
Cavarotalia annectens	19	0.22	0.00	0.00	0.22	0.15	0.15	0.00	0.15	0.00	0.23	0.29	0.00	0.00	0.00	0.15	0.16	0.00	0.00	0.16	0.00	0.00
Cellanthus biperforatus	20	0.00	0.00	0.00	0.00	0.43	0.45	0.32	0.40	0.50	0.29	0.20	0.00	0.31	0.26	0.26	0.00	0.26	0.22	0.16	0.31	0.20
Cellanthus craticulus	21	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Cellanthus sp.	22	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	0.15	0.00	0.00	0.00	0.00
Cheilochanus sp.	23	0.00	0.00	0.00	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	0.00	0.00	0.00
Cibicides cf. *C. fletcheri*	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	0.00	0.00	0.00	0.00	0.16	0.00	0.00
Cibicides sp. B	25	0.00	0.00	0.16	0.00	0.30	0.30	0.27	0.15	0.33	0.41	0.40	0.00	0.31	0.61	0.15	0.36	0.51	0.38	0.44	0.34	0.43
Cibicides sp.	26	0.00	0.00	0.00	0.00	0.15	0.00	0.22	0.00	0.26	0.33	0.00	0.00	0.16	0.00	0.26	0.16	0.26	0.15	0.35	0.13	0.20
Elphidium advenum	27	0.00	0.00	0.00	0.00	0.15	0.21	0.16	0.15	0.21	0.37	0.20	0.00	0.22	0.15	0.15	0.36	0.00	0.38	0.00	0.00	0.00
Elphidium crispum s.l.	28	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.15	0.00	0.00	0.00
Elphidium hyalocostatum	29	0.00	0.00	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	0.00	0.00	0.00	0.20
Elphidium indicum	30	0.00	0.00	0.00	0.00	0.21	0.15	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.21	0.16	0.15	0.00	0.00	0.00	0.14
Elphidium cf. *E. neosimplex*	31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium aff. *E. poeyanum*	32	0.00	0.00	0.00	0.16	0.26	0.00	0.16	0.00	0.15	0.00	0.14	0.00	0.00	0.21	0.15	0.00	0.15	0.22	0.22	0.25	0.20
Elphidium simplex	33	0.16	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	0.00	0.00	0.15	0.15	0.16	0.00	0.14
Elphidium aff. *E. simulatum*	34	0.00	0.00	0.00	0.16	0.21	0.21	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00
Elphidium singaporense	35	0.00	0.00	0.00	0.00	0.00	0.21	0.22	0.15	0.00	0.17	0.00	0.15	0.16	0.00	0.15	0.00	0.00	0.00	0.00	0.13	0.00
Elphidium sp.	36	0.00	0.00	0.00	0.00	0.21	0.21	0.22	0.00	0.00	0.29	0.32	0.00	0.27	0.21	0.30	0.23	0.30	0.35	0.27	0.22	0.38
Eponides sp.	37	0.00	0.00	0.00	0.00	0.26	0.21	0.27	0.15	0.15	0.00	0.38	0.22	0.22	0.26	0.00	0.16	0.37	0.00	0.16	0.28	0.29
Gavelinopsis praegeri	38	0.00	0.00	0.00	0.00	0.26	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.16	0.00	0.00	0.00	0.00	0.00
Globocassidulina bisecta	39	0.00	0.00	0.16	0.22	0.37	0.42	0.22	0.00	0.33	0.41	0.00	0.00	0.00	0.40	0.00	0.49	0.26	0.47	0.38	0.34	0.20
"Glomospira" fijiensis	40	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.17	0.00	0.22	0.16	0.00	0.00	0.00	0.00	0.00	0.16	0.22	0.00
Guttulina sp.	41	0.00	0.00	0.16	0.16	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	0.00	0.00	0.00	0.00
Hanzawaia nipponica	42	0.00	0.00	0.00	0.00	0.00	0.00	0.16	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
Haplophragmoides cf. *H. manilaensis*	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	0.00	0.00	0.00	0.00	0.00
Haplophragmoides wilberti	44	0.00	0.00	0.00	0.00	0.00	0.00	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
Indeterminate agglutinated	45	0.00	0.16	0.16	0.16	0.15	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Indeterminate calcareous	46	0.00	0.00	0.28	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.21	0.16	0.00	0.00	0.00	0.00	0.00
Indeterminate miliolid	47	0.22	0.50	0.00	0.22	0.50	0.62	0.36	0.43	0.58	0.69	0.48	0.27	0.54	0.55	0.52	0.57	0.61	0.49	0.38	0.38	0.35
Indeterminate rotaliid	48	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	0.15	0.00	0.00	0.14
?Jadammina sp.	49	0.00	0.00	0.16	0.42	0.45	0.30	0.39	0.34	0.00	0.37	0.14	0.00	0.27	0.37	0.21	0.36	0.34	0.44	0.22	0.38	0.20
Miliammina fusca	50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	51	0.00	0.00	0.33	0.22	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.21	0.00	0.00	0.18	0.00
Neoconorbina sp.	52	0.00	0.00	0.00	0.00	0.34	0.21	0.00	0.00	0.00	0.17	0.00	0.00	0.16	0.00	0.15	0.16	0.21	0.15	0.00	0.13	0.14
? Neoconorbina	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	0.00	0.00	0.14
Nodosariid	54	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
Nonion sp.	55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00
Pararotalia calcariformata	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
Pararotalia nipponica	57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.16	0.00	0.00
Pararotalia venusta	58	0.00	0.00	0.16	0.16	0.34	0.30	0.22	0.00	0.15	0.00	0.35	0.00	0.16	0.30	0.15	0.16	0.21	0.22	0.16	0.18	0.25
Pararotalia sp. A	59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.29
Pararotalia sp.	60	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	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Paratrochammina stoeni	61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.14	0.00	0.00	0.15	0.00	0.00	0.00	0.15	0.00	0.13	0.14
Peneroplis pertusus	62	0.65	0.00	0.60	0.32	0.30	0.00	0.00	0.15	0.00	0.17	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.18	0.00

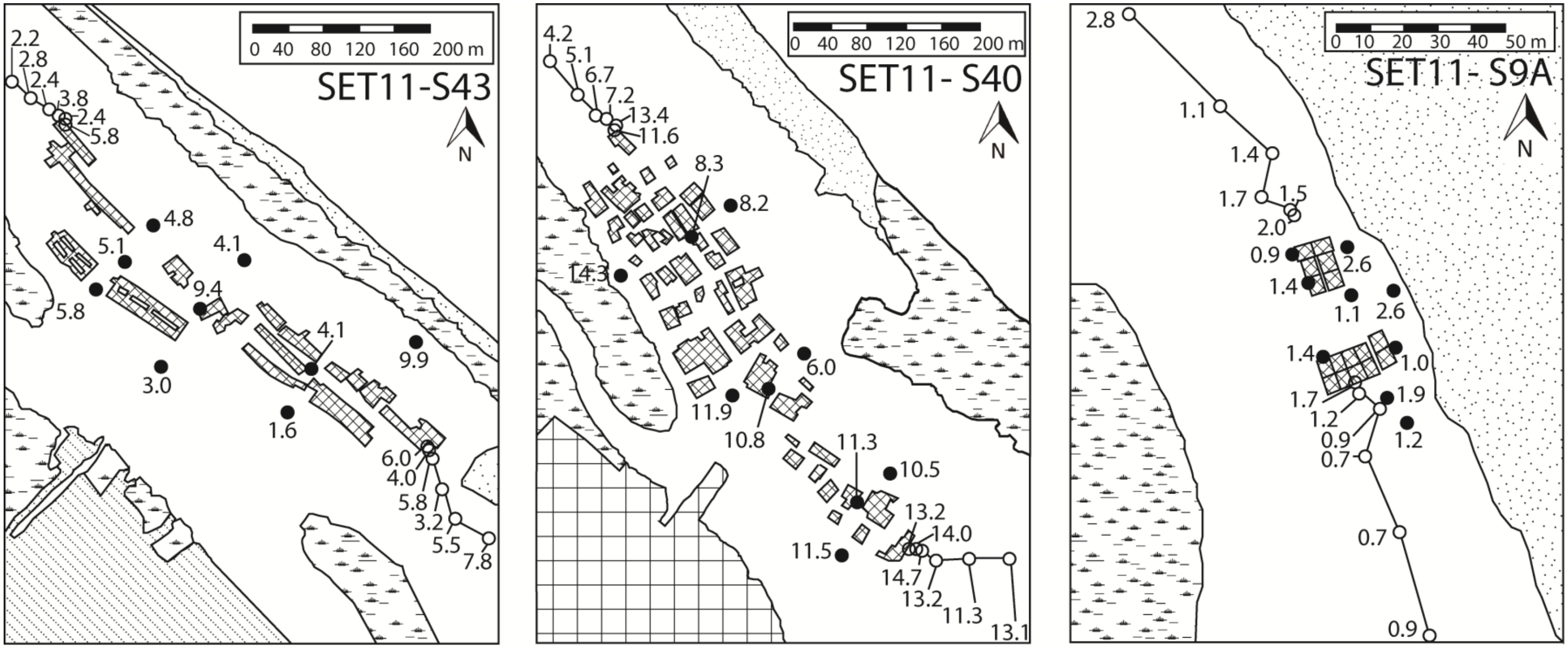
Planodiscorbis sp.	63	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.23	0.15	0.22	0.00	0.18	0.20
Planorbulina acervalis	64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudorotalia cf. *P. schroeteriana*	65	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.30	0.32	0.30	0.15	0.27	0.25	0.25
Quinqueloculina sp.	66	0.00	0.00	0.00	0.22	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	0.16	0.13	0.00
Reussella pulchra	67	0.00	0.16	0.00	0.00	0.21	0.21	0.42	0.21	0.21	0.63	0.73	0.00	0.57	0.65	0.52	0.59	0.63	0.58	0.69	0.58	0.63
Reussella spinulosa	68	0.00	0.31	0.16	0.45	0.40	0.39	0.39	0.68	0.60	0.63	0.59	0.00	0.59	0.67	0.39	0.43	0.30	0.31	0.61	0.60	0.73
Reussella sp. C	69	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.15	0.17	0.29	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.18	0.00
Rosalina globularis	70	0.00	0.27	0.00	0.00	0.15	0.21	0.00	0.15	0.00	0.17	0.25	0.00	0.16	0.00	0.21	0.23	0.00	0.00	0.16	0.00	0.00
Rosalina sp. B	71	0.00	0.00	0.16	0.22	0.21	0.15	0.36	0.00	0.00	0.63	0.20	0.27	0.16	0.00	0.00	0.46	0.37	0.44	0.27	0.25	0.20
Sagrina zanzibarica	72	0.00	0.00	0.00	0.00	0.21	0.00	0.16	0.00	0.00	0.17	0.29	0.22	0.35	0.26	0.00	0.16	0.00	0.00	0.27	0.13	0.20
Sagrinella lobata	73	0.00	0.16	0.23	0.22	0.43	0.33	0.39	0.00	0.21	0.00	0.32	0.22	0.31	0.53	0.00	0.36	0.51	0.41	0.47	0.53	0.43
Schackoinella globosa	74	0.00	0.41	0.16	0.42	0.40	0.69	0.48	0.00	0.82	0.00	0.59	0.27	0.63	0.76	0.30	0.57	0.51	0.66	0.67	0.75	0.63
Siphotrochammina lobata	75	0.00	0.00	0.00	0.00	0.00	0.15	0.22	0.00	0.30	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.15	0.15	0.16	0.18	0.14
Spirolina cylindracea	76	0.27	0.00	0.00	0.00	0.00	0.00	0.16	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
Spiroloculina manifesta	77	0.00	0.00	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	0.00	0.00	0.00	0.00
Trochammina amnicola	78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.15	0.00	0.13	0.00
Trochammina laevigata	79	0.61	0.52	0.60	0.48	0.21	0.00	0.16	0.37	0.15	0.17	0.00	0.31	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
"Trochammina ochracea"	80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 sp. E	81	0.27	0.16	0.23	0.22	0.00	0.15	0.00	0.21	0.00	0.00	0.00	0.15	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trochammina sp.	82	0.35	0.47	0.52	0.42	0.15	0.00	0.00	0.21	0.26	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wiesnerella sp.	83	0.27	0.31	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Species	Sample No. Species Code	T5-100	T5-60	T5-30	T5-15	T5-5	T5-0	S9A-1	S9A-2	S9A-3	S9A-4	S9A-5	S9A-7	S9A-8	S9A-9	T6-0	T6-5	T6-15	T6-30	T6-60	T6-100
Ammobaculites exiguus	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	0.00	0.00	0.00	0.00	0.00
Ammodiscus sp. A	2	0.52	0.36	0.45	0.40	0.65	0.27	0.25	0.00	0.17	0.48	1.16	0.52	0.32	0.39	0.37	0.36	0.36	0.49	0.38	0.46
Ammonia aff. *A aoteana*	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	0.00	0.00	0.00	0.00	0.00
Ammonia tepida	4	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	0.00	0.00	0.00
Ammonia sp.	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	7	1.02	1.13	0.78	0.76	0.83	0.98	0.91	0.75	0.68	0.69	0.77	0.75	0.64	0.65	0.93	0.78	0.82	0.84	0.38	0.38
Amphistegina lessonii	8	0.17	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.31	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00
Arenoparrella mexicana	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	10	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00
Asterorotalia pulchella	11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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.	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
Brizalina subtenuis	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	0.16	0.00	0.00	0.18	0.00	0.00	0.00	0.00
Bruneica clypea	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
Buliminella elegantissima	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
Buliminoides williamsoni	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
Cancris carinatus	17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cavarotalia annectens	19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cellanthus biperforatus	20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cellanthus craticulus	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
Cellanthus sp.	22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cheilochanus sp.	23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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*	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	0.00	0.00	0.00	0.00	0.00	0.00
Cibicides sp. B	25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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.	26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 crispum s.l.	28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	30	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elphidium cf. *E. neosimplex*	31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 aff. *E. poeyanum*	32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 simplex	33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 aff. *E. simulatum*	34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 singaporense	35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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.	36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eponides sp.	37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Globocassidulina bisecta	39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
"Glomospira" fijiensis	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
Guttulina sp.	41	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00
Hanzawaia nipponica	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	0.00	0.00	0.00	0.00
Haplophragmoides cf. *H. manilaensis*	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	0.00	0.00	0.00	0.00
Haplophragmoides wilberti	44	0.34	0.00	0.00	0.00	0.24	0.27	0.00	0.22	0.00	0.28	0.35	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Indeterminate agglutinated	45	0.00	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
Indeterminate calcareous	46	0.42	0.36	0.00	0.18	0.39	0.47	0.00	0.32	0.00	0.16	0.59	0.52	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.27
Indeterminate miliolid	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	0.00	0.00	0.00
Indeterminate rotaliid	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	0.00	0.00	0.00	0.00	0.00	0.00
?Jadammina sp.	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
Miliammina fusca	50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	51	1.41	1.70	1.72	1.87	1.67	1.65	1.99	2.13	2.25	1.96	0.67	1.95	2.26	2.05	1.57	2.08	2.05	2.09	2.54	2.43
Neoconorbina sp.	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	0.00	0.00	0.00	0.00
? Neoconorbina	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	0.00	0.00
Nodosariid	54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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.	55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 calcariformata	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
Pararotalia nipponica	57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 venusta	58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 sp. A	59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 sp.	60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	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
Peneroplis pertusus	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	0.00
Planodiscorbis sp.	63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 cf. *P. schroeteriana*	65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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.	66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	67	0.30	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
Reussella spinulosa	68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 sp. C	69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 sp. B	71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	76	0.00	0.00	0.15	0.00	0.17	0.00	0.00	0.00	0.00	0.45	0.31	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00
Spiroloculina manifesta	77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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 laevigata	79	0.78	0.59	0.91	0.78	0.72	0.63	0.57	0.50	0.52	0.28	0.87	0.37	0.36	0.61	1.01	0.48	0.51	0.31	0.27	0.27
"Trochammina ochracea"	80	0.17	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.28	0.31	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00
Trochammina sp. E	81	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trochammina sp.	82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wiesnerella sp.	83	0.17	0.00	0.00	0.18	0.00	0.38	0.00	0.00	0.00	0.00	0.56	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX E

