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Assemblage Comparisons of Living Benthic Foraminifera at Bathyal Sites Oiled and Un-Oiled by the Deepwater Horizon Blowout in the Northeastern Gulf of Mexico

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ASSEMBLAGE COMPARISONS OF LIVING BENTHIC FORAMINIFERA AT BATHYAL SITES OILED AND UN-OILED BY THE DEEPWATER HORIZON BLOWOUT IN THE NORTHEASTERN GULF OF MEXICO

by

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ABSTRACT

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Live benthic foraminiferal assemblages were studied at contaminated and uncontaminated bathyal sites around the wellhead of the Deepwater Horizon oil spill. Samples collected in October of 2010 and 2011 and summer of 2012 were divided into uncontaminated (GIP 12, 21, K, and 25 and Obs0), moderately oiled (GIP 16 and 17) and heavily oiled groups (GIP 15), in which the TPAH concentrations ranged from 29 to 7,553 ng/g in 2010. Metric multidimensional scaling (MDS) and cluster analyses were conducted to compare all surface samples. Additionally, the heavily oiled site (GIP 15) and an uncontaminated site (GIP 25) were studied downcore to assess the impact on the foraminiferal depth of habitation (DOH).

A total of 284 species from 6 suborders have been identified in the ≥ 45-µm size fraction. Three pseudo-replicates at Obs0 had more similarity in species distribution and diversity than any other site. The MDS and cluster analyses show that the surface assemblages are within a single biofacies except for two sites (GIP 21 and K). The assemblages from the heavily oiled and un-oiled cores were distinctly different. In 2010, the standing stock was nearly two times greater

at the heavily oiled site, but the DOH was half the depth of the un-oiled site. In 2011, the standing stock of the two sites was similar, but the DOH remained shallower at the oiled site. The trends in density, DOH, standing stock, diversity, and abundance of an opportunistic species (*Bulimina aculeata*) at the heavily oiled site appear consistent with hypertrophy.

DEDICATION

I dedicate this thesis to my loving family. To my amazing husband, Hugo L. Rodriguez, this work would not have been possible without your loving support and patience. The strong work put into this research and thesis writing would not have been possible without the guidance and encouragement to always follow my dreams from that of my wonderful parents, Sonia Abolafia Bezares and David Cruz-Wells.

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I would also like to acknowledge the committee members, Drs. Charlotte Brunner, Kevin Briggs and Vernon Asper, for their advice and guidance throughout the entire length of the project. Additional thanks to Dr. Kevin Briggs for the use of his macrofaunal data. To my major professor, Dr. Charlotte Brunner, I would like to give enormous appreciation for her support and guidance but most of all for the honor of accepting me into her lab where I was granted the opportunity in working with what I enjoy most, the Foraminifera.

I would like to give a warm thank you to Dr. Kevin Yeager of the Department of Earth and Environmental Sciences at the University of Kentucky for the use of his sedimentary data and for his good humor aboard the R/V *Cape Hatteras*. Special thanks go to Dr. Brad Rosenheim of the College of Marine Science at the University of South Florida for the opportunity to join the CARTHE cruise in the summer of 2012 and collect the pseudo-replicates at the Obs0 site. Appreciation is also in order for Dr. Barun Sen Gupta and Lorene Smith of the Department of Geology and Geophysics at Louisiana State University for allowing the use of their foraminiferal collection. Acknowledgment must go to Dr. J.T. Johnson for his statistical guidance. Deepest thanks to the lab technicians (Logan Dedeaux, Candis Mallett, Carlo Fortner, Jennifer Brizzolara, and Joseph Keim) and fellow students (Franklin Williams, Shivakumar Shivarudrappa, and Sarah Epps) for their help and guidance with sampling, processing, and data analysis.

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LIST OF ABBREVIATIONS

Consortium for Advanced Research on the Transport of Hydrocarbon (CARTHE) Observation Site .... *Obs*

Depth of Habitation .... *DOH*

Gulf Institute Petroleum .... *GIP*

Gulf of Mexico .... *GOM*

Multidimensional Scaling .... *MDS*

Number of Species .... *S index*

Pielou's Diversity Index .... *J index*

Shannon-Wiener Diversity Index .... *H' index*

Simpson's Diversity Index .... *D index*

Species Richness .... *SR index*

Total Polycyclic Aromatic Hydrocarbons .... *TPAH*

CHAPTER I

INTRODUCTION

The Deepwater Horizon (DWH) oil spill, one of the largest marine blowouts to occur historically, began on April 20, 2010 and released 4.9 ± 10% (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011) to 5.2 million barrels (Crone and Tolstoy, 2010) of oil into the northern Gulf of Mexico (GOM). Oil continued to pour into the GOM for three months before the Macondo well was finally sealed off. The crude oil contaminated hundreds of miles of coastline and affected the associated ecosystems (Henkel et al., 2012). The oil that wasn't recovered, evaporated, or ignited at the surface went into deep subsurface plumes according to Ryerson et al. (2012). In addition, an unknown amount of oil sank to the sea floor and possibly affected hydrocarbon-sensitive, benthic communities (OSAT, 2010). The main goal of the proposed study is to determine how hydrocarbon exposure affects the structure of benthic foraminiferal communities in regards to species composition, standing stock, and diversity and address whether the distributions present after the spill follow the point source model of pollution as applied to Foraminifera (Resig, 1960; Alve, 1995). Additionally, the identification of possible pollution-tolerant species can further support the use of benthic foraminifers as bioindicators for future studies (Frontalini and Coccioni, 2011).

Benthic Foraminifera are small, amoeboid protists that form their shells from calcium carbonate, non-mineralized organic material, small cemented grains, or, in rare instances, silica (Goldstein, 1999). They tend to compose about half of the meiofauna in bathyal and abyssal sea sediments, playing an important role within the benthic communities (Gooday, 1986; Bernhard et al., 2008; Rowe et al., 2008). Bacteria are one of the food sources for many foraminifers, and it is through bacterial consumption that the foraminifers provide a link of carbon transfer from the microbial trophic level to the higher trophic levels (Goldstein and Corliss, 1994; Nomaki et al., 2006). Studies have shown predation on foraminifers by decapods, fish, gastropods, holothuroids, isopods, molluscs, polychaetes, and scaphopods either accidently or selectively (Buzas and Carle, 1979; Hickman and Lipps, 1983; Lipps, 1988; Langer et al., 1995; Gudmundsson et al., 2000; Goldbeck et al., 2005; Debenay et al., 2011). The goal of the proposed study is to evaluate and monitor the effect of the DWH oil on bathyal Foraminifera, a critical link in the food web and the carbon cycle

Sediment cores were collected with the aid of a team of scientists, technicians, and fellow graduate students from several sites in the areas surrounding the Macondo well-head in the fall of 2010 and 2011 under the grant titled, “Responses of Benthic Communities and Sedimentary Dynamics to Hydrocarbon Exposure in Neritic and Bathyal Ecosystems: Phase II” which was funded by BP through the Northern Gulf Institute. The Geochemical and Environmental Research Group (GERG) analyzed the concentrations of total polycyclic aromatic hydrocarbons (TPAHs) for all yearly samples, and Dr. Patrick Louchouarn from Texas A & M University interpreted the TPAH data. Dr. Kevin Briggs assayed the macrofauna. Their results and interpretations are used in the discussion section of the thesis.

A variety of terms and measurements are used to describe the benthic biota in terms of abundance and distribution and must be defined before proceeding into the background information. The depth of habitation (DOH) is the depth to which 95% of the living assemblage populates the sediment (Corliss and Emerson, 1990). The standing stock as defined in this study refers to the number of live specimens within the depth of habitation. Density is a measurement of the total number of live individuals per unit volume of sediment (in this study, 10 cm^3). The S index refers to the total number of species in a sample (consistently about 300-350 specimens in this study). Species richness refers to the total number of species minus one divided by the total specimen count in a sample. Species diversity is a measure of all the species present in a sample weighted by their relative abundances [e.g., the Shannon-Weiner Index (*H'*)]. The term "assemblage" indicates a group of species present within a given environment. A biofacies refers to a volume of sediment characterized by "a distinctive assemblage of species formed under one set of environmental conditions" (Kaesler, 1966; Lagoe, 1979; Bates and Jackson, 1995).

Background

Scientists have used fossils of foraminifers as proxies of various environmental parameters—such as temperature, salinity, and sea-level—to evaluate paleoenvironments. Foraminifera have also proved useful as bioindicators in determining the contamination effects on the overall benthic community due to their high diversity, short life cycle, short reproductive cycle, and good shell preservation (Ernst et al., 2006; Gabellini, 2009; Frontalini and Coccioni, 2011). Because of their short life cycle (weeks to possibly a year), Foraminifera tend to respond quickly to environmental change (Ernst et al., 2006; Gabellini, 2009; Sen Gupta et al., 2009; Frontalini and Coccioni, 2011). Furthermore, since they occur in nearly all marine environments and can be quantified in a small amount of sediment, foraminifers are useful bioindicators for sediment polluted by heavy metals, urban sewage, organic waste from aquaculture, and oil spills (Martínez-Colón et al., 2009; Bouchet et al., 2012; Foster et al., 2012).

Effects of Oil Pollution on Foraminifera

Hydrocarbon exposure has been suspected of causing physiological ill effects in foraminifers (e.g., membrane damage, reproduction inhibition, and interference in chamber construction). The population density and diversity are affected by the combination of these ill effects (Morvan et al., 2004). A study by Morvan et al. (2004) found the lowest specimen density and S index on a coastal mudflat in the 9 months immediately after the Erika oil spill; however, a year later the density and S index increased.

Culture studies with varying concentrations of Erika spill oil caused deformities and lower population density at higher oil concentrations. Morvan et al. (2004) noticed deformities in 45% of juveniles and a few adults in treatments with $\geq$5.5 mg per 100 mL of Erika spill oil. Deformities have been noted in other studies to be a possible sign of environmental stress (natural and due to pollution) or mechanical damage (Boltovskoy et al., 1991; Yanko et al., 1999; Polovodova and Schönfeld, 2008). In the study of Morvan et al. (2004), the microcosms with 30 and 72 mg of Erika oil per 100 mL of seawater had no signs of reproduction or growth and all life activity ceased after two months. Further culture studies using Erika spill oil by Ernst et al. (2006) found higher mortality rates in contaminated mesocosms; however, the total number of deformed tests was not significant in their analysis. Unfortunately, it is unclear how to compare oil concentrations/thresholds of Ernst et al. (2006) to those of Morvan et al. (2004) because of differences in methodology. Density declined in all of Ernst's mesocosms—including the control. Nonetheless, the decline was stronger in the oiled mesocosms (Ernst et al., 2006).

Model of Foraminiferal Response to Pollution

Resig (1960) and subsequently others (i.e., Bandy et al., 1964a; Bandy et al. 1964b; Bandy et al., 1965; Alve, 1995) discussed a pollution model based on the effects of point-source contamination in coastal environments. However, the model may be applied to estuarine environments and over broad regions as modified by Brunner et al. (2013). The model (Figure 1) predicts an abiotic center at the source pollution if the pollution is sufficiently toxic, but as pollution declines with distance from the source, a hypertrophic zone will develop. The hypertrophic zone is characterized by low species diversity, high standing stock, high relative frequencies of tolerant species, and, as modified by Brunner et al. (2013), a shallow DOH. Hypertrophy is an indication of an unbalanced food web due in part to reduced predation and competition, thus causing a high abundance of stressed tolerant species (Alve, 1995). Normal levels of these variables return as pollution concentration declines down-gradient to levels below the threshold of foraminiferal impact (Resig, 1960; Alve, 1995). The model can also be applied in time series, where impacted environments go through a gradient from abiotic to normal conditions over a few years (Alve, 1995). Ideally, the effects from the DWH oil spill on the benthic, bathyal biota should follow this pollution model.

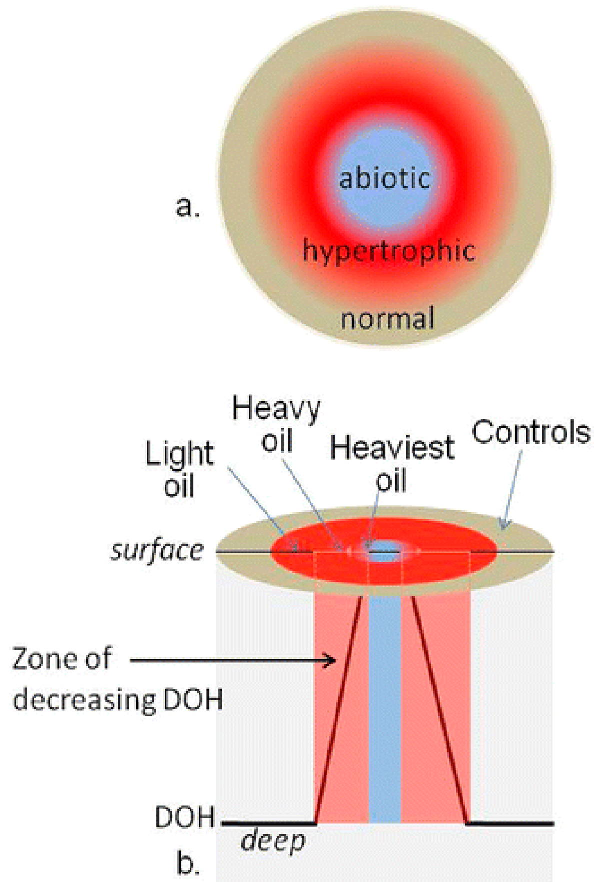


Figure 1. Point-source pollution model. “Models of standing stock in relation to a point source of pollution,” Environmental Science & Technology, volume 47, p. 9121. The top portion (a) is a modification from Resig (1960) and the bottom portion (b) has the depth of habitation (DOH) addition by Brunner et al. (2013). Copyright 2013 American Chemical Society. Reprinted with permission from Brunner et al. (2013). The permission granted is located in Appendix H.

Size Class

The quantitative analysis of benthic Foraminifera is a subject of much debate. More specifically, the size fraction used for analysis varies among researchers. It wasn’t until recently that a standard protocol was initiated for the collection and preparation of foraminifers in bio-monitoring studies (Schönfeld et al., 2012). A sieve size is chosen based on how effectively it will retain an abundant number of specimens in the largest size class possible to facilitate identification. However, a large size class might miss the smaller adult foraminifers as well as juveniles. Conversely, residues that include smaller size classes might contain excess unwanted materials (Schröder et al., 1987). For example, an analysis done by Schröder et al. (1987) demonstrated that use of the >125-μm size fraction resulted in a significant loss of smaller specimens in the 63-125-μm fraction. However, they did not establish if significant numbers of Foraminifera occurred in the size fractions smaller than 63 μm. A study done by Pawlowski (1991) found abundant foraminifers in the size class from 32 to 63 μm, contrary to the suggestion of Schröder et al. (1987) that the >63-μm fraction is the best suited for achieving a better species spectrum. In addition, Kurbjeweit et al. (2000) found high abundance within the 30-125 μm size class, which contributed 20 to 65% of the specimens in their study. Studies wanting to document the entire population of foraminifers, for aspects of pollution or ecological documentation, may use a smaller size fraction (>32 or >45 μm) than paleoceanographic studies, which generally use larger classes (>63 or >150 μm), which are sensitive enough for the application (Schröder et at., 1987; Pawlowski, 1991; Scott et al., 2008). Therefore, using a smaller size fraction (>45 μm, the limit of the available microscope) in the present study to determine oil effects on the foraminifers will provide the benefits of both a greater specimen count and a larger proportion of the total live benthic assemblage, including small adults and juvenile specimens.

Depth of Habitation

The DOH of foraminifers is important to consider because the depth of infaunal specimens can vary between environments and is dependent on factors like abundance and quality of food and predation. Many studies assumed that infaunal foraminifers live only within the top one centimeter of sediment (Parker, 1954; Robinson et al., 2004; Lobegeier and Sen Gupta, 2008). However, the few studies documenting the DOH in the bathyal environment did find the depth of habitation to vary from 5 to 15 cm below the sediment-water interface (e.g, see Gooday, 1986; Corliss and Emerson, 1990; and, and their subsequent publications). The DOH shallows in unfavorable conditions—whether created by natural (Corliss and Emerson, 1990) or man-made pollution (Brunner et al., 2013)—and can be a useful tool as a pollution indicator.

Living Assemblages in the GOM

Numerous studies have documented the benthic assemblages of Foraminifera in the GOM; however, only a few have looked at the live assemblages. The following studies documented density, diversity, and dominance in their investigations in the GOM. The ≥ 74 μm residues from various sites studied by Parker (1954) consisted of 205 species with densities ranging from 1 to 27 individuals/10 cm^3, and the assemblages were dominated by calcareous taxa. Prior to the blowout, a surface sample near the Macondo well head consisted of 94 species in a size range of 63 to 2000 μm with an average density of 24 individuals/10 cm^3, and 60% of the assemblage consisted of agglutinated forms (LeRoy and Hodgkinson, 1975). Surface samples from the northern GOM consisted of 60 species in the ≥ 63 μm residues with densities ranging from 4 to 45 individuals/10 cm^3, and all samples were dominated by agglutinated foraminifers (Bernhard et al., 2008). All studies mentioned analyzed the live assemblages within the 0-3 cm at bathyal depths; however, LeRoy and Hodgkinson (1975) analyzed the total assemblage (live plus dead). The thesis results will be compared to the studies by Parker (1954) and Bernhard et al., (2008) keeping in mind the differences in sampling and processing techniques.

Living Assemblages at Hydrocarbon Seeps of the GOM

Seeps are naturally occurring environments where organisms have adapted to the hydrocarbons, and studies documenting the benthic assemblages present in these environments may enable identification of hydrocarbon-tolerant species. Lobegeier and Sen Gupta (2008) quantified foraminiferal assemblages at hydrocarbon seeps in the GOM and found that the ≥63 μm residue consisted of 183 species and that the density ranged from 0.2 to 174 individuals/10 cm^3. The diversity of calcareous and agglutinated species at non-seep sites was greater than that at seep areas at depths from 245 to 1,081 m, and calcareous taxa dominated nearly all the sites with few exceptions (Lobegeier and Sen Gupta, 2008; Sen Gupta et al., 2009). However, Sen Gupta et al. (2009) documented no apparent difference in the S index between seep and non-seep sites at depths >1,800 m. The Robinson et al. (2004) study found densities ranging from 7 to 17 individuals/10 cm^3, with one outlier of about 100 individuals/10 cm^3 within control and seep sites. The highest values were at the seep sites, in contradiction to Lobegeier and Sen Gupta (2008). The study also found the assemblage consisted of 65 species with a dominance of calcareous forms (Robinson et al., 2004). The highest densities found at seeps were documented by Lobegeier and Sen Gupta (2008) within the GOM but could potentially be higher with the use of a smaller fraction analysis. All of these studies suffered from small sample size, with many samples having <50 live specimens/sample, thus limiting interpretation of density, diversity, and assemblages.