Distribution of Fisher's alpha diversity index in relation to the location of fish cages.



APPENDIX F

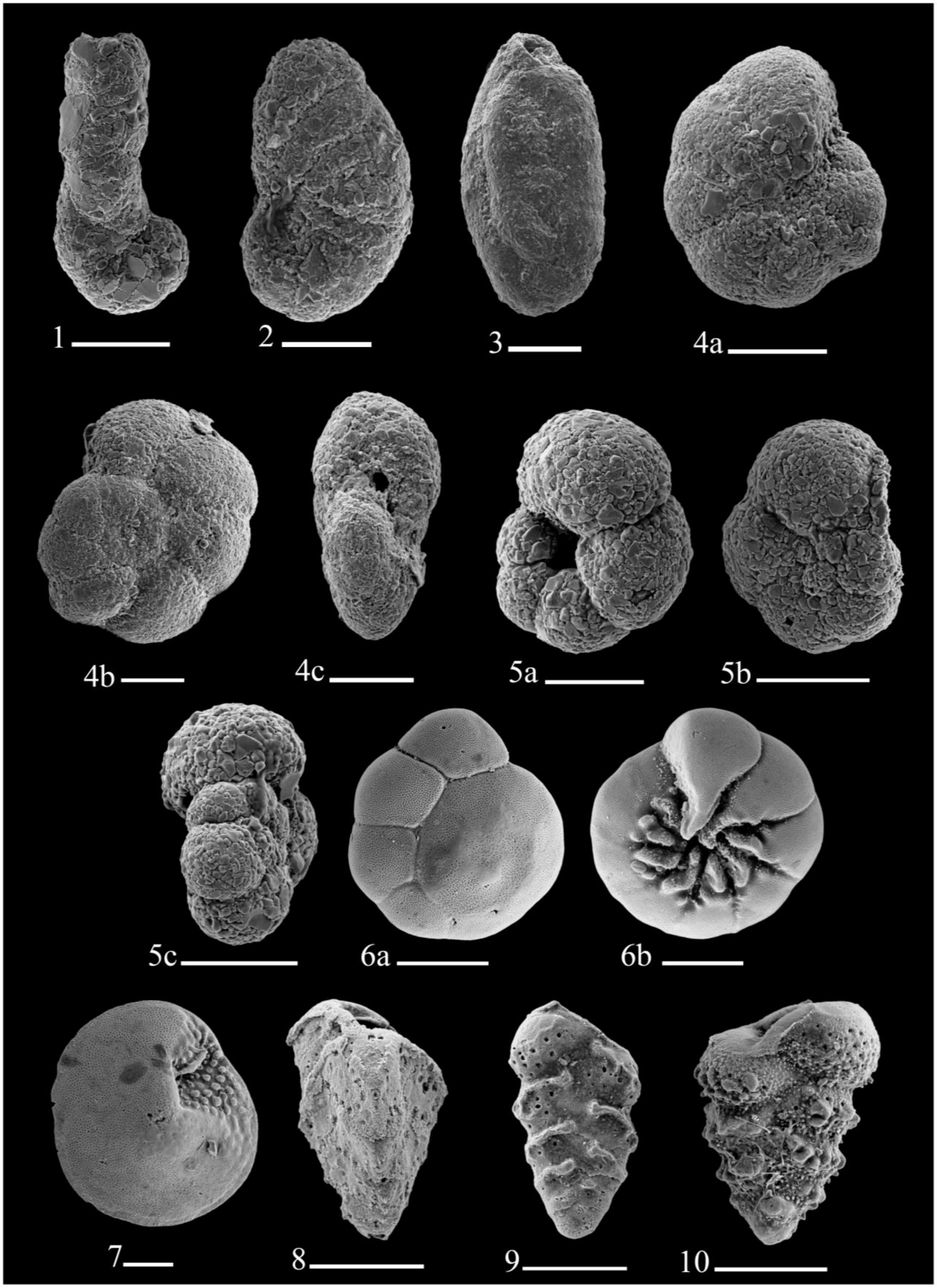
PLATE 1: Abundant foraminifera in the Setiu estuary and lagoon. Scale bars = 100 µm.

Agglutinated foraminifera:

1. *Ammobaculites exiguus*
2. *Ammotium directum*
3. *Miliammina fusca*
4. *Paratrochammina stoeni*
5. *Trochammina amnicola*

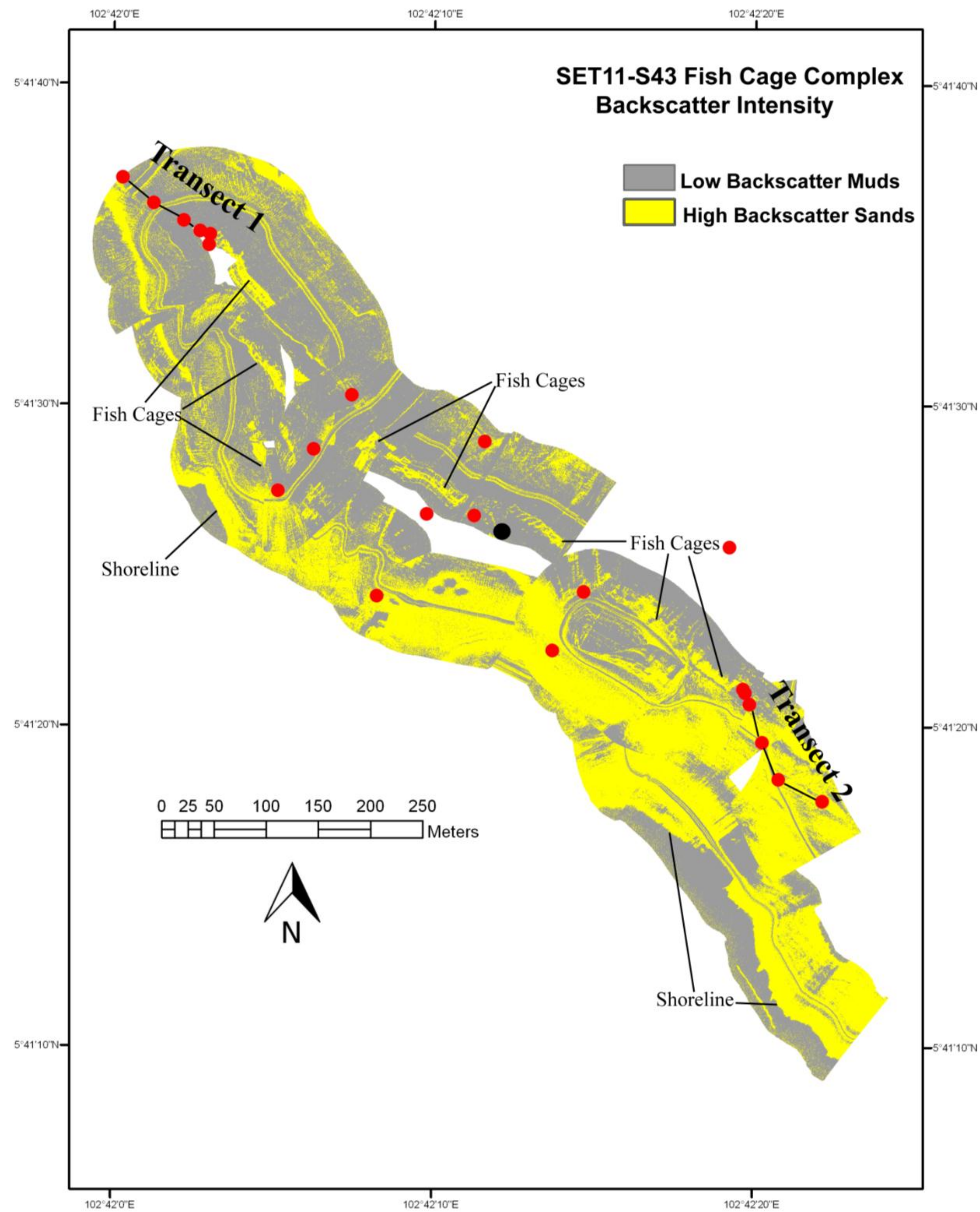
Calcareous foraminfera:

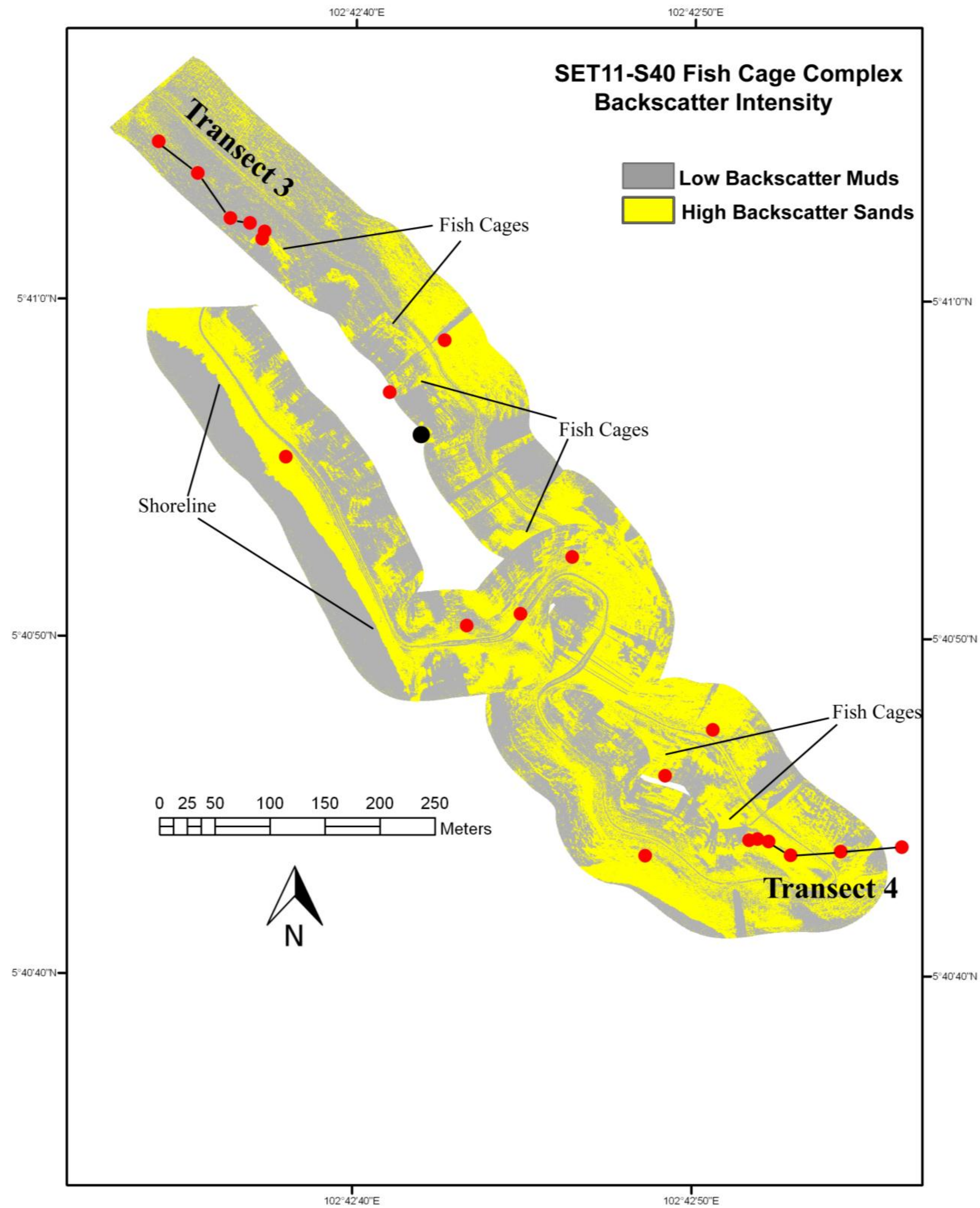
6. *Ammonia* aff. *A. aoteana*
7. *Amphistegina lessonii*
8. *Reussella pulchra*
9. *Sagrinella lobata*
10. *Sagrina zanzabarica*


1
2
3
4a
4b
4c
5a
5b
5c
6a
6b
7
8
9
10

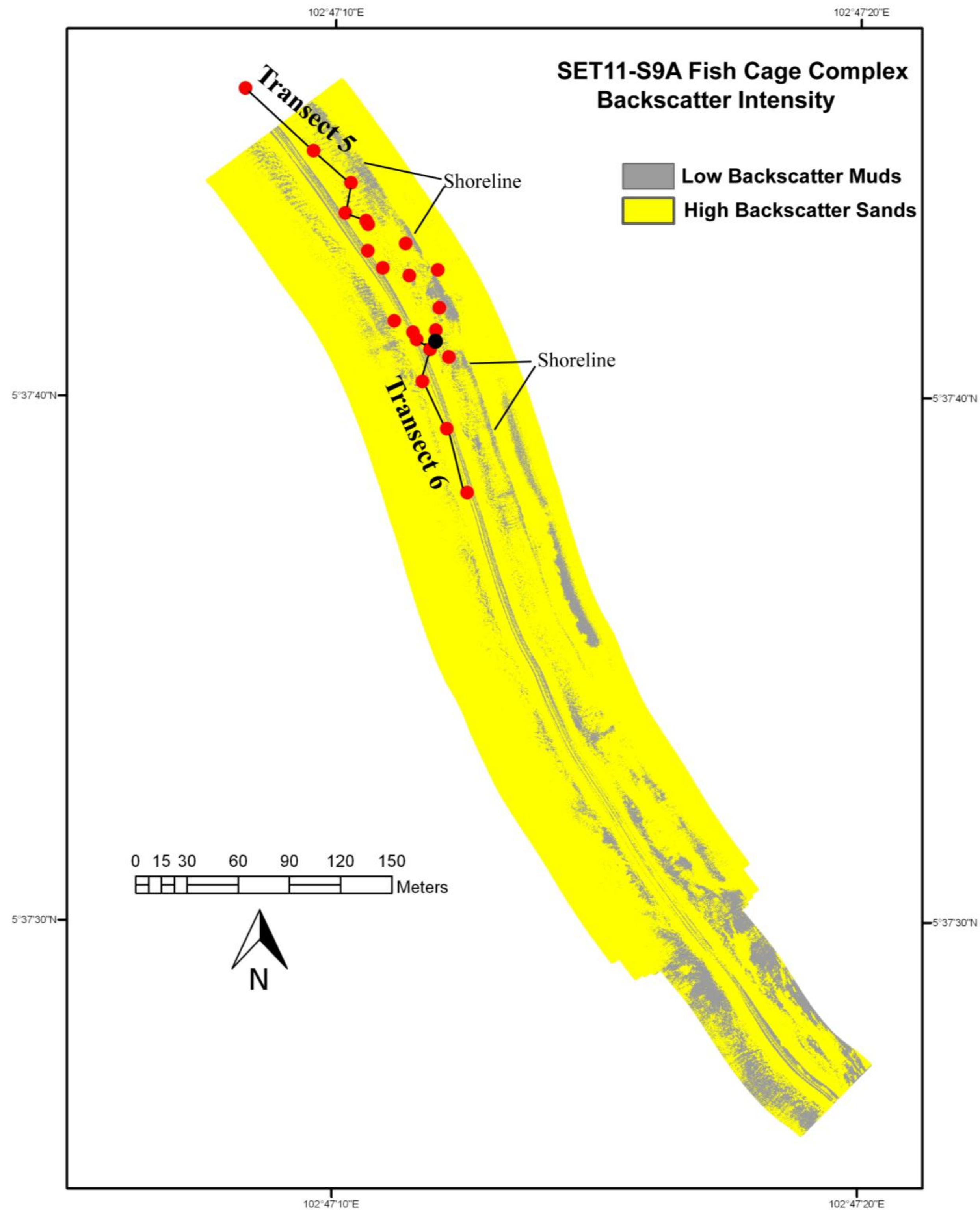
APPENDIX G

Backscatter intensity average at 16 pixels +/- 2 m of sample location regressed against percent mud. Yellow backscatter indicates sands and grey backscatter indicates muds.



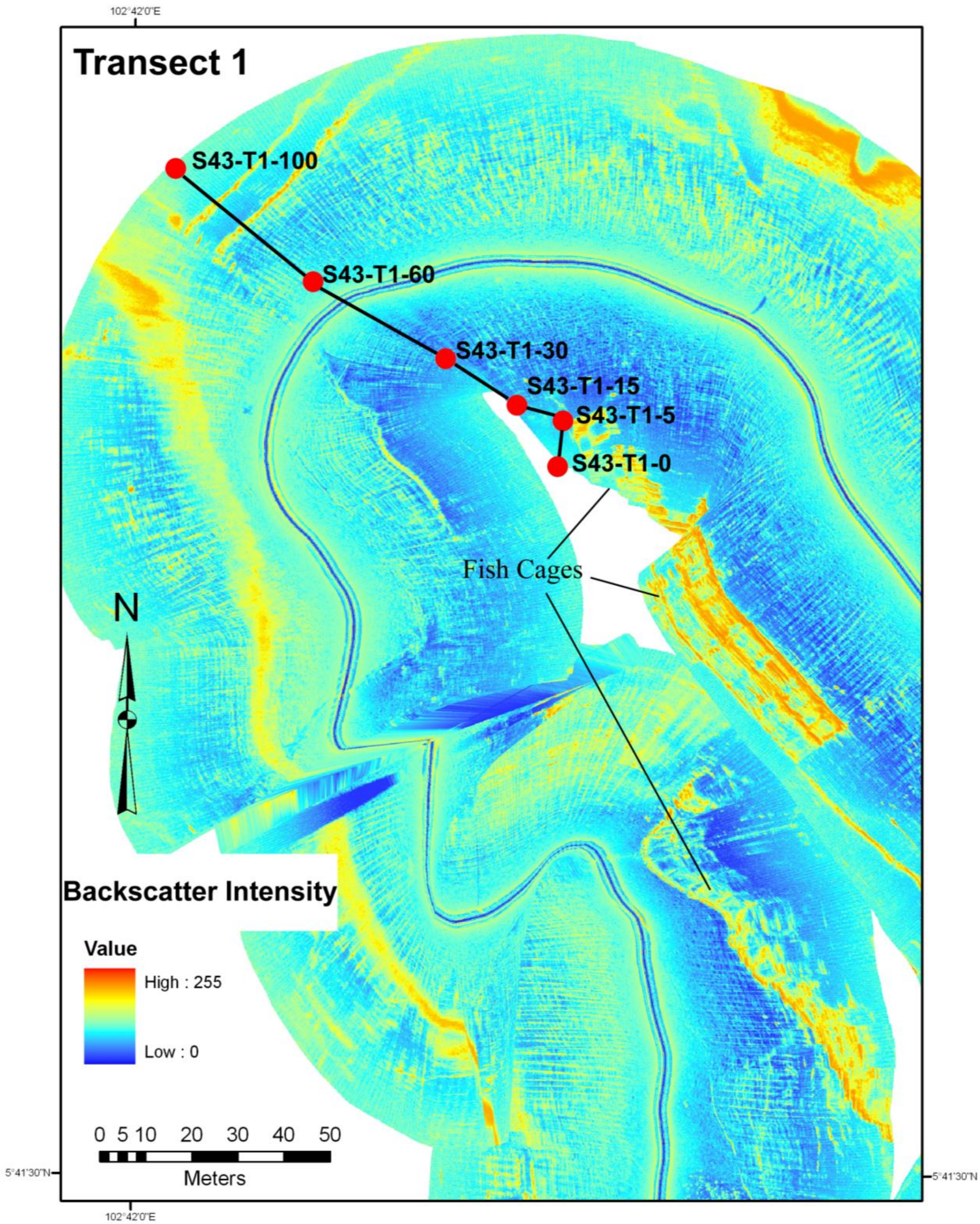


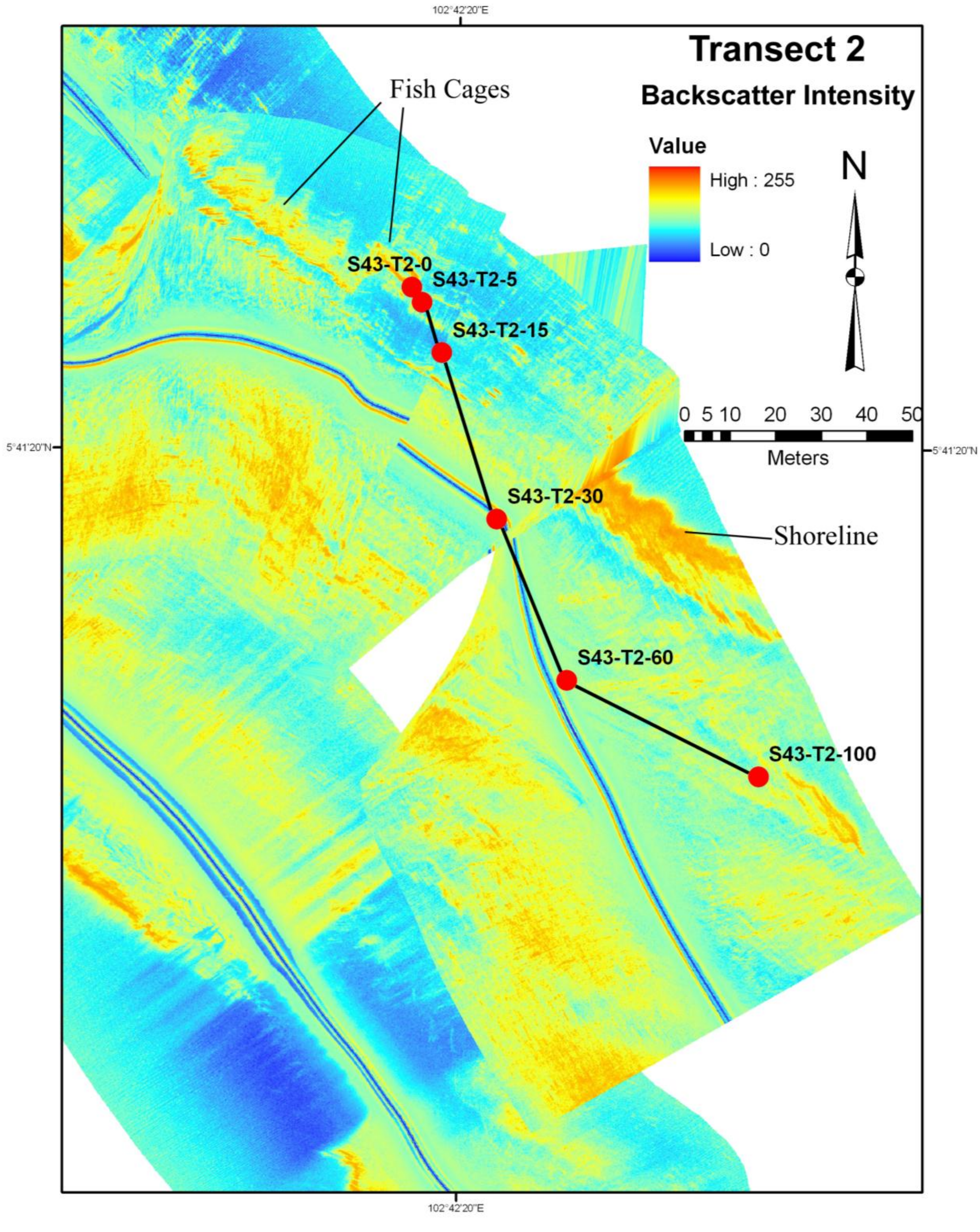
SET11-S40 Fish Cage Complex
Backscatter Intensity
Low Backscatter Muds
High Backscatter Sands
Transect 3
Transect 4
Fish Cages
Fish Cages
Fish Cages
Shoreline
0 25 50 100 150 200 250
Meters
N
102°42'40"E
102°42'50"E
5°41'0"N
5°40'50"N
5°40'40"N