Background Level of [TPAH] in the Bathyal GOM

A few studies have analyzed the [TPAH] in the GOM prior to the DWH oil spill. In order to distinguish the background levels from that of the [TPAH] present due to the spill, the studies by Long and Morgan (1991) and Wade et al. (2008) were used to classify contamination levels into three groups: background, moderate, and high. In their study of lower bathyal and abyssal water depths in the GOM, Wade et al. (2008) found a median [TPAH] of 92 ng/g within the range of non-detectable to 1,033 ng/g, the highest near offshore platforms (all values exclude perylene, which can be produced biogenically). A [TPAH] of 1,000 ng/g (without perylene) will be termed the limit of high background, a conservative choice because all but one value of Wade et al. (2008) is below this concentration (the 85^{th} percentile is ~110 ng/g).

Long and Morgan (1990) determined that biological ill effects can occur in selected macrofauna at [TPAH] as low as 870 ng/g, occur 10% of the time in [TPAH] of 4,000 ng/g (ER-L), and occur 50% of the time in [TPAH] of 35,000 ng/g (ER-M). With this guidance, a concentration > 4,000 ng/g will be termed highly contaminated, and a concentration between 1,000 and 4,000 ng/g will be considered moderately contaminated.

Biofacies

The biofacies characterized by past investigations are important to consider when comparing the assemblages for oil effects. Assemblages of benthic Foraminifera generally vary grossly with water depth, and it would simplify comparisons if all the samples in this study were from the same biofacies. The samples from this study will be compared to biofacies defined by others, including Dignes (1978), Culver and Buzas (1981), Poag (1981), and Sen Gupta et al. (2009). Accommodations will be made if some samples fall into different biofacies.

Replication

The use of replicate samples is fundamental to determination of natural assemblage variation within an environment. However, due to the lack of funding and time constraints, only a few foraminiferal studies have performed replicate analyses and none were in the GOM. According to Gutzmann et al. (2004), true replicates are represented by the use of repetitive deployments, and sediment cores from a single cast are arguably considered “pseudo-replicates” because they may not meet the criterion of random sampling as described by Hurlbert (1984). Gooday and Rathburn (1999) suggest using at least two replicates from a single sampling period in studies documenting temporal processes in order to differentiate spatial and temporal components of population variability, but macrofaunal workers recommend five replicates for diverse populations, like that of bathyal Foraminifera (e.g., Rowe and Kennicutt, 2001). The two to three replicate samples taken at each site by Nozawa et al. (2006) in abyssal depths were quite variable in density with a median of 273 specimens 10 cm^{-2} embraced by $10^{th}/90^{th}$ percentiles of 135/640 specimens 10 cm^{-2} (site 824: 133-362 specimens 10 cm^{-2}, site 827: 184-444 specimens 10 cm^{-2}, and site 838: 137-835 specimens 10 cm^{-2}). A study conducted by Cornelius and Gooday (2004) used two to three cores from different deployments from five stations and found high variability within replicates of three sites with a median of 341 specimens 10 cm^{-2} embraced by $10^{th}/90^{th}$ percentiles of 141/611 specimens 10 cm^{-2} (site 131: 133-623 specimens 10 cm^{-2}, site 132: 304-1090 specimens 10 cm^{-2}, and site 137: 113-449 specimens 10 cm^{-2}). The pseudo-replicate analysis by Bubenshchikova et al. (2008) found similar standing stocks at four of their sites, but all other sites were highly variable with a median of 1005 specimens 50 cm^{-2} embraced by $10^{th}/90^{th}$ percentiles of 256/3125 specimens 50 cm^{-2} (site 108: 3446-3687 specimens 50 cm^{-2}, site 110: 1908-2375 specimens 50 cm^{-2}, and site 112: 1656-1928 specimens 50 cm^{-2}). High natural variability can make it challenging to find significant differences between oiled and un-oiled sites.

Objectives

The goal of the proposed study is to determine what, if any, deleterious effects impact the bathyal benthic foraminifers associated with oil spilled during the DWH event. The main objective is to compare the living benthic assemblages of Foraminifera at oiled and un-oiled bathyal sites near the DWH oil spill. The second objective is to compare samples collected in 2010 to samples in 2011 to determine whether signs of recovery occur with decreased [TPAH] and whether differences and/or similarities exist in community structure (e.g., abundance of opportunistic species), conceivably as a result of decreased [TPAH]. The third objective is to compare three pseudo-replicates from the Obs0 site to determine the magnitude of variability in specimen density, species frequency, and diversity.

The fourth objective is to compare the trends of foraminiferal abundance among sites to the same trends of macrofaunal abundance (Rom et al., 2011; K. B. Briggs, 2012, personal communication). Comparisons of macrofauna with Foraminifera in regards to oil spill response might prove useful in determining if similar trends of increased opportunistic species and decreased densities at heavily oiled sites occur. Reports, such as Mojtahid et al. (2008) and Bandy et al. (1964a and b), documented an increase in abundance of opportunistic species of both macrofauna and Foraminifera near sewage outfalls, although the overall densities of these two groups decreased. Additionally, Foraminifera appear more sensitive to pollution based on a few differences between the two groups (e.g., high abundance of macrofauna near a disposal site whereas foraminiferal abundance was low or absent; Mojtahid et al., 2008).

Hypotheses

H1. The standing stock, S index, diversity, and density (defined in the introduction) of foraminifers will be higher at the uncontaminated sites in comparison to heavily contaminated sites. Additionally, sites with moderate to heavy oil contamination will show signs of a hypertrophic zonation (e.g., shallow DOH and increased densities).

H2. If the communities of Foraminifera follow the point-source pollution model, the depth of habitation will be shallower at the contaminated sites in comparison to the uncontaminated sites.

H3. The heavily oiled site will have different dominant (opportunistic) species than the uncontaminated site.

H4. The contaminated sites will have differences in assemblage structure in comparison to the uncontaminated sites (e.g., low abundance of juveniles and agglutinated species).

H5. If oiled sites show signs of stress in the 2010 samples, then the samples from 2011 will show signs of recovery (e.g., increase in the S index and density comparable to that at unoiled sites).

H6. The variability between the three pseudo-replicates from the Obs0 site will be less than the variability between oiled and un-oiled samples.

CHAPTER II

METHODOLOGY

Coring and Sampling

Sediment Collection and Sample Preparation

Samples were collected onboard the R/V *Cape Hatteras* in October 2010 and 2011 in the northern Gulf of Mexico (Figure 2). Seven sites were chosen from bathyal depths, at what was presumed to be the same foraminiferal biofacies. The sites were categorized based on the three groups of [TPAH] as classified based on results from Long and Morgan (1991) and Wade et al. (2008): un-oiled (< 1,000 ng/g), moderately oiled (< 4,000 ng/g), and heavily oiled (> 4,000 ng/g). Samples were placed within one of the three concentration groups based on the TPAHs interpreted by Dr. Patrick Louchouarn. An additional site was sampled in 2012 onboard the R/V *Pelican* to collect pseudo-replicates, replicates from the same cast spaced in a non-random manner. Sediment samples were collected with a multicoring device (Ocean Instruments MC800), which takes eight pseudo-replicate cores with diameters of 9.5 cm. Sediment core descriptions and photographs were processed by Jennifer Brizzolara and Franklin Williams for each of the collected samples.

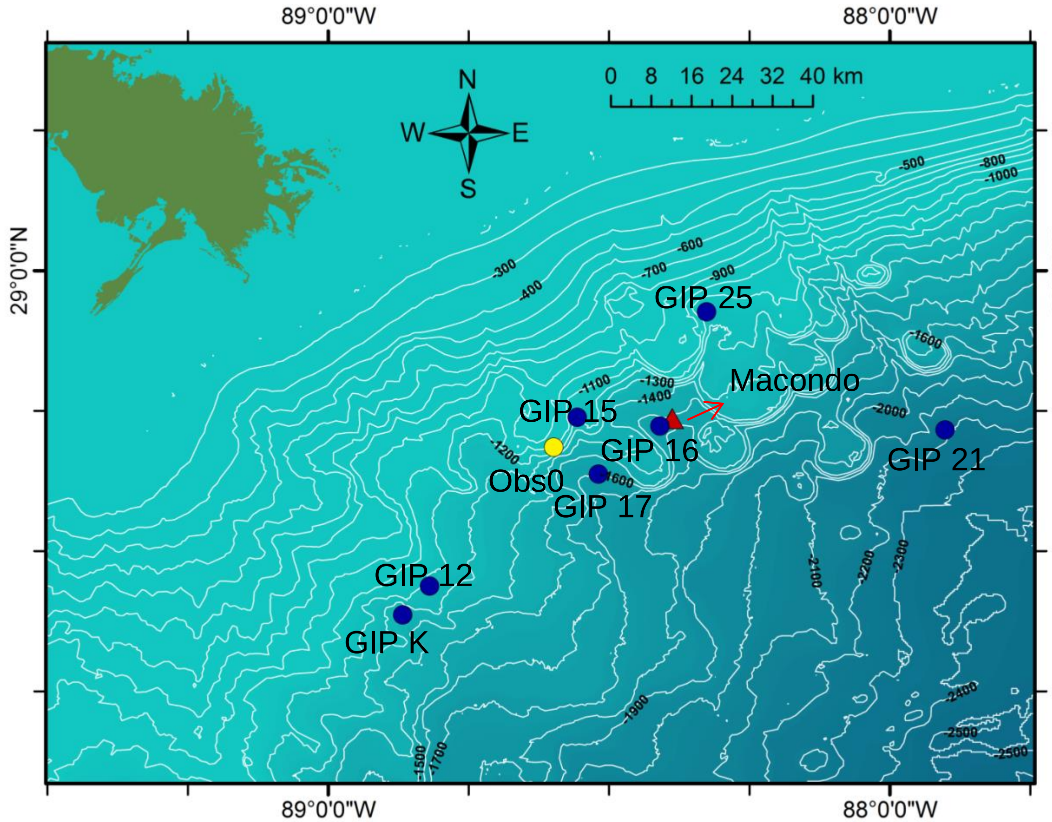


Figure 2. Site locations for this study in the northern Gulf of Mexico. Blue circles indicate GIP sites collected in 2010 and/or 2011. The yellow circle corresponds to the Obs0 site where pseudo-replicates were collected in 2012. The red triangle shows the location of the Macondo wellhead.