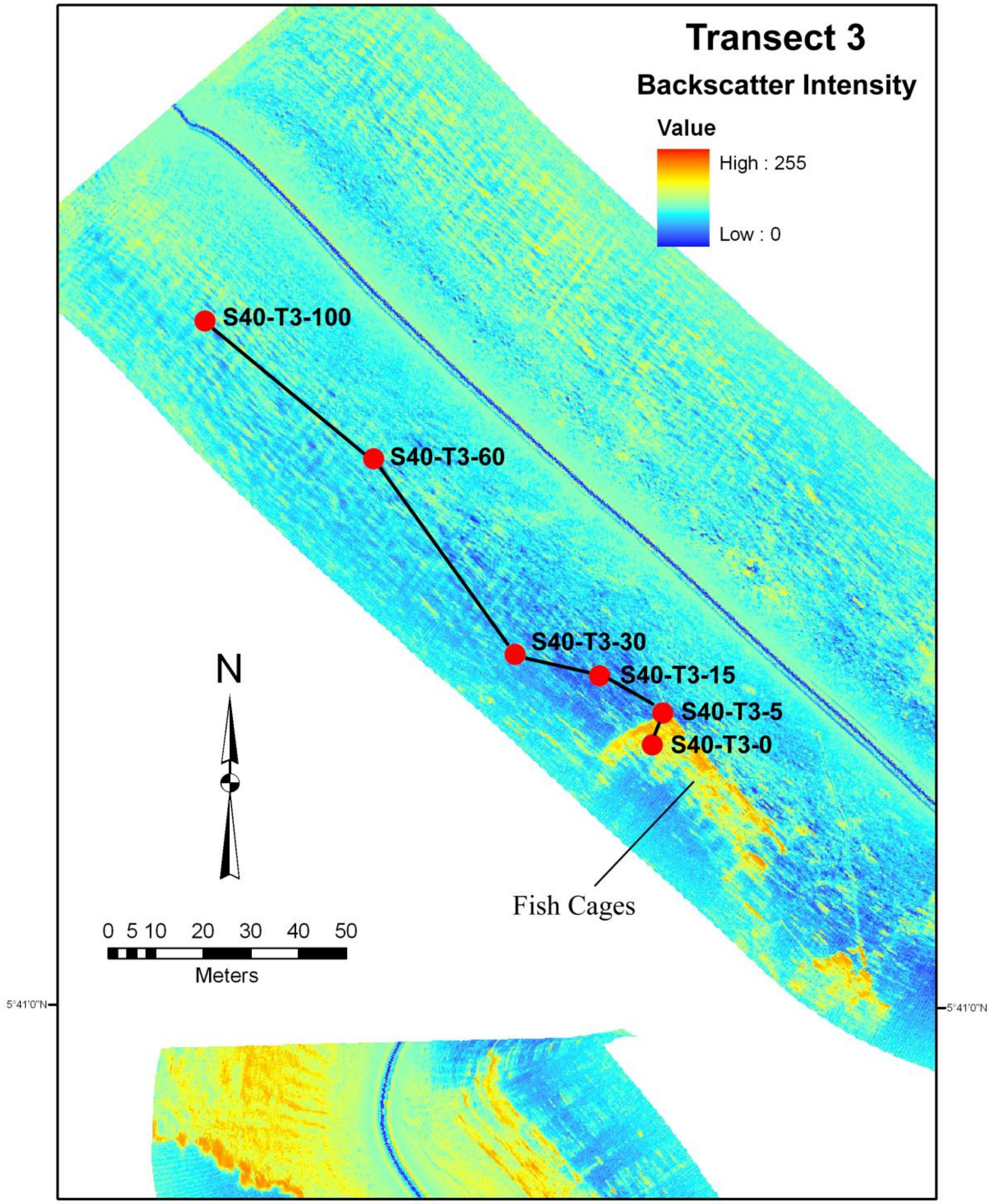

SET11-S9A Fish Cage Complex
Backscatter Intensity
Low Backscatter Muds
High Backscatter Sands
Transect 5
Transect 6
Shoreline
Shoreline
102°47'10"E
102°47'20"E
5°37'40"N
5°37'30"N
0 15 30 60 90 120 150
Meters
N

APPENDIX H

Expanded side scan sonar images (T1, T2, T3).




102°42'20"E
Transect 2
Backscatter Intensity
Value
High : 255
Low : 0
N
Fish Cages
S43-T2-0
S43-T2-5
S43-T2-15
0 5 10 20 30 40 50
Meters
5°41'20"N
5°41'20"N
S43-T2-30
Shoreline
S43-T2-60
S43-T2-100
102°42'20"E


Transect 3
Backscatter Intensity
Value
High : 255
Low : 0
S40-T3-100
S40-T3-60
S40-T3-30
S40-T3-15
S40-T3-5
S40-T3-0
N
Fish Cages
0 5 10 20 30 40 50
Meters
5°41'0"N
5°41'0"N

APPENDIX I

Grain-size weights by phi size (Ro-Tap).

Site Location	Gravel Weight (g)	Sand Weight (g)	Mud Weight (g)	Total Weight (g)	Pan	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
S43-T1-100	0	0	1.23	1.23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S43-T1-60	0	0	1.15	1.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S43-T1-30	0	0	1.65	1.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S43-T1-15	0	0.1	1.57	1.67	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0	0	0	0	0
S43-T1-5	0	0.08	1.5	1.58	0.01	0.03	0	0.01	0	0.01	0.01	0.01	0.01	0	0	0	0	0
S43 T1-0	0	0.13	1.51	1.64	0.01	0.01	0	0.01	0	0.1	0	0	0.01	0	0	0	0	0
S43-1	0.06	4.52	0.46	5.04	0.05	0.15	0.14	0.12	0.33	0.83	1.02	0.96	0.64	0.27	0.06	0.04	0.02	0
S43-2	0	0.06	1.6	1.66	0.01	0.02	0.01	0.01	0.02	0	0	0	0	0	0	0	0	0
S43-3	0	0	1.48	1.48	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S43-4	0.26	7.12	1.2	8.58	0.08	0.99	1	0.43	0.59	1.05	0.98	0.98	0.68	0.28	0.14	0.04	0	0.22
S43-5	0	0.18	1.22	1.4	0	0.06	0.02	0.01	0	0	0.02	0.02	0.02	0.01	0.02	0	0	0
S43-6	0	0.11	1.66	1.77	0.02	0.02	0.04	0	0	0.02	0.01	0	0.01	0.01	0	0	0	0
S43-7	0.06	11.05	0.15	11.26	0.03	0.06	0.12	0.23	0.72	1.5	2.36	2.84	1.64	1.09	0.49	0.06	0	0
S43-8	0	0.1	2.22	2.32	0.02	0.04	0.02	0	0.01	0	0.01	0	0	0.02	0	0	0	0
S43-9	0	0.16	2.03	2.19	0.03	0.08	0.04	0.01	0.01	0.01	0	0.01	0	0	0	0	0	0
S43-T2-0	0.15	2.05	6.04	8.24	0.09	0.52	0.55	0.27	0.14	0.13	0.12	0.11	0.13	0.06	0.02	0.01	0.01	0.13
S43-T2-5	0.94	20.36	2.35	23.65	0.08	0.34	0.43	0.81	0.95	2	3.37	4.42	3.81	2.45	1.78	0.8	0.14	0
S43-T2-15	0.66	29.21	0.39	30.26	0.02	0.02	0.02	0.12	1.09	4.4	8.16	8.2	4.16	2.1	0.94	0.34	0.32	0
S43-T2-30	1.81	30.97	0.25	33.03	0	0	0.06	0.18	0.96	4.34	7.18	8.12	4.77	2.93	2.43	1.4	0.41	0
S43-T2-60	4.08	40.29	0.25	44.62	0.01	0.03	0.09	0.12	0.89	3.72	8.55	11.34	6.75	4.9	3.9	2.16	1.35	0.57
S43-T2-100	6.33	27.28	0.28	33.89	0	0.06	0.05	0.19	1.16	3.03	4.41	5.57	5.9	3.35	3.56	2.36	1.4	2.57
S40-T3-100	0.01	2.16	5.52	7.69	0.17	0.74	0.54	0.18	0.14	0.21	0.14	0.13	0.04	0.03	0.01	0.01	0	0
S40-T3-60	0.07	0.57	4.8	5.44	0.09	0.31	0.06	0.03	0.04	0.04	0.02	0.02	0.04	0.01	0	0	0.07	0
S40-T3-30	0.02	0.53	6.06	6.61	0.32	0.32	0.13	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0	0
S40-T3-15	0	1.54	7.02	8.56	0.21	0.94	0.43	0.02	0.05	0.07	0.01	0.01	0.01	0	0	0	0	0
S40-T3-5	0	1.08	3.82	4.9	0.13	0.71	0.22	0.03	0.02	0.02	0.03	0.01	0.02	0.01	0.01	0	0	0
S40-T3-0	0.08	2.64	6.32	9.04	1.36	0.56	1.18	0.21	0.15	0.16	0.16	0.1	0.1	0.01	0.01	0.01	0	0.07
S40-1	0.1	25.6	4.1	29.8	1.02	6.93	6.75	1.73	1.56	2.17	2.16	2.13	1.4	0.54	0.23	0.01	0.09	0
S40-2	0.01	8.16	4.92	13.09	0.4	3.12	3.97	0.69	0.18	0.1	0.03	0.02	0.02	0.02	0.01	0.01	0	0
S40-3	0	11.49	4.77	16.26	2.94	1.54	2.04	0.65	2.31	2.74	1.41	0.51	0.21	0.05	0.03	0	0	0
S40-4	0	6.45	0.86	7.31	0.16	2.08	2.94	0.98	0.15	0.09	0.08	0.05	0.04	0.03	0.01	0	0	0
S40-5	0	17.67	2.48	20.15	0.17	3.9	8.07	4.8	0.64	0.13	0.07	0.03	0.01	0.01	0.01	0	0	0
S40-6	0.35	19.24	1.32	20.91	0.57	0.51	0.9	0.43	1.48	3.58	3.95	3.72	2.4	1.64	0.63	0.11	0.24	0
S40-7	0.09	12.2	1.49	13.78	0.33	3.24	6.52	2	0.21	0.11	0.05	0.03	0.02	0.02	0	0	0.09	0
S40-8	0.01	10.92	6.25	17.18	3.43	1.21	6.3	2.48	0.43	0.17	0.12	0.1	0.06	0.04	0.01	0.01	0	0
S40-9	1.42	32.59	0.03	34.04	0	0.04	0.24	2.48	5.37	5.78	4.23	4.67	4.65	2.95	2.18	0.94	0.48	0
S40-T4-0	0.05	9.94	3.07	13.06	1.18	1.01	3.64	3.13	1.51	0.34	0.12	0.08	0.05	0.05	0.01	0.05	0	0
S40-T4-5	0	9.26	mud lost		0.18	2.45	3.59	2.36	0.57	0.15	0.07	0.04	0.03	0	0	0	0	0
S40-T4-15	0.41	12.1	mud lost		0.29	2.96	5.36	2.5	0.65	0.2	0.2	0.06	0.06	0.05	0.06	0.01	0.27	0.13
S40-T4-30	0.25	9.96	5.59	15.8	3.07	0.93	5.34	2.87	0.62	0.1	0.05	0.03	0.02	0	0	0	0	0.25
S40-T4-60	0.07	15.76	4.07	19.9	0.48	4.46	4.52	1.65	0.97	1.2	0.95	0.9	0.67	0.33	0.11	0.01	0	0.06
S40-T4-100	0.36	15.73	3.86	19.95	0.26	2.91	7.7	4.17	0.58	0.14	0.07	0.07	0.04	0.03	0.02	0.02	0.22	0.12
S9A-T5-100	1.97	32.48	0.57	35.02	0.01	0.02	0.03	0.11	0.66	4.76	9.19	8.89	5.08	2.11	1.63	0.95	0.89	0.13
S9A-T5-60	0.03	28.62	0.6	29.25	0.02	0.03	0.05	0.11	0.83	4.96	8.65	8.33	3.78	1.39	0.49	0.03	0	0
S9A-T5-30	0.05	15.69	3.96	19.7	0.04	0.04	0.16	0.27	0.85	3.1	5.17	4.23	1.28	0.43	0.16	0.05	0	0
S9A-T5-15	0.09	25.17	0.2	25.46	0	0	0.02	0.02	0.28	2.78	6.96	8.52	4.69	1.58	0.32	0.09	0	0
S9A-T5-5	1.27	19.05	1.41	21.73	0.05	0.05	0.12	0.23	0.9	3.11	5.41	5.24	2.19	1.13	0.67	0.64	0.49	0.14
S9A-T5-0	1.29	36.81	0.19	38.29	0	0.02	0.04	0.17	0.58	2.96	7.39	10.92	8.69	3.89	2.15	1.06	0.11	0.12
S9A-1	0.2	14.45	0.33	14.98	0.02	0.02	0.03	0.11	0.44	2.37	3.63	3.56	2.44	1.1	0.75	0.13	0.07	0
S9A-2	0.09	19.74	0.58	20.41	0	0.02	0.02	0.11	0.45	2.71	5.98	6.37	2.72	1.07	0.29	0.09	0	0
S9A-3	0.04	25.68	1.85	27.57	0	0.03	0.11	0.41	1.4	5.57	7.73	6.25	2.77	1.08	0.33	0.04	0	0
S9A-4	0.1	1.11	5.53	6.74	0.06	0.07	0.19	0.17	0.11	0.09	0.13	0.11	0.09	0.1	0.05	0.04	0.06	0
S9A-5	0.02	0.8	4.89	5.71	0.02	0.09	0.09	0.13	0.1	0.1	0.07	0.07	0.06	0.03	0.06	0.01	0.01	0
S9A-6	0	0.04	4.7	4.74	0	0.01	0	0	0.01	0	0	0	0.01	0.01	0	0	0	0
S9A-7	1.3	31.62	0.19	33.11	0	0	0	0.04	0.32	3.52	7.94	8.3	5.73	3.79	1.98	0.67	0.63	0
S9A-8	0.01	39.1	2.02	41.13	0.02	0.01	0	0.1	1.34	7.11	13.18	11.2	4.14	1.58	0.44	0.01	0	0
S9A-9	0	0.18	5.89	6.07	0	0.01	0.01	0	0.02	0.04	0.06	0.03	0.01	0	0	0	0	0
S9A-T6-0	0.16	36.57	0.61	37.34	0	0.01	0.01	0.06	0.44	3.26	10.04	13.46	6.01	2.57	0.71	0.13	0.03	0
S9A-T6-5	0.2	32.89	1.14	34.23	0.03	0.01	0.02	0.09	0.85	6.52	10.35	8.93	4.31	1.33	0.48	0.17	0.03	0
S9A-T6-15	0.29	34.51	0.45	35.25	0	0	0.04	0.28	1.01	6.57	10.99	9.29	4.14	1.47	0.72	0.24	0.05	0
S9A-T6-30	0.07	26.72	0.48	27.27	0	0.02	0.03	0.05	0.4	3.58	7.87	8.34	3.79	1.83	0.81	0.02	0.05	0
S9A-T6-60	0.11	56.29	0.39	56.79	0.01	0.01	0.01	0.09	1.24	10.11	18.24	15.16	7.91	2.45	1.07	0.11	0	0
S9A-T6-100	0.44	36.67	1.5	38.61	0.01	0.02	0.02	0.11	0.58	5.79	10.78	10.35	5.53	2.46	1.03	0.16	0.28	0