Each core tube was extruded into a clean plastic tube and refrigerated until further processing, usually within 24 hours. The top 10 cm of each sediment core was sliced at 1-cm intervals. The sliced samples were placed into museum bottles containing 100 mL of a solution of 0.5 g/L rose Bengal in filtered seawater buffered with sodium borate. The volume of the sample was measured to ± 3mL by displacement of the solution. The samples were stirred vigorously to disaggregate the sediment and to thoroughly mix it with the stain solution. The sample solutions were refrigerated for at least 24 hours to allow sufficient time for staining of the live specimens. Following the 24-hour soaking period, the samples were washed through a sieve with 45 μm openings. The ≥45 μm residue was refrigerated in a solution containing 5 mL of the buffered rose Bengal solution in addition to 10 mL of isopropyl alcohol as a preservative.

Rose Bengal was chosen as the stain for analyzing live specimens. Walton (1952) suggested the use of rose Bengal stain to identify live specimens. Bernhard (1988), Murray and Bowser (2000), and Bernhard (2000) found false positives in specimens that died recently from disease or adverse environmental changes. Bernhard (2000) suggested using rose Bengal in combination with a more accurate secondary analysis (i.e., fluorescence spectroscopy), all of which are suited to assessing a few specimens, not large numbers. The strategy has proven impractical and has not been adopted. Instead, knowing that the stain tends to overestimate the number of live specimens, workers (e.g., Saffert and Thomas, 1998) have devised stringent criteria for accepting a specimen as live, hence reducing the number of false positives. The protocol is described below. It is suggested that live specimens reported herein should be viewed as including both live and some recently dead specimens.

Stained specimens are considered live or recently dead if the cytoplasm is stained throughout the test with a deep and even pink shade, if the first several whorls or initial chambers (depending on species morphology) are deeply stained, or if the last chambers are filled by deep pink cytoplasm with unstained cytoplasm visible in the earlier chambers. Specimens with discontinuous, patchy, and/or light stain are not considered as live specimens (Corliss and

Emerson, 1990; Sen Gupta et al., 2009). The staining quality of all specimens was assessed while wet in the Petri dish and prior to drying.

Sample Splitting and Specimen Identification

The prepared samples from the top 1-cm interval from each of the eight sites were split in a settling-type, wet splitter modified from the design of Scott and Hermelin (1993). Samples were split to a size convenient to spread on a gridded Petri dish and suspended in buffered tap water to inhibit carbonate dissolution. Entire aliquots were picked until 300 or more stained foraminifera were accumulated. The picked specimens were mounted on a photographic-style, micropaleontological slide containing 60-squares for identification and storage. Selected specimens were photographed with an Olympus Microfire color digital camera mounted on an Olympus SZX16 microscope that has a maximum magnification of 115x.

Cores from two of the eight sites, one with the lowest [TPAH] and one with the highest [TPAH], were sampled below the first centimeter depth in the sediment. In these cores, slices were picked downcore until 95% of the living assemblage was accumulated (Corliss and Emerson, 1990). The top centimeter of additional sites was analyzed.

Assignments to genera and higher taxonomic classes follow Loeblich and Tappan (1987). Specimen identification was done with reference to the original descriptions available from the online Catalogue of Foraminifera (Ellis and Messina, 1941—available at http://www.micropress.org/). In addition, images and taxonomic notes that have proved useful include those of Bernhard et al.

(2008), Denne and Sen Gupta (1989, 1991, and 2003), LeRoy and Hodgkinson (1975), Lobegeier and Sen Gupta (2008), Loeblich and Tappan (1998), Parker (1954), Phleger (1954), and Sen Gupta et al. (2009). Identifications—of the nearly 300 species—were made to the lowest possible taxonomic level. Unidentified specimens were compared to type material in the Barun Sen Gupta Collection at Louisiana State University. For specimens unidentifiable through additional sources, temporary names (sp. A, sp. B, etc.) were assigned and consistently applied throughout all samples.

Data Calculations and Analyses

Density, diversity, standing stock, depth of habitation (DOH), and relative frequencies of species, orders, and juvenile specimens were calculated for each site. Specimens were considered juveniles if they consisted of either half the number of chambers compared to their adult stage or a single whorl compared to three whorls in the adult based on its original description or published taxonomic notes. Due to the lack of replicates at all but one site, statistical analyses for significant differences were not possible.

The three pseudo-replicates from the Obs-0 site were compared to determine the magnitude of variability in densities and taxa content. Percentiles (25^{th}, 50^{th}, and 75^{th}) were calculated for density to determine the magnitude of variability among the pseudo-replicates and to all other surface samples.

Density was calculated for each sample using the equation

$$\text{Density} = T*(6^{s})*(10)/ (P*V).$$

T is the number of specimens counted, *s* is the number of times the sample was split, *P* is the number of pans counted, *V* is the sample volume (cm^3) measured by displacement, the constant, 6, is the number of aliquots in the splitter device and 10 is the volume (cm^3) to which the density is commonly standardized in foraminiferal work. The standing stock for GIP 15 and GIP 25 was calculated by summing all densities within the DOH. The relative frequency for each species present per sample was calculated by dividing the total number of specimens by the total number of individuals of the *i*th species and multiplying by 100.

The following diversity indices were calculated for each sample: Shannon-Wiener diversity (*H'*), Simpson diversity (*D*), Pielou (*J'*), and the number of species (S). *H'* is $-\Sigma p_i \ln p_i$, where p_i is the number of individuals of the *i*th species divided by the total number of specimens within a sample (Denoyelle et al., 2010; Panieri et al., 2012; Shannon, 1948). *D* is $\Sigma [n_i*(n_i-1)/(N*(N-1)]$, where n_i is the total number of individuals of the *i*th species and *N* is the total number of specimens within a sample (Panieri et al., 2012; Simpson, 1949). A sample is more diverse if the *H'* index is high; however, the opposite is true for the *D* index, which is a measure of dominance (Denoyelle et al., 2010; Panieri et al., 2012). The *J*' index is ($H'/(\ln S)$; Hill, 1973). A sample is considered equitably distributed in its species frequencies (without any dominant species) if *J'* equals one (Hayek and Buzas, 1997). Species richness (SR) and Simpson diversity index (1-D) were also calculated for each of the samples in order to compare the Foraminifera and macrofauna. SR is ($(S-1)/\ln N$; Narayan and Pandolfi, 2010). These simplifying measures are particularly useful for comparison of samples because of the great diversity in the samples.

Hierarchical cluster analyses, similar to analyses done by Culver and Buzas (1983), Denne and Sen Gupta (2003), Lagoe (1979), and Mello and Buzas (1968), were performed to evaluate the biofacies within the study locations, and compare the results to previously documented biofacies within the GOM. All hierarchical cluster analyses were performed using IBM SPSS statistical software on the Bray-Curtis similarity index estimated from the specimen counts. The cluster analyses were based on between-groups linkage. Two types of cluster analyses were performed—Q-mode (samples) and R-mode (species)—for all surface samples from both years with the addition of the three pseudo-replicate samples (Lagoe, 1979). A Q-mode cluster analysis was also performed on all downcore samples from GIP 15 and 25.

Metric multidimensional scaling (MDS) was used to compare samples from both collection years and determine any relationships with the physical variables. MDS is a type of multivariate technique that displays interrelationships among samples by determining the linear distances between samples in Bray-Curtis coefficient space; it is well suited for a variety of data (Bartholomew et al., 2008). Analyses of MDS were performed using SPSS with the Bray-Curtis similarity index. Proximity distances were created under PROXSCAL using Euclidean distance and interval proximity transformation. The number of axes that represent the data was chosen by reviewing the scree plot (normalized raw stress plotted against dimensionality) and locating the “elbow.” The “elbow” is the location on the scree plot where dimensionality is no longer or only slightly affected by stress (Bartholomew et al., 2008). Interpretation of each axis was done in OriginLab by plotting bivariate plots of each MDS axis against the following variables: water depth, specimen density, latitude, longitude, [TPAH], distance to the oil footprint of Montagna et al. (2013), and taxa frequencies. Variables with R^2 values of > 0.40 were chosen as the best representation of the MDS axes based on the lowest occurring R^2 value in the data.

CHAPTER III

RESULTS

Physical Variables

Concentrations of Total Polycyclic Aromatic Hydrocarbons

Samples collected in 2010 through 2012 were collected within bathyal depths and vary in their [TPAH] (Table 1). The water depths for the eight sites ranged from 1,135 to 2,180 m, the deepest site being GIP 21. The sites vary in distance from 0 to 50 km from the moderately contaminated footprint documented in Montagna et al. (2013); GIP K is the study location most distal to the footprint. The [TPAH] from both collection years ranged from 29 to 7,553 ng/g in the surface samples. Samples collected in 2010 are placed into three groups based on [TPAH]: GIP 12, 21, and 25 are considered un-oiled with concentrations below a high background of <1,000 ng/g; GIP 16 and 17 are considered a moderately-oiled group; and only one site, GIP 15, is considered heavily-oiled with a [TPAH] >4,000 ng/g. GIP K serves as the 2011 proxy for GIP 12 because it is nearby (8 km distant), and somewhat similar in depth (1349 m and 1210 m, respectively). All samples collected in 2011 are within background levels, including the sites that were contaminated in 2010. The biomarkers analyzed by GERG and interpreted by Dr. Louchouarn confirm that the Macondo well is the likely source of oil.