APPENDIX J

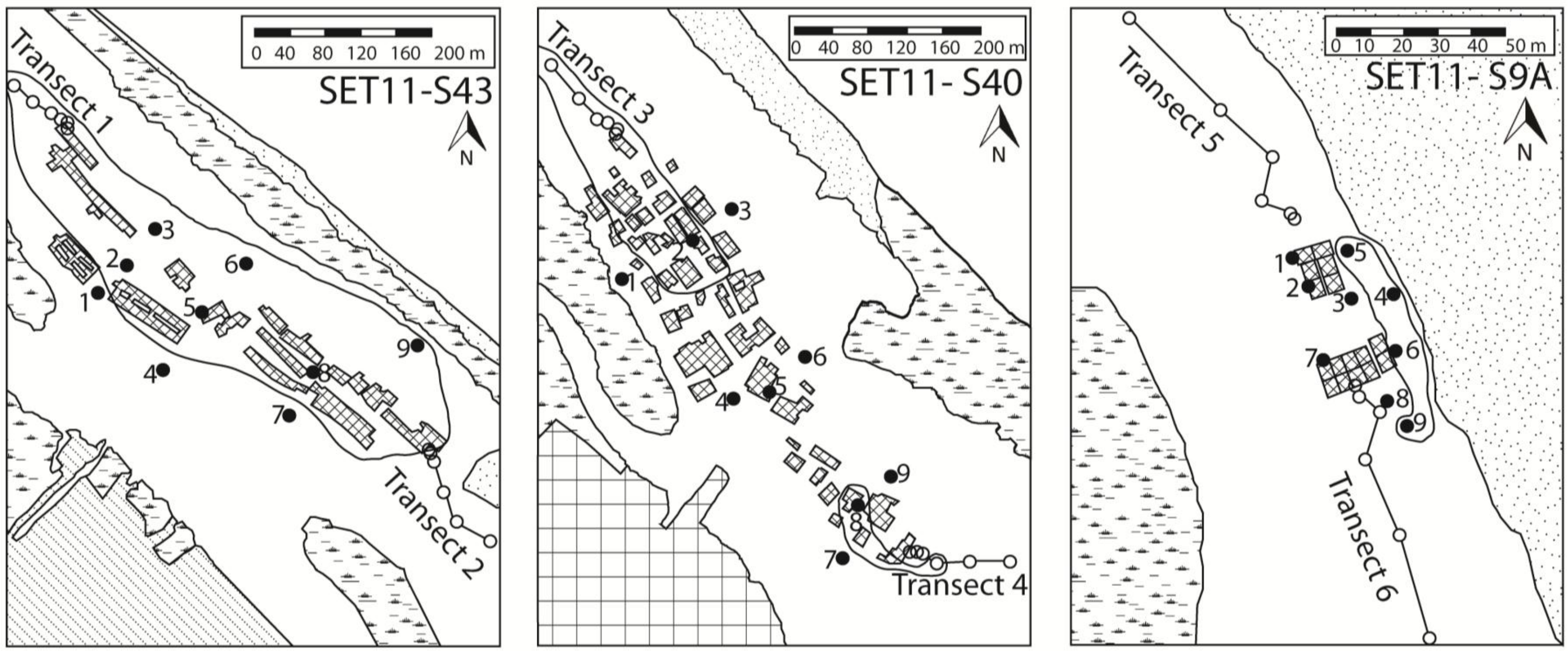
Comparison and total weight difference for samples from the SET11-S40 fish farm complex.

The values provided under “Post Bleaching” is the way all grain-size data were presented for all samples. Only the SET11-S40 samples and corresponding transects were initially dried and weighed before wet sieving to separate mud from coarser material. The differences calculated are for mud weights only. The large discrepancy in the weights is likely due to the absence/ dissolution of salts when wet sieving, taking a dry weight when sediment was not fully dry (retention of water by clays) and possible loss due to sedigraph attempts.

Post Bleaching- Mud Weighed in Boat				Mud Weight Based on Sand Weight Subtracted from Initial Dry Weight								
Site Location	**Weigh Boat (g)**	**Mud in Boat (g)**	**Mud (g)**	**Weigh Boat (g)**	**Dry Weight (in boat) (g)**	**Dry Weight (g)**	**Sand Weight (in boat) (g)**	**Sand Weight (g)**	**Percent Sand (g)**	**Mud Weight (g)**	**Percent Mud (g)**	**Difference (g)**
S40-T3-100	11.47	16.82	5.35	0.12	9.66	9.54	2.17	2.05	21.53	7.49	78.47	2.14
S40-T3-60	11.53	16.24	4.71	0.21	7.57	7.36	0.64	0.43	5.90	6.93	94.10	2.22
S40-T3-30	11.32	17.06	5.74	0.15	8.69	8.54	0.55	0.40	4.67	8.14	95.33	2.40
S40-T3-15	11.16	17.97	6.81	0.12	10.84	10.72	1.54	1.42	13.29	9.30	86.71	2.49
S40-T3-5	11.41	15.10	3.69	0.09	6.95	6.85	1.08	0.99	14.39	5.87	85.61	2.18
S40-T3-0	11.13	16.09	4.96	0.13	11.83	11.70	2.72	2.59	22.10	9.11	77.90	4.15
S40-1	11.35	14.43	3.08	0.01	32.19	32.18	25.70	25.69	79.84	6.49	20.16	3.41
S40-2	11.40	15.92	4.52	0.06	15.57	15.51	8.17	8.11	52.27	7.40	47.73	2.88
S40-3	11.41	13.24	1.83	0.08	18.41	18.33	11.49	11.41	62.23	6.92	37.77	5.09
S40-4	11.22	11.92	0.70	0.14	9.16	9.02	6.45	6.31	69.96	2.71	30.04	2.01
S40-5	11.36	13.67	2.31	0.01	22.46	22.45	17.67	17.66	78.66	4.79	21.34	2.48
S40-6	11.54	12.29	0.75	0.52	23.34	22.82	19.59	19.07	83.57	3.75	16.43	3.00
S40-7	11.62	12.78	1.16	0.47	16.09	15.62	12.29	11.82	75.68	3.80	24.32	2.64
S40-8	11.25	14.07	2.82	0.52	19.83	19.31	10.93	10.41	53.90	8.90	46.10	6.08
S40-9	11.40	11.43	0.03	0.56	36.96	36.40	34.01	33.45	91.89	2.95	8.11	2.92
S40-T4-0	11.33	13.22	1.89	0.13	15.39	15.26	9.99	9.86	64.63	5.40	35.37	3.51
S40-T4-5	LOST	LOST	LOST	0.15	13.44	13.29	9.26	9.11	68.53	4.18	31.47	
S40-T4-15	LOST	LOST	LOST	0.03	17.72	17.69	12.51	12.48	70.53	5.21	29.47	
S40-T4-30	11.74	14.26	2.52	0.11	17.96	17.85	10.21	10.10	56.58	7.75	43.42	5.23
S40-T4-60	11.42	15.01	3.59	0.11	22.52	22.41	15.83	15.72	70.16	6.69	29.84	3.10
S40-T4-100	11.29	14.89	3.60	0.11	22.34	22.22	16.09	15.98	71.89	6.25	28.11	2.65

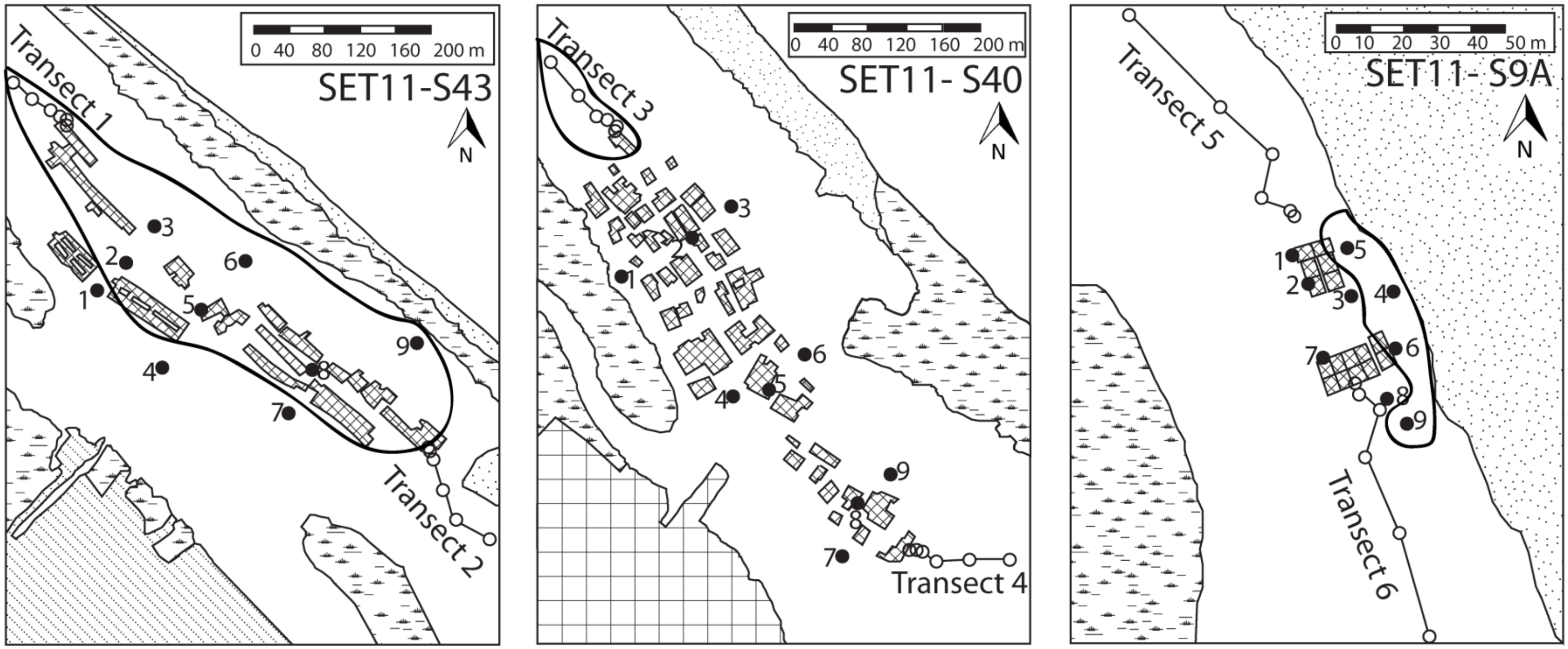
APPENDIX K

Contour map with contours encompassing the location of sediments with a mean grain-size value >4φ (mud) based on Gradistat grain-size analysis.