Table 1

Physical Variables of GIP and Obs Sites

Site	Depth (m)	Latitude	Longitude	2010 TPAH	2011 TPAH	Oil Footprint (km)
GIP 12	1210	28°26.275' N	88°49.166' W	272	X	40.8
GIP 15*	1207	28°44.315' N	88°33.390' W	7553	368	13.4
GIP 16	1560	28°43.383' N	88°24.577' W	2512	450	0
GIP 17	1595	28°38.237' N	88°31.128' W	3077	NA	4.3
GIP 21	2180	28°42.960' N	87°54.086' W	169	367	43.9
GIP 25*	1160	28°55.602' N	88°19.579' W	73	261	15.2
GIP K	1349	28°41.110' N	88°35.932' W	X	318	47.9
Obs0	1135	28°41.110' N	88°35.932' W	X	29	13.6

Note. The table shows all GIP sites used herein and their corresponding water depths, latitude, longitude, [TPAH] for collection years 2010 and 2011, and distances to the moderately contaminated footprint from Montagna's et al. (2013) study. Sites marked by * were counted in 1-cm intervals with increasing depth in sediment until 95% of the living assemblage was accumulated. For all others, only the top 1-cm was counted. Obs0 pertains to the site where pseudo-replicate samples were taken in the summer of 2012.

Sediment-Surface Descriptions

All GIP surface samples have a muddy texture with some variability in foraminiferal sand content, burrowing, and hue. All surface samples are either yellowish red (10YR) or yellowish (2.5Y) in hue with value/chroma of 3/3, with one exception, GIP 16 (2010), which was 4/3 in value/chroma. Several samples contain noticeable, though sparse, sand-size material [foraminifera; GIP 12, 15, 16 (2011), 17, 25 (2011), and Obs0] and the others appear sand-free. Two surface samples have distinct burrow structures [GIP 15 (2011) and 17 (2010)].

Sediment-Core Descriptions

The surface layer at GIP 25 and 15 are different in hue from the rest of the downcore sediment (Appendix G). The surface layers at GIP 25 and 15 for both years are either yellowish red (10YR) or yellow (2.5Y) in hue with a dark, grayish value/chroma of 3/3 and have sparse foraminiferal sands, except GIP 25 (2011), which appears sand-free. In contrast, the subsurface sediment is mainly olive yellow (5Y) in hue with value/chroma ranging from dark olive to medium grayish olive (3/2, 4/2, 4/3, or 5/2). Two intervals in GIP 15 (2010: 7-to-10 cm) and GIP 25 (2011: 1.5-to-2 cm) have a yellowish (2.5Y) hue with value/chroma of 3/2 and 4/2, respectively.

Both sites have a muddy texture with some similar features in the subsurface sediment, with a few differences between years. The 1-to-10-cm interval of each core contains sparse foraminiferal sand, except GIP 15 (2011). Several dark spots, possibly pyrite precursor minerals, are scattered throughout the two GIP 25 cores. Distinct burrow structures mark both GIP 25 cores (2010:

3 cm; 2011: 2, 4, and 10 cm) and one large burrow-like structure from the surface to 6 cm and several smaller burrows distinguish the 2011 core of GIP 15. A few pockets of fecal pellets are scattered throughout all four GIP 25 and 15 cores.

Foraminiferal Density

Surface Samples

The median of specimen density (specimens/10 cm^3) among the surface samples are apparently different between years with a median of 565 embraced by 25^{th} and 75^{th} percentiles of 465 and 798 in 2010, a median of 729 embraced by 25^{th} and 75^{th} percentiles of 711 and 755 from 2011, and a median of 1,050 embraced by 25^{th} and 75^{th} percentiles of 890 and 1,276 for the pseudo-replicates (Figure 3, Tables 2 and 3). The foraminiferal density in the 2010 surface samples ranges between 382 and 2,172 specimens/10 cm^3 (Figure 4). The density in the heavily oiled site, GIP 15, is three to six times greater than that of any other surface sample in 2010. However, no visible trend in specimen density can be seen with increasing [TPAH] from the background to moderately oiled groups. The 2011 samples have [TPAH]s that are within background levels and have a density between 638 and 1,230 specimens/10 cm^3, with the maximum density occurring at GIP 15 (Figure 5). The three pseudo-replicates range in density from 890 to 1,276 specimens/10 cm^3 (Figure 6). The variability between background and moderately oiled groups from 2010 and all surface samples from 2011 diminishes if the sample from GIP 15 (2010) is removed.

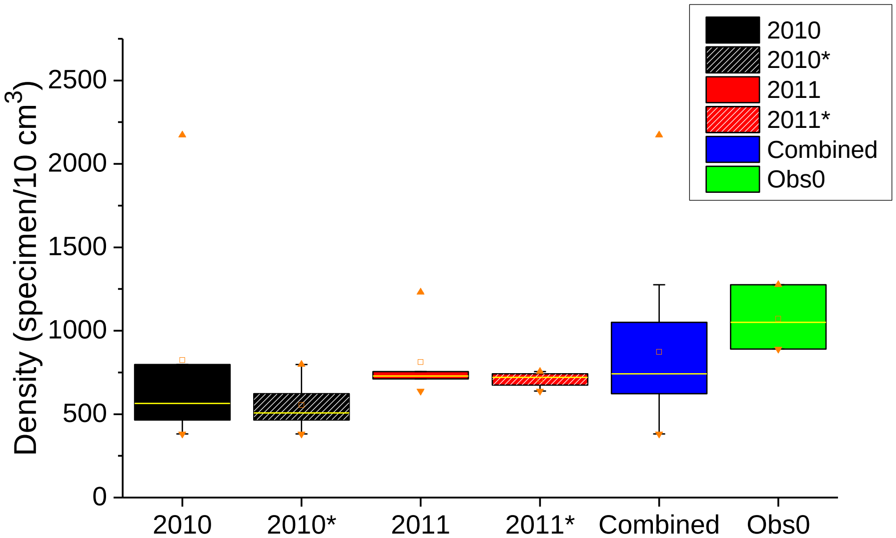


Figure 3. Whisker plot of specimen density versus sites. The * in the legend and x-axis indicates removal of GIP 15. The top and bottom of the colored boxes are the 25th and 75th percentiles. The yellow line, open orange box, and filled orange triangle indicate median, mean, and1st/99th percentiles, respectively. The capped, vertical bars extending from the boxes indicate maximum and minimum values. The 2010 and 2011 groups contain six and five surface samples, respectively. The combined group contains a total 14 surface samples. The Obs0 group contains three pseudo-replicates.

Table 2

Specimen Densities of All Surface Samples

Sample	Density (specimens/ 10 cm^3)
GIP 12_10	622
GIP 15_10	2172
GIP 16_10	798
GIP 17_10	382
GIP 21_10	465

Table 2 (continued).

Sample	Density (specimens/ 10 cm^3)
GIP 25_10	507
GIP K_11	755
GIP 15_11	1230
GIP 16_11	638
GIP 17_11	729
GIP 25_11	711
Obs0a_12	1050
Obs0b_12	1276
Obs0c_12	890

Note. Samples from 2010, 2011, and 2012 are indicated by "_10," "_11," and "_12," respectively.

Table 3

Measures of Central Tendency for Specimen Density

Group	Median	25%
Surface Samples (2010)	565	465
Surface Samples (2011)	729	711
Pseudo-Replicates (Obs0)	1050	890
GIP 25's Downcore (2010)	263	229
GIP 25's Downcore (2011)	290	276
GIP 15's Downcore (2010)	436	118

Note. Medians and percentiles are in units of specimens/ 10 cm^3.

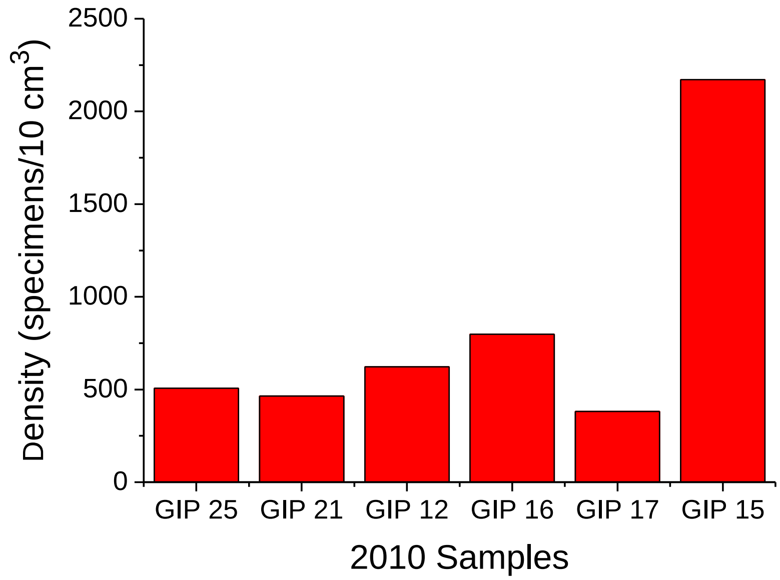


Figure 4. Specimen density of surface samples from 2010. The samples are ordered from left to right by increasing [TPAH].

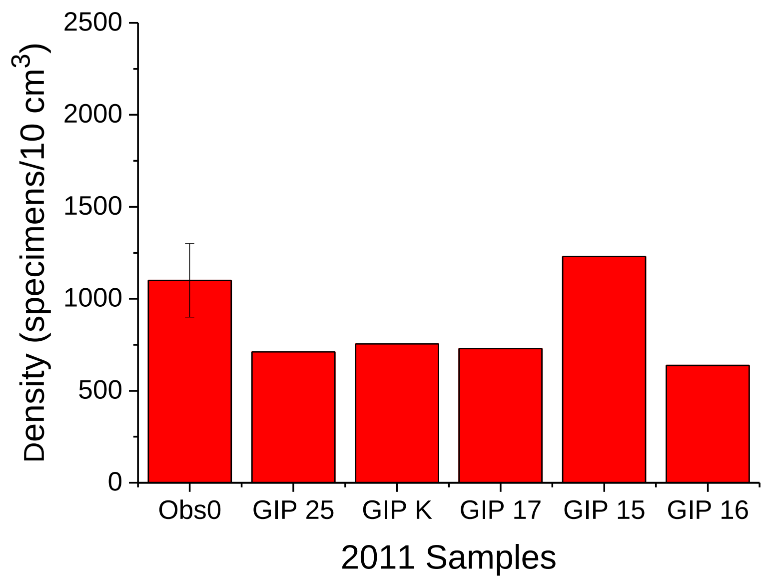


Figure 5. Specimen density of surface samples from 2011. All samples have [TPAH] <1,000 ng/g (background concentrations) and are ordered *from left to right by increasing [TPAH].*

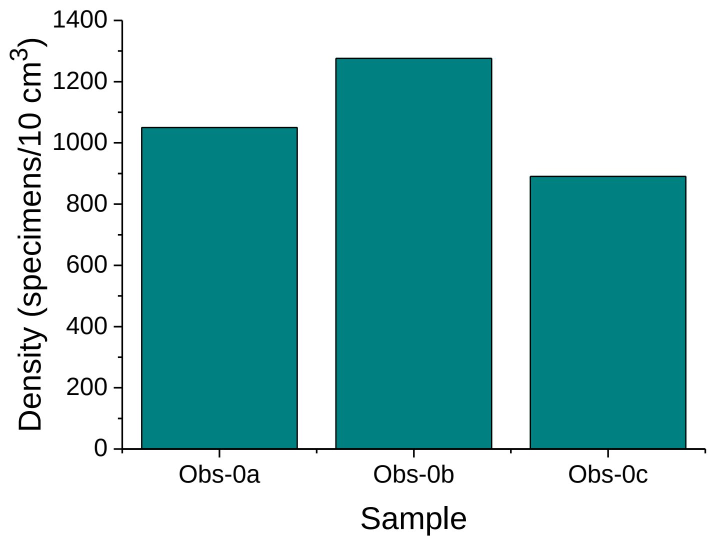


Figure 6. Specimen density of the three pseudo-replicates. All three samples were collected in the summer of 2012 and have a [TPAH] of 29 ng/g (background concentration).

Cores (GIP 25 versus GIP 15)

The median of specimen density (specimens/10 cm^3) among the downcore samples at GIP 25 are similar between years with a median of 263 embraced by 25^{th} and 75^{th} percentiles of 229 and 311 in 2010 and a median of 290 embraced by 25^{th} and 75^{th} percentiles of 276 and 578 in 2011 (Tables 3 and 4). The downcore density remains relatively constant from the surface to 10 cm with a relative minimum near 5 cm. The density in 2010 decreased from 507 specimens/10 cm^3 at the surface to 129 specimens/10 cm^3 at 5 cm (Figure 7), then increased to 323 specimens/10 cm^3 at 8 cm, and decreased again to 233 specimens/10 cm^3 at 10 cm. Density in the 2011 core has a similar trend (Figure 8). The density decreased from 711 to 165 specimens/10 cm^3 from the surface to 5 cm, then increased to 627 specimens/10 cm^3 by 10 cm depth in core.

Table 4

Specimen Densities of GIP 25's Downcore Samples

Sample	Density (specimens/ 10 cm^3)
GIP 25_10 (0-1 cm)	507
GIP 25_10 (1-2 cm)	252
GIP 25_10 (2-3 cm)	229
GIP 25_10 (3-4 cm)	141
GIP 25_10 (4-5 cm)	129
GIP 25_10 (5-6 cm)	274
GIP 25_10 (6-7 cm)	311
GIP 25_10 (7-8 cm)	323
GIP 25_10 (8-9 cm)	278
GIP 25_10 (9-10 cm)	233
GIP 25_11 (0-1 cm)	711
GIP 25_11 (1-2 cm)	300
GIP 25_11 (2-3 cm)	281
GIP 25_11 (3-4 cm)	233
GIP 25_11 (4-5 cm)	165
GIP 25_11 (5-6 cm)	279
GIP 25_11 (6-7 cm)	276
GIP 25_11 (7-8 cm)	453
GIP 25_11 (8-9 cm)	578
GIP 25_11 (9-10 cm)	627

Note. Samples from 2010 and 2011 are indicated by "_10," and "_11," respectively.

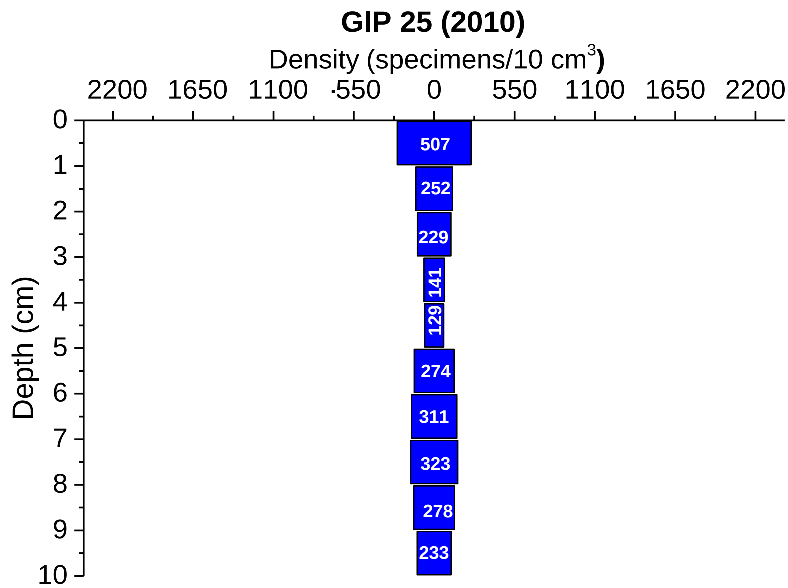


Figure 7. Specimen density for downcore samples at GIP 25 (2010). Values in white indicate density at each depth interval.

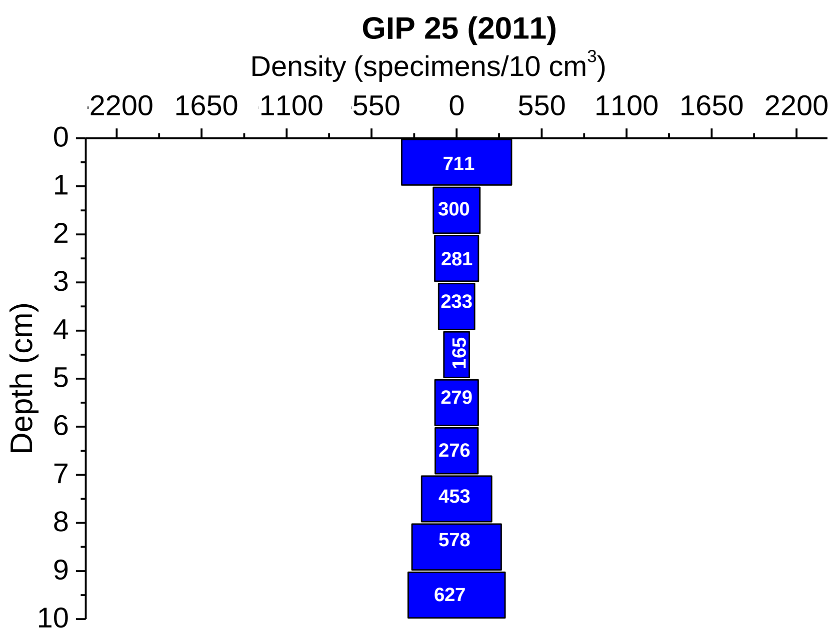


Figure 8. Specimen density for downcore samples at GIP 25 (2011). Values in white indicate density at each depth interval.

The depth of habitation exceeds 10 cm for both collection years at GIP 25 (Table 5). The last depth interval at GIP 25 has only 91 and 84% of the living assemblage for both collection years. The standing stock in 2010 was lower (2,675 specimens/10 cm^3) than that in 2011 (3,903 specimens/10 cm^3).

Table 5

Downcore DOH, Living Percentage, and Standing Stock

Site (Year)	Standing Stock (specimens/ 10 cm^2)	Depth of Habitation (cm)	Live Percentage
GIP 15 (2010)H	GIP 15 (2010)H	GIP 15 (2010)H	GIP 15 (2010)H
GIP 15 (2011)H	GIP 15 (2011)H	GIP 15 (2011)H	GIP 15 (2011)H
GIP 25 (2010)C	GIP 25 (2010)C	GIP 25 (2010)C	GIP 25 (2010)C
GIP 25 (2011)C	GIP 25 (2011)C	GIP 25 (2011)C	GIP 25 (2011)C

Note. H = heavily oiled; C = control. $^+$ indicates that the depth of habitation is deeper than 10 cm.