APPENDIX L

Contour map with contours encompassing the location of sediments with the predominant grain-size >4φ (mud) based on the Farrell/Folk analysis.



APPENDIX M

Sediment grain-size results for the Setiu estuary and lagoon samples produced by Gradistat. Two samples (T4-5 and T4-15) were lost. Stations are listed from north to south.

Station	Mean:	Mean:	Sorting (S):	Sorting:	Skewness (*Sk*):	Skewness	Kurtosis (*K*):	Kurtosis	Mode (f):	Notes
S43-T1-100										all mud
S43-T1-60										all mud
S43-T1-30										all mud
S43-T1-15	5.866	Coarse Silt	1.402	Poorly Sorted	-0.070	Symmetrical	0.858	Platykurtic	3.237	
S43-T1-5	5.887	Coarse Silt	1.297	Poorly Sorted	-0.002	Symmetrical	0.741	Platykurtic	3.731	
S43 T1-0	5.822	Coarse Silt	1.638	Poorly Sorted	-0.169	Coarse Skewed	1.114	Leptokurtic	1.747	
S43-1	1.444	Medium Sand	1.525	Poorly Sorted	0.367	Very Fine Skewed	1.839	Very Leptokurtic	1.247	
S43-2	5.919	Coarse Silt	1.271	Poorly Sorted	0.004	Symmetrical	0.732	Platykurtic	2.237	
S43-3										all mud
S43-4	2.120	Fine Sand	1.910	Poorly Sorted	0.228	Fine Skewed	1.104	Mesokurtic	3.237	
S43-5	5.698	Coarse Silt	1.808	Poorly Sorted	-0.194	Coarse Skewed	1.205	Leptokurtic	3.731	
S43-6	5.861	Coarse Silt	1.383	Poorly Sorted	-0.055	Symmetrical	0.830	Platykurtic	3.237	
S43-7	0.928	Coarse Sand	0.891	Moderately Sorted	0.042	Symmetrical	1.068	Mesokurtic	0.747	
S43-8	5.904	Coarse Silt	1.282	Poorly Sorted	0.002	Symmetrical	0.735	Platykurtic	3.731	
S43-9	5.836	Coarse Silt	1.360	Poorly Sorted	-0.027	Symmetrical	0.780	Platykurtic	3.731	
S43-T2-0	5.183	Coarse Silt	2.050	Very Poorly Sorted	-0.178	Coarse Skewed	1.030	Mesokurtic	3.237	
S43-T2-5	1.038	Medium Sand	1.758	Poorly Sorted	0.362	Very Fine Skewed	1.724	Very Leptokurtic	0.747	
S43-T2-15	0.903	Coarse Sand	0.766	Moderately Sorted	-0.109	Coarse Skewed	1.125	Leptokurtic	1.247	
S43-T2-30	0.673	Coarse Sand	0.926	Moderately Sorted	-0.190	Coarse Skewed	1.025	Mesokurtic	0.747	
S43-T2-60	0.465	Coarse Sand	0.993	Moderately Sorted	-0.228	Coarse Skewed	1.028	Mesokurtic	0.747	
S43-T2-100	0.182	Coarse Sand	1.286	Poorly Sorted	-0.166	Coarse Skewed	0.969	Mesokurtic	0.247	
S40-T3-100	5.203	Coarse Silt	1.886	Poorly Sorted	-0.093	Symmetrical	0.907	Mesokurtic	3.731	
S40-T3-60	5.727	Coarse Silt	1.494	Poorly Sorted	-0.070	Symmetrical	0.858	Platykurtic	3.731	
S40-T3-30	5.812	Coarse Silt	1.372	Poorly Sorted	-0.025	Symmetrical	0.777	Platykurtic	3.731	
S40-T3-15	5.556	Coarse Silt	1.508	Poorly Sorted	-0.007	Symmetrical	0.749	Platykurtic	3.731	
S40-T3-5	5.459	Coarse Silt	1.538	Poorly Sorted	0.024	Symmetrical	0.723	Platykurtic	3.731	
S40-T3-0	5.133	Coarse Silt	1.920	Poorly Sorted	-0.086	Symmetrical	0.853	Platykurtic	3.237	
S40-1	2.742	Fine Sand	1.672	Poorly Sorted	-0.214	Coarse Skewed	1.272	Leptokurtic	3.237	
S40-2	4.378	Very Coarse Silt	1.519	Poorly Sorted	0.593	Very Fine Skewed	0.948	Mesokurtic	3.237	
S40-3	3.477	Very Fine Sand	2.018	Very Poorly Sorted	0.326	Very Fine Skewed	0.942	Mesokurtic	1.747	
S40-4	3.377	Very Fine Sand	0.882	Moderately Sorted	0.244	Fine Skewed	2.446	Very Leptokurtic	3.237	
S40-5	3.292	Very Fine Sand	0.879	Moderately Sorted	0.347	Very Fine Skewed	2.200	Very Leptokurtic	3.237	
S40-6	1.259	Medium Sand	1.368	Poorly Sorted	0.212	Fine Skewed	1.554	Very Leptokurtic	1.247	
S40-7	3.369	Very Fine Sand	0.790	Moderately Sorted	0.360	Very Fine Skewed	2.432	Very Leptokurtic	3.237	
S40-8	4.161	Very Coarse Silt	1.612	Poorly Sorted	0.644	Very Fine Skewed	0.953	Mesokurtic	3.237	
S40-9	1.064	Medium Sand	1.157	Poorly Sorted	-0.112	Coarse Skewed	0.847	Platykurtic	1.747	
S40-T4-0	3.620	Very Fine Sand	1.499	Poorly Sorted	0.512	Very Fine Skewed	1.727	Very Leptokurtic	3.237	
S40-T4-5										LOST
S40-T4-15										LOST
S40-T4-30	4.093	Very Coarse Silt	1.645	Poorly Sorted	0.612	Very Fine Skewed	0.980	Mesokurtic	3.237	
S40-T4-60	3.249	Very Fine Sand	1.835	Poorly Sorted	0.020	Symmetrical	1.796	Very Leptokurtic	3.237	
S40-T4-100	3.557	Very Fine Sand	1.212	Poorly Sorted	0.490	Very Fine Skewed	2.284	Very Leptokurtic	3.237	
inlet										
S9A-T5-100	0.801	Coarse Sand	0.860	Moderately Sorted	-0.218	Coarse Skewed	1.191	Leptokurtic	1.247	

S9A-T5-60	1.028	Medium Sand	0.672	Moderately Well Sorted	-0.037	Symmetrical	1.071	Mesokurtic	1.247
S9A-T5-30	2.267	Fine Sand	2.082	Very Poorly Sorted	0.651	Very Fine Skewed	2.094	Very Leptokurtic	1.247
S9A-T5-15	0.837	Coarse Sand	0.621	Moderately Well Sorted	-0.035	Symmetrical	1.047	Mesokurtic	0.747
S9A-T5-5	1.000	Medium Sand	1.362	Poorly Sorted	0.113	Fine Skewed	2.369	Very Leptokurtic	1.247
S9A-T5-0	0.613	Coarse Sand	0.783	Moderately Sorted	-0.079	Symmetrical	1.114	Leptokurtic	0.747
S9A-1	0.893	Coarse Sand	0.831	Moderately Sorted	-0.074	Symmetrical	1.059	Mesokurtic	1.247
S9A-2	0.956	Coarse Sand	0.696	Moderately Well Sorted	-0.021	Symmetrical	1.199	Leptokurtic	0.747
S9A-3	1.222	Medium Sand	1.123	Poorly Sorted	0.264	Fine Skewed	2.049	Very Leptokurtic	1.247
S9A-4	5.364	Coarse Silt	2.077	Very Poorly Sorted	-0.271	Coarse Skewed	1.220	Leptokurtic	3.237
S9A-5	5.658	Coarse Silt	1.773	Poorly Sorted	-0.173	Coarse Skewed	1.128	Leptokurtic	2.737
S9A-6	5.977	Coarse Silt	1.227	Poorly Sorted	0.012	Symmetrical	0.721	Platykurtic	2.237
S9A-7	0.638	Coarse Sand	0.828	Moderately Sorted	-0.171	Coarse Skewed	0.999	Mesokurtic	0.747
S9A-8	1.137	Medium Sand	0.749	Moderately Sorted	0.130	Fine Skewed	1.402	Leptokurtic	1.247
S9A-9	5.933	Coarse Silt	1.260	Poorly Sorted	0.006	Symmetrical	0.729	Platykurtic	1.247
S9A-T6-0	0.822	Coarse Sand	0.633	Moderately Well Sorted	-0.045	Symmetrical	1.168	Leptokurtic	0.747
S9A-T6-5	1.075	Medium Sand	0.689	Moderately Well Sorted	-0.030	Symmetrical	1.087	Mesokurtic	1.247
S9A-T6-15	1.052	Medium Sand	0.672	Moderately Well Sorted	-0.113	Coarse Skewed	1.070	Mesokurtic	1.247
S9A-T6-30	0.888	Coarse Sand	0.676	Moderately Well Sorted	-0.102	Coarse Skewed	1.125	Leptokurtic	0.747
S9A-T6-60	1.006	Medium Sand	0.641	Moderately Well Sorted	-0.118	Coarse Skewed	1.016	Mesokurtic	1.247
S9A-T6-100	0.944	Coarse Sand	0.763	Moderately Sorted	-0.052	Symmetrical	1.181	Leptokurtic	1.247

APPENDIX N

Calculated loss on ignition (LOI) values and percentages based on sediment (sed.) weight differences from burning off organic matter in the furnace.