The median of specimen density (specimens/10 cm^3) among the downcore samples at GIP 15 is somewhat similar between years with a median of 436 embraced by 25th and 75th percentiles of 118 and 1,066 in 2010 and a median of 500 embraced by 25th and 75th percentiles of 223 and 1,027 in 2011 (Tables 3 and 6). In contrast to the GIP 25 cores, the density decreases rapidly with increasing depth. Specimen density in the 2010 core from GIP 15 decreases exponentially downcore from 2,172 specimens/10 cm^3 at the surface to 90 specimens/10 cm^3 at 6 cm (Figure 9). The decline in density in the 2011 core is more gradual, decreasing from 1,230 specimens/10 cm^3 at the surface to 161 specimens/10 cm^3 at 6 cm. The density in the surface of the 2010 core is nearly two times greater than that in the 2011 core (Figure 10). No density minimum occurs at GIP 15, as with the cores at GIP 25.

Table 6

Specimen Densities of GIP 15's Downcore Samples

Sample	Density (specimens/ 10 cm^3)
GIP 15_10 (0-1 cm)	2172
GIP 15_10 (1-2 cm)	1066
GIP 15_10 (2-3 cm)	609
GIP 15_10 (3-4 cm)	202
GIP 15_10 (4-5 cm)	118
GIP 15_10 (5-6 cm)	90
GIP 15_11 (0-1 cm)	1230
GIP 15_11 (1-2 cm)	1027
GIP 15_11 (2-3 cm)	619
GIP 15_11 (3-4 cm)	381
GIP 15_11 (4-5 cm)	223
GIP 15_11 (5-6 cm)	161

Note. Samples from 2010 and 2011 are indicated by "_10," and "_11," respectively.

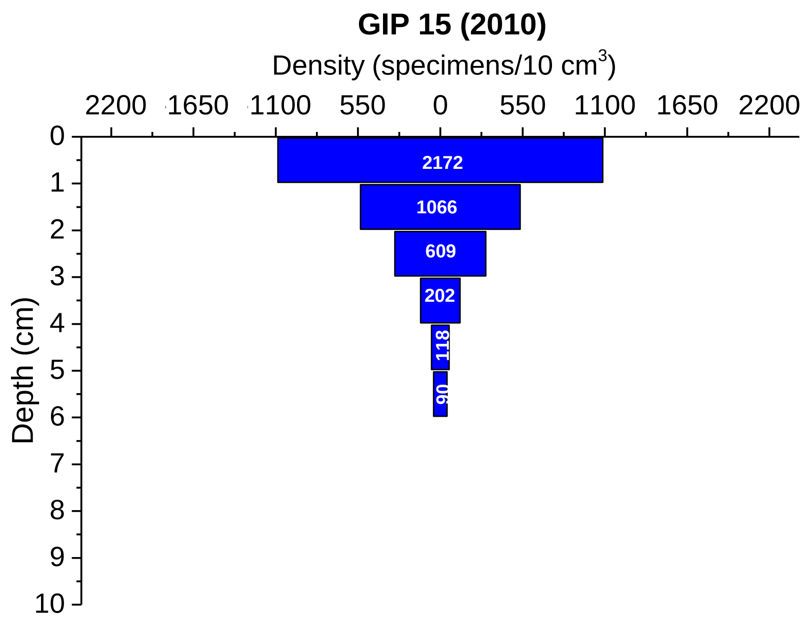


Figure 9. Specimen density for downcore samples at GIP 15 (2010). Values in white indicate density at each depth interval.

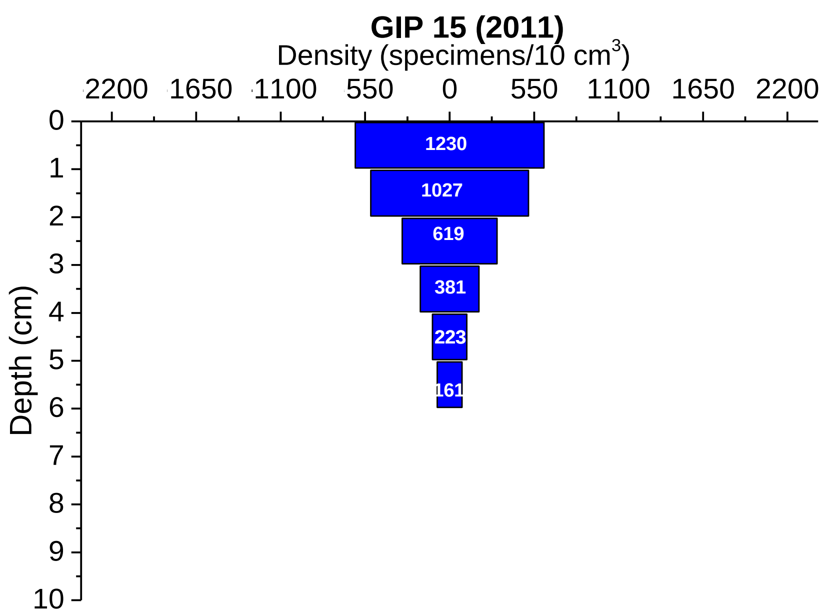


Figure 10. Specimen density for downcore samples at GIP 15 (2011). Values in white indicate density at each depth interval.

The depth of habitation at GIP 15 extends to only 6 cm for both collection years (Table 5). By the 5–to-6-cm interval, 98% and 96% of the living assemblage was accumulated in the 2010 and 2011 cores, respectively. The standing stock at GIP 15 in 2010 is much higher (4,318 specimens/10 cm^3) than in 2011 (3,642 specimens/10 cm^3).

The downcore samples from both collection years at GIP 25—an un-oiled site—and GIP 15—the most heavily oiled site—vary in density, standing stock, and depth of habitation. The surface sample at GIP 15 is four and two times greater than that at GIP 25 in 2010 and 2011, respectively. The downcore samples at GIP 25 show the least variability between collection years. The variability between collection years at GIP 15 is much higher than at GIP 25. In 2010, the standing stock at GIP 15 is nearly twice that of GIP 25. In 2011, however, the standing stock for GIP 15 and 25 is more similar than in the prior year. The depth of habitation remains at >10 cm at GIP 25 and at 6 cm at GIP 15 during both years.

Foraminiferal Assemblage

General Information

A total of 284 species from six suborders was documented from the eight study sites (Appendices A to D). Two suborders, Rotaliina and Textulariina, dominated all 42 samples with relative frequencies ranging from 17 to 83%. The rest of the assemblage consisted of the suborders Lagenina, Miliolina, and Robertinina, with relative frequencies ranging from 3 to 18%. A sixth suborder, Spirillinina, was documented in only one sample, GIP 25 (5-6 cm), from the 2011 collection. Twenty-six species comprise >5% of the assemblage in at least one sample (Appendix E). Photographs were taken of the 15 species with relative frequencies of >10% in a least one sample (Appendix F).

Suborders

Surface samples. A total of five suborders were encountered in the surface samples from all collection years; however, their distributions vary by site and year. Textulariina dominated all three pseudo-replicates followed by the suborder, Rotaliina (Figure 11). One of the pseudo-replicates (Obs0a) did not have any species from the suborder, Robertinina. Textulariina is most abundant or equal to the abundance of Rotaliina in four surface samples in both years (2010: GIP 16, 17, 21, and 25; 2011: GIP 15, 16, 17, and K; Figures 12 and 13). Although no clear trend can be seen in suborders with increasing [TPAH], GIP 15 and 17 show fewer Miliolina in 2010 than in 2011. Furthermore, no species from Lagenina or Robertinina were documented at GIP 15 from 2010, and Lagenina replaced the suborder, Miliolina in 2011. GIP 15 in 2010 contained the highest percentage of Rotaliina species of any other surface sample from either year.

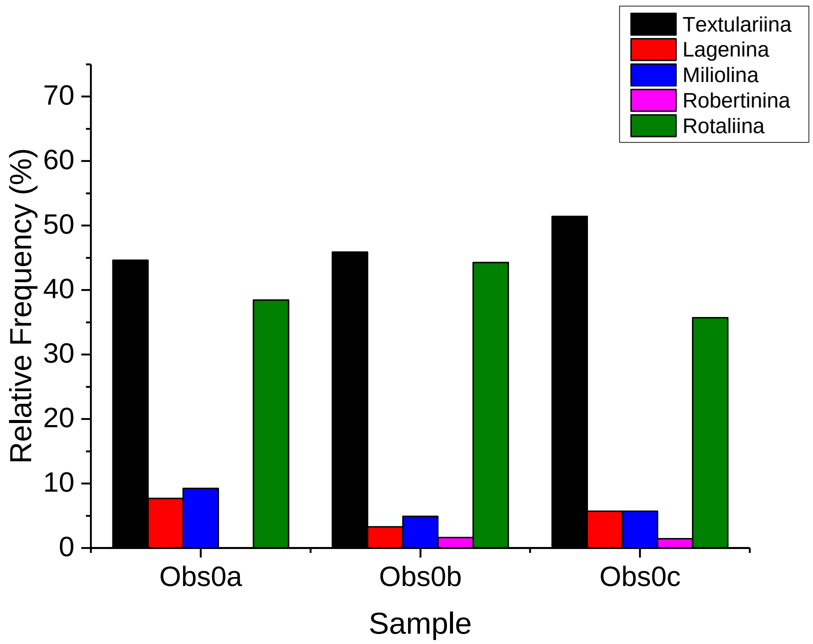


Figure 11. Relative frequency of suborders from Obs0. The Obs0a sample did not contain any species from the suborder, Robertinina.