Site Location	Crucible Weight (g)	Sed. Weight In Crucible Before Furnace (g)	Sed. Weight Before Furnace (g)	Sed. Weight In Crucible After Furnace (g)	Sed. Weight After Furnace (g)	Difference (g)	LOI	% LOI
S43-T1-100	8.8713	11.4726	2.6013	11.1097	2.2384	0.3629	0.1395	13.95
S43-T1-60	8.8593	12.4454	3.5861	11.9472	3.0879	0.4982	0.1389	13.89
S43-T1-30	8.5799	11.1268	2.5469	10.7969	2.217	0.3299	0.1295	12.95
S43-T1-15	7.5221	10.3571	2.835	9.9979	2.4758	0.3592	0.1267	12.67
S43-T1-5	8.1519	10.6416	2.4897	10.2785	2.1266	0.3631	0.1458	14.58
S43 T1-0	8.665	9.9523	1.2873	9.7857	1.1207	0.1666	0.1294	12.94
S43-1	9.2647	15.3398	6.0751	15.1941	5.9294	0.1457	0.0240	2.40
S43-2	8.248	9.8407	1.5927	9.6263	1.3783	0.2144	0.1346	13.46
S43-3	9.335	11.7725	2.4375	11.3902	2.0552	0.3823	0.1568	15.68
S43-4	8.8083	14.5091	5.7008	14.3853	5.577	0.1238	0.0217	2.17
S43-5	8.7662	11.2166	2.4504	10.9077	2.1415	0.3089	0.1261	12.61
S43-6	8.8796	11.9178	3.0382	11.5114	2.6318	0.4064	0.1338	13.38
S43-7	8.602	16.8074	8.2054	16.7522	8.1502	0.0552	0.0067	0.67
S43-8	8.9423	11.5383	2.596	11.1916	2.2493	0.3467	0.1336	13.36
S43-9	7.5571	10.8855	3.3284	10.4728	2.9157	0.4127	0.1240	12.40
S43-T2-0	8.5681	11.1171	2.549	10.7622	2.1941	0.3549	0.1392	13.92
S43-T2-5	9.3016	19.4849	10.1833	19.3586	10.057	0.1263	0.0124	1.24
S43-T2-15	9.373	18.0291	8.6561	17.9703	8.5973	0.0588	0.0068	0.68
S43-T2-30	7.4501	15.8665	8.4164	15.8133	8.3632	0.0532	0.0063	0.63
S43-T2-60	8.5832	16.9507	8.3675	16.9013	8.3181	0.0494	0.0059	0.59
S43-T2-100	8.3068	17.2387	8.9319	17.1859	8.8791	0.0528	0.0059	0.59
S40-T3-100	8.8709	12.6086	3.7377	12.295	3.4241	0.3136	0.0839	8.39
S40-T3-60	8.8587	11.6618	2.8031	11.2984	2.4397	0.3634	0.1296	12.96
S40-T3-30	8.5796	11.8478	3.2682	11.3544	2.7748	0.4934	0.1510	15.10
S40-T3-15	7.5219	10.3803	2.8584	10.0863	2.5644	0.294	0.1029	10.29
S40-T3-5	8.1515	10.2515	2.1	10.0363	1.8848	0.2152	0.1025	10.25
S40-T3-0	8.6648	12.0723	3.4075	11.7573	3.0925	0.315	0.0924	9.24
S40-1	9.2648	15.9449	6.6801	15.7744	6.5096	0.1705	0.0255	2.55
S40-2	8.2476	11.8168	3.5692	11.5708	3.3232	0.246	0.0689	6.89
S40-3	9.3347	15.0588	5.7241	14.9151	5.5804	0.1437	0.0251	2.51
S40-4	8.8078	14.1657	5.3579	13.9872	5.1794	0.1785	0.0333	3.33
S40-5	8.7665	14.4731	5.7066	14.2672	5.5007	0.2059	0.0361	3.61
S40-6	8.8791	16.8518	7.9727	16.7615	7.8824	0.0903	0.0113	1.13
S40-7	8.6021	14.4442	5.8421	14.2598	5.6577	0.1844	0.0316	3.16
S40-8	8.9419	14.212	5.2701	13.9338	4.9919	0.2782	0.0528	5.28
S40-9	7.557	17.5224	9.9654	17.4525	9.8955	0.0699	0.0070	0.70
S40-T4-0	8.566	12.4827	3.9167	12.3561	3.7901	0.1266	0.0323	3.23
S40-T4-5	9.2998	14.2284	4.9286	14.0641	4.7643	0.1643	0.0333	3.33
S40-T4-15	9.3713	14.2087	4.8374	14.0383	4.667	0.1704	0.0352	3.52
S40-T4-30	7.4487	12.1169	4.6682	11.9629	4.5142	0.154	0.0330	3.30
S40-T4-60	8.5819	12.5762	3.9943	12.4169	3.835	0.1593	0.0399	3.99
S40-T4-100	8.3054	12.6405	4.3351	12.5091	4.2037	0.1314	0.0303	3.03
S9A-T5-100	8.8708	17.6861	8.8153	17.6277	8.7569	0.0584	0.0066	0.66
S9A-T5-60	8.8792	17.6959	8.8167	17.6433	8.7641	0.0526	0.0060	0.60
S9A-T5-30	8.5793	14.9791	6.3998	14.763	6.1837	0.2161	0.0338	3.38
S9A-T5-15	7.5217	15.1976	7.6759	15.1505	7.6288	0.0471	0.0061	0.61
S9A-T5-5	8.1511	16.8872	8.7361	16.814	8.6629	0.0732	0.0084	0.84
S9A-T5-0	8.2473	15.7767	7.5294	15.7319	7.4846	0.0448	0.0060	0.60
S9A-1	9.265	17.3095	8.0445	17.2602	7.9952	0.0493	0.0061	0.61
S9A-2	8.6614	16.9419	8.2805	16.8818	8.2204	0.0601	0.0073	0.73
S9A-3	9.3348	16.955	7.6202	16.8717	7.5369	0.0833	0.0109	1.09
S9A-4	8.8084	11.442	2.6336	11.1633	2.3549	0.2787	0.1058	10.58
S9A-5	8.766	11.8643	3.0983	11.6052	2.8392	0.2591	0.0836	8.36
S9A-6	8.8582	11.2463	2.3881	10.9576	2.0994	0.2887	0.1209	12.09
S9A-7	8.6018	16.3984	7.7966	16.3878	7.786	0.0106	0.0014	0.14
S9A-8	8.942	16.8509	7.9089	16.7677	7.8257	0.0832	0.0105	1.05
S9A-9	7.5571	10.0207	2.4636	9.7189	2.1618	0.3018	0.1225	12.25
S9A-T6-0	8.5683	17.4335	8.8652	17.3723	8.804	0.0612	0.0069	0.69
S9A-T6-5	9.3013	18.2844	8.9831	18.2377	8.9364	0.0467	0.0052	0.52
S9A-T6-15	9.3728	18.7355	9.3627	18.6693	9.2965	0.0662	0.0071	0.71
S9A-T6-30	7.4533	17.5202	10.0669	17.4642	10.0109	0.056	0.0056	0.56
S9A-T6-60	8.5845	18.1254	9.5409	18.0681	9.4836	0.0573	0.0060	0.60
S9A-T6-100	8.3064	17.3556	9.0492	17.2833	8.9769	0.0723	0.0080	0.80

APPENDIX O

The cumulative finer mass percentages of particle diameters ranging from 0.29 µm to 91.73 µm produced by Micromeritics Sedigraph III 5120 Particle Size Analyzer.

T1-0		T1-5		T1-30		T1-60		T1-100		S43-1		S43-2		S43-5		S43-6		S43-8	
Particle Diameter (µm)	Finer Mass Percent	Particle Diameter (µm)	Finer Mass Percent	Particle Diameter (µm)	Finer Mass Percent	Particle Diameter (µm)	Finer Mass Percent	Particle Diameter (µm)	Finer Mass Percent	Particle Diameter (µm)	Finer Mass Percent	Particle Diameter (µm)	Finer Mass Percent	Particle Diameter (µm)	Finer Mass Percent	Particle Diameter (µm)	Finer Mass Percent	Particle Diameter (µm)	Finer Mass Percent
0.29	24.36	0.29	34.20	0.29	15.05	0.29	40.67	0.29	42.71	0.29	35.34	0.29	39.80	0.29	33.85	0.29	37.55	0.29	32.27
0.31	24.36	0.31	34.20	0.31	15.05	0.31	40.67	0.31	42.71	0.31	35.34	0.31	39.80	0.31	33.85	0.31	37.55	0.31	32.27
0.33	25.82	0.33	35.56	0.33	19.66	0.33	41.50	0.33	43.99	0.33	36.61	0.33	40.95	0.33	34.73	0.33	38.77	0.33	33.61
0.34	27.22	0.34	36.87	0.34	23.97	0.34	42.40	0.34	45.16	0.34	37.78	0.34	42.23	0.34	35.70	0.34	39.91	0.34	35.04
0.37	28.55	0.37	38.10	0.37	27.91	0.37	43.34	0.37	46.22	0.37	38.86	0.37	43.60	0.37	36.75	0.37	40.98	0.37	36.49
0.39	29.84	0.39	39.22	0.39	31.47	0.39	44.27	0.39	47.19	0.39	39.85	0.39	45.02	0.39	37.84	0.39	41.98	0.39	37.88
0.41	31.09	0.41	40.22	0.41	34.64	0.41	45.17	0.41	48.09	0.41	40.75	0.41	46.41	0.41	38.93	0.41	42.92	0.41	39.14
0.43	32.33	0.43	41.08	0.43	37.45	0.43	45.99	0.43	48.95	0.43	41.58	0.43	47.74	0.43	40.00	0.43	43.78	0.43	40.20
0.46	33.58	0.46	41.81	0.46	39.90	0.46	46.73	0.46	49.82	0.46	42.37	0.46	48.96	0.46	41.00	0.46	44.56	0.46	41.06
0.49	34.85	0.49	42.43	0.49	42.04	0.49	47.37	0.49	50.73	0.49	43.18	0.49	50.06	0.49	41.93	0.49	45.26	0.49	41.73
0.52	36.13	0.52	42.93	0.52	43.90	0.52	47.92	0.52	51.69	0.52	44.05	0.52	51.03	0.52	42.78	0.52	45.88	0.52	42.24
0.55	37.38	0.55	43.36	0.55	45.49	0.55	48.40	0.55	52.71	0.55	45.02	0.55	51.88	0.55	43.54	0.55	46.43	0.55	42.67
0.58	38.58	0.58	43.74	0.58	46.84	0.58	48.85	0.58	53.77	0.58	46.12	0.58	52.62	0.58	44.24	0.58	46.95	0.58	43.06
0.61	39.70	0.61	44.10	0.61	47.97	0.61	49.30	0.61	54.80	0.61	47.35	0.61	53.27	0.61	44.88	0.61	47.47	0.61	43.48
0.65	40.72	0.65	44.47	0.65	48.88	0.65	49.79	0.65	55.75	0.65	48.69	0.65	53.86	0.65	45.47	0.65	48.03	0.65	43.96
0.69	41.67	0.69	44.85	0.69	49.60	0.69	50.35	0.69	56.57	0.69	50.11	0.69	54.41	0.69	46.05	0.69	48.64	0.69	44.51
0.73	42.56	0.73	45.27	0.73	50.18	0.73	50.97	0.73	57.21	0.73	51.58	0.73	54.95	0.73	46.62	0.73	49.30	0.73	45.13
0.77	43.46	0.77	45.72	0.77	50.66	0.77	51.64	0.77	57.67	0.77	53.06	0.77	55.50	0.77	47.21	0.77	49.99	0.77	45.82
0.82	44.39	0.82	46.23	0.82	51.10	0.82	52.33	0.82	57.97	0.82	54.53	0.82	56.10	0.82	47.82	0.82	50.68	0.82	46.55
0.87	45.38	0.87	46.78	0.87	51.53	0.87	53.01	0.87	58.17	0.87	55.93	0.87	56.76	0.87	48.48	0.87	51.32	0.87	47.30
0.92	46.43	0.92	47.38	0.92	52.02	0.92	53.67	0.92	58.33	0.92	57.21	0.92	57.48	0.92	49.19	0.92	51.91	0.92	48.06
0.97	47.51	0.97	48.03	0.97	52.57	0.97	54.28	0.97	58.51	0.97	58.29	0.97	58.24	0.97	49.94	0.97	52.44	0.97	48.83
1.03	48.58	1.03	48.73	1.03	53.19	1.03	54.87	1.03	58.78	1.03	59.09	1.03	59.04	1.03	50.74	1.03	52.91	1.03	49.60
1.09	49.60	1.09	49.47	1.09	53.86	1.09	55.44	1.09	59.17	1.09	59.59	1.09	59.85	1.09	51.55	1.09	53.35	1.09	50.40
1.15	50.54	1.15	50.22	1.15	54.55	1.15	56.02	1.15	59.68	1.15	59.78	1.15	60.62	1.15	52.36	1.15	53.80	1.15	51.23
1.22	51.38	1.22	50.97	1.22	55.23	1.22	56.61	1.22	60.30	1.22	59.75	1.22	61.36	1.22	53.14	1.22	54.28	1.22	52.10
1.30	52.15	1.30	51.69	1.30	55.86	1.30	57.22	1.30	61.00	1.30	59.59	1.30	62.04	1.30	53.86	1.30	54.81	1.30	53.00
1.37	52.86	1.37	52.34	1.37	56.44	1.37	57.84	1.37	61.74	1.37	59.45	1.37	62.68	1.37	54.53	1.37	55.38	1.37	53.93
1.45	53.55	1.45	52.92	1.45	56.94	1.45	58.46	1.45	62.48	1.45	59.46	1.45	63.29	1.45	55.14	1.45	55.99	1.45	54.85
1.54	54.26	1.54	53.44	1.54	57.39	1.54	59.06	1.54	63.20	1.54	59.70	1.54	63.89	1.54	55.69	1.54	56.61	1.54	55.74
1.63	55.00	1.63	53.92	1.63	57.79	1.63	59.64	1.63	63.90	1.63	60.19	1.63	64.51	1.63	56.20	1.63	57.25	1.63	56.58
1.73	55.79	1.73	54.40	1.73	58.17	1.73	60.18	1.73	64.57	1.73	60.89	1.73	65.18	1.73	56.71	1.73	57.89	1.73	57.36
1.83	56.60	1.83	54.92	1.83	58.56	1.83	60.69	1.83	65.22	1.83	61.71	1.83	65.90	1.83	57.21	1.83	58.54	1.83	58.09
1.94	57.45	1.94	55.53	1.94	58.97	1.94	61.19	1.94	65.88	1.94	62.57	1.94	66.67	1.94	57.74	1.94	59.21	1.94	58.78
2.05	58.32	2.05	56.21	2.05	59.42	2.05	61.68	2.05	66.56	2.05	63.39	2.05	67.47	2.05	58.29	2.05	59.91	2.05	59.46
2.18	59.21	2.18	56.97	2.18	59.93	2.18	62.18	2.18	67.25	2.18	64.15	2.18	68.30	2.18	58.87	2.18	60.64	2.18	60.15
2.30	60.12	2.30	57.77	2.30	60.51	2.30	62.71	2.30	67.95	2.30	64.87	2.30	69.12	2.30	59.47	2.30	61.40	2.30	60.86
2.44	61.07	2.44	58.57	2.44	61.17	2.44	63.26	2.44	68.66	2.44	65.60	2.44	69.92	2.44	60.08	2.44	62.17	2.44	61.61
2.59	62.04	2.59	59.33	2.59	61.92	2.59	63.84	2.59	69.36	2.59	66.40	2.59	70.67	2.59	60.69	2.59	62.93	2.59	62.39
2.74	63.05	2.74	60.05	2.74	62.76	2.74	64.45	2.74	70.03	2.74	67.29	2.74	71.38	2.74	61.29	2.74	63.67	2.74	63.18
2.90	64.08	2.90	60.71	2.90	63.71	2.90	65.08	2.90	70.69	2.90	68.29	2.90	72.05	2.90	61.88	2.90	64.39	2.90	63.97
3.07	65.14	3.07	61.34	3.07	64.75	3.07	65.75	3.07	71.34	3.07	69.35	3.07	72.68	3.07	62.45	3.07	65.11	3.07	64.76
3.25	66.22	3.25	61.99	3.25	65.86	3.25	66.46	3.25	72.00	3.25	70.44	3.25	73.30	3.25	63.03	3.25	65.85	3.25	65.56
3.45	67.33	3.45	62.68	3.45	67.01	3.45	67.24	3.45	72.70	3.45	71.49	3.45	73.91	3.45	63.61	3.45	66.63	3.45	66.37
3.65	68.46	3.65	63.46	3.65	68.18	3.65	68.13	3.65	73.48	3.65	72.48	3.65	74.55	3.65	64.24	3.65	67.49	3.65	67.22
3.87	69.63	3.87	64.35	3.87	69.33	3.87	69.15	3.87	74.38	3.87	73.41	3.87	75.25	3.87	64.92	3.87	68.43	3.87	68.12
4.10	70.82	4.10	65.36	4.10	70.42	4.10	70.31	4.10	75.41	4.10	74.31	4.10	76.05	4.10	65.69	4.10	69.44	4.10	69.07
4.34	72.03	4.34	66.49	4.34	71.44	4.34	71.61	4.34	76.57	4.34	75.22	4.34	76.96	4.34	66.55	4.34	70.50	4.34	70.09
4.60	73.22	4.60	67.72	4.60	72.38	4.60	73.00	4.60	77.81	4.60	76.18	4.60	77.99	4.60	67.50	4.60	71.57	4.60	71.16
4.87	74.38	4.87	69.02	4.87	73.27	4.87	74.43	4.87	79.08	4.87	77.24	4.87	79.13	4.87	68.52	4.87	72.64	4.87	72.27
5.16	75.46	5.16	70.35	5.16	74.11	5.16	75.84	5.16	80.31	5.16	78.42	5.16	80.33	5.16	69.59	5.16	73.67	5.16	73.40
5.46	76.47	5.46	71.67	5.46	74.95	5.46	77.16	5.46	81.44	5.46	79.71	5.46	81.54	5.46	70.67	5.46	74.67	5.46	74.54
5.79	77.41	5.79	72.95	5.79	75.82	5.79	78.34	5.79	82.44	5.79	81.12	5.79	82.69	5.79	71.74	5.79	75.62	5.79	75.67

6.13	78.31	6.13	74.16	6.13	76.72	6.13	79.38	6.13	83.32	6.13	82.64	6.13	83.72	6.13	72.76	6.13	76.56	6.13	76.78
6.49	79.20	6.49	75.30	6.49	77.67	6.49	80.26	6.49	84.11	6.49	84.24	6.49	84.59	6.49	73.73	6.49	77.47	6.49	77.85
6.88	80.13	6.88	76.37	6.88	78.67	6.88	81.02	6.88	84.89	6.88	85.90	6.88	85.29	6.88	74.63	6.88	78.36	6.88	78.86
7.29	81.11	7.29	77.41	7.29	79.70	7.29	81.68	7.29	85.70	7.29	87.54	7.29	85.85	7.29	75.47	7.29	79.23	7.29	79.81
7.72	82.14	7.72	78.44	7.72	80.74	7.72	82.30	7.72	86.56	7.72	89.06	7.72	86.30	7.72	76.27	7.72	80.07	7.72	80.69
8.18	83.22	8.18	79.48	8.18	81.77	8.18	82.92	8.18	87.46	8.18	90.37	8.18	86.68	8.18	77.02	8.18	80.87	8.18	81.49
8.66	84.29	8.66	80.55	8.66	82.76	8.66	83.58	8.66	88.37	8.66	91.36	8.66	87.07	8.66	77.74	8.66	81.65	8.66	82.22
9.17	85.32	9.17	81.63	9.17	83.71	9.17	84.31	9.17	89.22	9.17	92.03	9.17	87.50	9.17	78.44	9.17	82.41	9.17	82.89
9.72	86.26	9.72	82.67	9.72	84.59	9.72	85.13	9.72	89.99	9.72	92.40	9.72	88.01	9.72	79.10	9.72	83.14	9.72	83.51
10.29	87.11	10.29	83.65	10.29	85.41	10.29	86.06	10.29	90.64	10.29	92.59	10.29	88.60	10.29	79.73	10.29	83.84	10.29	84.09
10.90	87.87	10.90	84.53	10.90	86.17	10.90	87.10	10.90	91.21	10.90	92.75	10.90	89.28	10.90	80.32	10.90	84.53	10.90	84.63
11.55	88.55	11.55	85.30	11.55	86.90	11.55	88.21	11.55	91.73	11.55	93.04	11.55	90.02	11.55	80.91	11.55	85.19	11.55	85.15
12.23	89.20	12.23	86.00	12.23	87.59	12.23	89.37	12.23	92.26	12.23	93.55	12.23	90.76	12.23	81.50	12.23	85.83	12.23	85.67
12.96	89.85	12.96	86.66	12.96	88.26	12.96	90.54	12.96	92.84	12.96	94.30	12.96	91.48	12.96	82.12	12.96	86.49	12.96	86.21
13.72	90.52	13.72	87.34	13.72	88.93	13.72	91.67	13.72	93.50	13.72	95.23	13.72	92.13	13.72	82.82	13.72	87.17	13.72	86.79
14.54	91.23	14.54	88.10	14.54	89.60	14.54	92.73	14.54	94.24	14.54	96.18	14.54	92.69	14.54	83.60	14.54	87.92	14.54	87.44
15.40	91.95	15.40	88.94	15.40	90.27	15.40	93.68	15.40	95.04	15.40	97.01	15.40	93.17	15.40	84.46	15.40	88.74	15.40	88.15
16.31	92.66	16.31	89.85	16.31	90.95	16.31	94.51	16.31	95.89	16.31	97.57	16.31	93.60	16.31	85.38	16.31	89.63	16.31	88.92
17.28	93.33	17.28	90.78	17.28	91.64	17.28	95.21	17.28	96.73	17.28	97.81	17.28	94.00	17.28	86.33	17.28	90.56	17.28	89.73
18.30	93.92	18.30	91.65	18.30	92.35	18.30	95.78	18.30	97.54	18.30	97.75	18.30	94.42	18.30	87.24	18.30	91.49	18.30	90.55
19.39	94.41	19.39	92.41	19.39	93.09	19.39	96.22	19.39	98.27	19.39	97.50	19.39	94.89	19.39	88.10	19.39	92.37	19.39	91.34
20.54	94.81	20.54	93.03	20.54	93.87	20.54	96.55	20.54	98.89	20.54	97.21	20.54	95.40	20.54	88.85	20.54	93.16	20.54	92.07
21.75	95.13	21.75	93.52	21.75	94.67	21.75	96.78	21.75	99.37	21.75	97.01	21.75	95.95	21.75	89.50	21.75	93.83	21.75	92.72
23.04	95.40	23.04	93.93	23.04	95.48	23.04	96.94	23.04	99.69	23.04	97.00	23.04	96.50	23.04	90.06	23.04	94.38	23.04	93.29
24.41	95.64	24.41	94.34	24.41	96.24	24.41	97.05	24.41	99.83	24.41	97.24	24.41	97.03	24.41	90.54	24.41	94.82	24.41	93.79
25.85	95.89	25.85	94.81	25.85	96.93	25.85	97.15	25.85	99.79	25.85	97.68	25.85	97.52	25.85	90.99	25.85	95.19	25.85	94.25
27.38	96.17	27.38	95.39	27.38	97.48	27.38	97.25	27.38	99.59	27.38	98.25	27.38	97.95	27.38	91.43	27.38	95.51	27.38	94.68
29.01	96.46	29.01	96.09	29.01	97.86	29.01	97.38	29.01	99.27	29.01	98.83	29.01	98.32	29.01	91.89	29.01	95.81	29.01	95.12
30.73	96.76	30.73	96.85	30.73	98.07	30.73	97.54	30.73	98.88	30.73	99.32	30.73	98.66	30.73	92.39	30.73	96.12	30.73	95.57
32.55	97.06	32.55	97.63	32.55	98.12	32.55	97.74	32.55	98.49	32.55	99.64	32.55	98.95	32.55	92.94	32.55	96.46	32.55	96.02
34.47	97.33	34.47	98.33	34.47	98.05	34.47	97.98	34.47	98.14	34.47	99.76	34.47	99.20	34.47	93.54	34.47	96.83	34.47	96.48
36.52	97.57	36.52	98.89	36.52	97.93	36.52	98.23	36.52	97.89	36.52	99.69	36.52	99.42	36.52	94.18	36.52	97.25	36.52	96.91
38.68	97.76	38.68	99.25	38.68	97.81	38.68	98.49	38.68	97.76	38.68	99.46	38.68	99.59	38.68	94.85	38.68	97.70	38.68	97.30
40.97	97.92	40.97	99.41	40.97	97.76	40.97	98.72	40.97	97.74	40.97	99.10	40.97	99.71	40.97	95.51	40.97	98.17	40.97	97.62
43.40	98.04	43.40	99.38	43.40	97.83	43.40	98.90	43.40	97.83	43.40	98.64	43.40	99.78	43.40	96.16	43.40	98.64	43.40	97.88
45.97	98.13	45.97	99.21	45.97	98.03	45.97	99.00	45.97	97.99	45.97	98.09	45.97	99.81	45.97	96.77	45.97	99.07	45.97	98.07
48.70	98.18	48.70	98.94	48.70	98.37	48.70	99.02	48.70	98.20	48.70	97.44	48.70	99.80	48.70	97.32	48.70	99.46	48.70	98.22
51.58	98.19	51.58	98.64	51.58	98.83	51.58	98.96	51.58	98.41	51.58	96.69	51.58	99.77	51.58	97.79	51.58	99.76	51.58	98.35
54.64	98.17	54.64	98.36	54.64	99.35	54.64	98.82	54.64	98.61	54.64	95.86	54.64	99.74	54.64	98.19	54.64	99.98	54.64	98.49
57.88	98.11	57.88	98.12	57.88	99.89	57.88	98.63	57.88	98.77	57.88	95.00	57.88	99.70	57.88	98.50	57.88	100.11	57.88	98.64
61.31	98.04	61.31	97.96	61.31	100.41	61.31	98.44	61.31	98.89	61.31	94.15	61.31	99.68	61.31	98.75	61.31	100.17	61.31	98.83
64.94	97.96	64.94	97.87	64.94	100.85	64.94	98.26	64.94	98.98	64.94	93.42	64.94	99.68	64.94	98.94	64.94	100.16	64.94	99.03
68.79	97.88	68.79	97.86	68.79	101.21	68.79	98.14	68.79	99.03	68.79	92.87	68.79	99.69	68.79	99.09	68.79	100.12	68.79	99.24
72.86	97.83	72.86	97.92	72.86	101.47	72.86	98.09	72.86	99.06	72.86	92.55	72.86	99.73	72.86	99.21	72.86	100.06	72.86	99.45
77.18	97.80	77.18	98.04	77.18	101.64	77.18	98.12	77.18	99.09	77.18	92.50	77.18	99.78	77.18	99.31	77.18	100.01	77.18	99.63
81.75	97.80	81.75	98.22	81.75	101.74	81.75	98.23	81.75	99.14	81.75	92.69	81.75	99.86	81.75	99.40	81.75	99.98	81.75	99.79
86.60	97.85	86.60	98.45	86.60	101.81	86.60	98.42	86.60	99.21	86.60	93.11	86.60	99.95	86.60	99.48	86.60	99.98	86.60	99.93
91.73	97.89	91.73	98.64	91.73	101.84	91.73	98.58	91.73	99.28	91.73	93.52	91.73	100.02	91.73	99.54	91.73	99.99	91.73	100.01