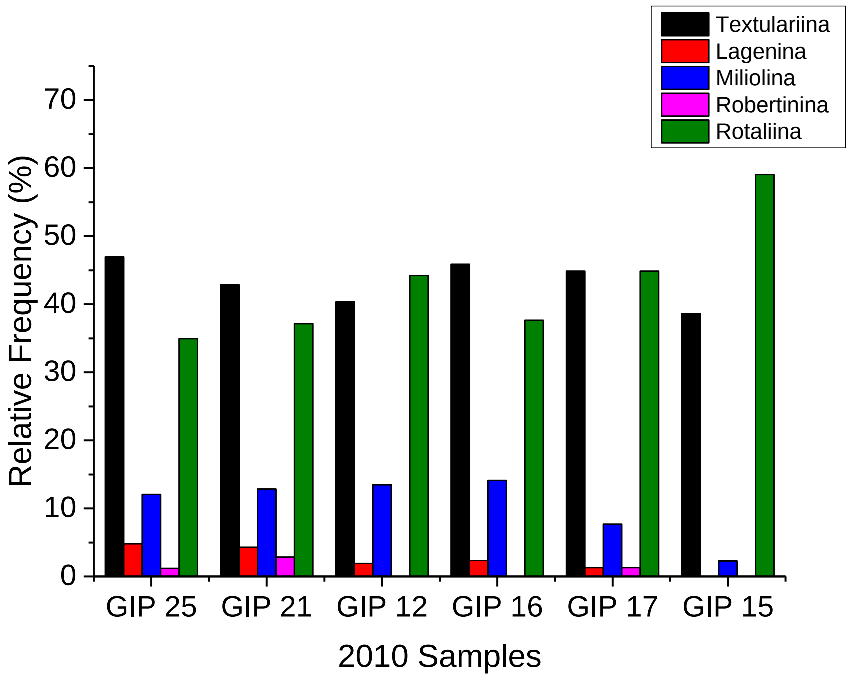


Figure 12. Relative frequency of suborders from 2010 surface samples. Surface samples are ordered by increasing [TPAH] from left to right. GIP 12 and 16 did not contain any species from the suborder, Robertinina. *GIP 15 did not contain any species from the suborders, Lagenina or Robertinina.*

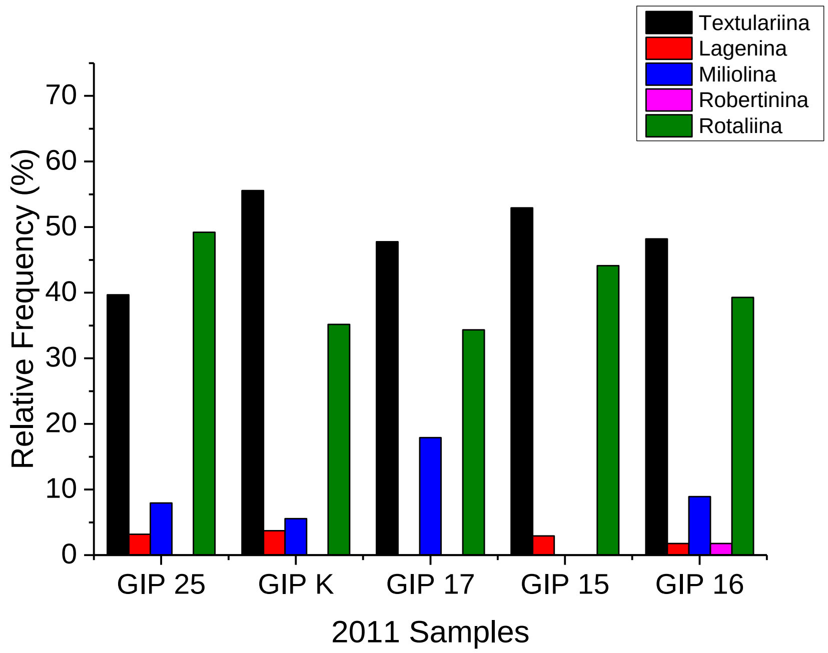


Figure 13. Relative frequency of suborders from 2011 surface samples. All samples have [TPAH] <1,000 ng/g (background concentrations) and are ordered by increasing [TPAH] from left to right. GIP 25, K, 17, and 15 do not contain any species from the suborder, Robertinina. GIP 17 does not contain any species from the suborder Lagenina. GIP 15 does not contain any species from the suborder, Miliolina.

Cores (GIP 25 versus GIP 15)

The assemblage at the control site (GIP 25) for both years mainly consists of the suborders Rotaliina and Textulariina (Figures 14 and 15). The main constituent of all downcore samples from both years is Rotaliina, except in the case of the 2010 surface sample where Textulariina has a greater percentage. The rest of the assemblage for both years at GIP 25 consists of Miliolina and Lagenina, and one species each in the suborders Robertinina and Spirillinina in 2010 and 2011, respectively.

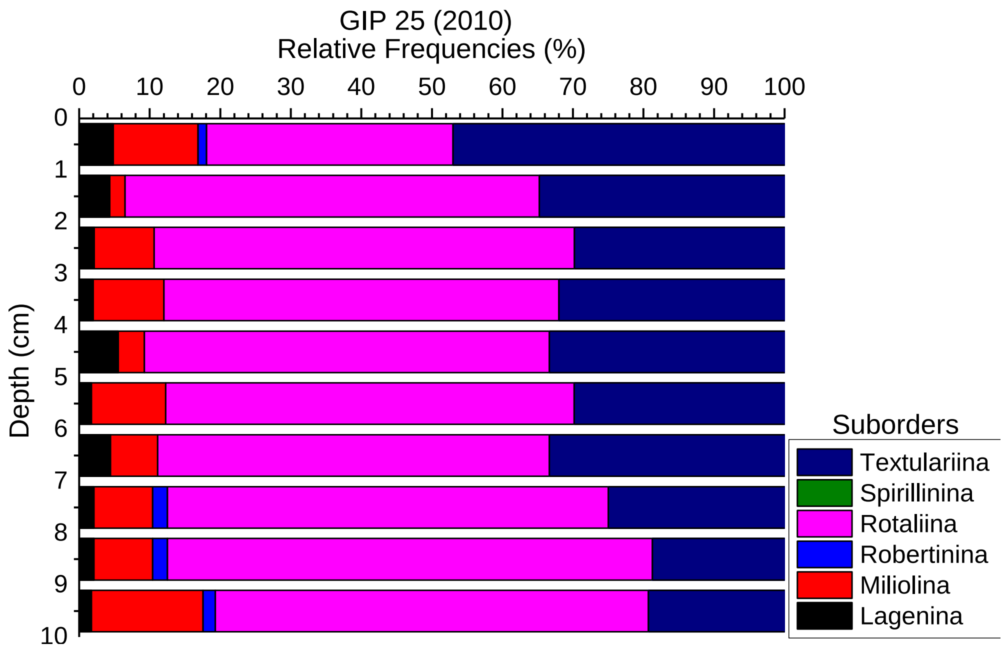


Figure 14. Relative frequency of suborders from GIP 25 downcore samples (2010). None of the downcore samples contain any species from the suborder, Spirillinina. The 1-to-7-cm interval does not contain any species from the suborder, Robertinina.

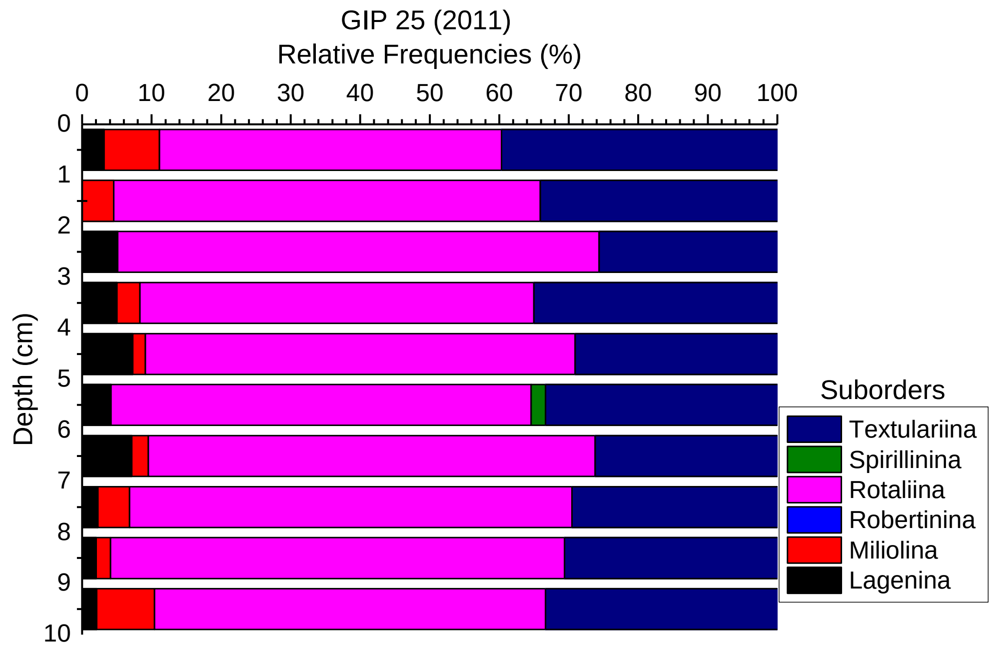


Figure 15. Relative frequency of suborders from GIP 25 downcore samples (2011). None of the downcore samples contain any species from the suborder, Robertinina. The 5-to-6-cm interval is the only downcore sample with the suborder, Spirillinina.

The suborder Rotaliina exceeds Textulariina in the assemblage at the heavily oiled site (GIP 15) for both years except for the 0-to-2-cm interval of the 2011 core, where Textulariina has greater percentages (Figures 16 and 17). The two minor constituents of the assemblage at GIP 15 are Lagenina and Miliolina for 2010 and Lagenina in four samples in 2011. The suborder Miliolina occurs in only one subsurface sample (1 to 2 cm) in the 2011 core.

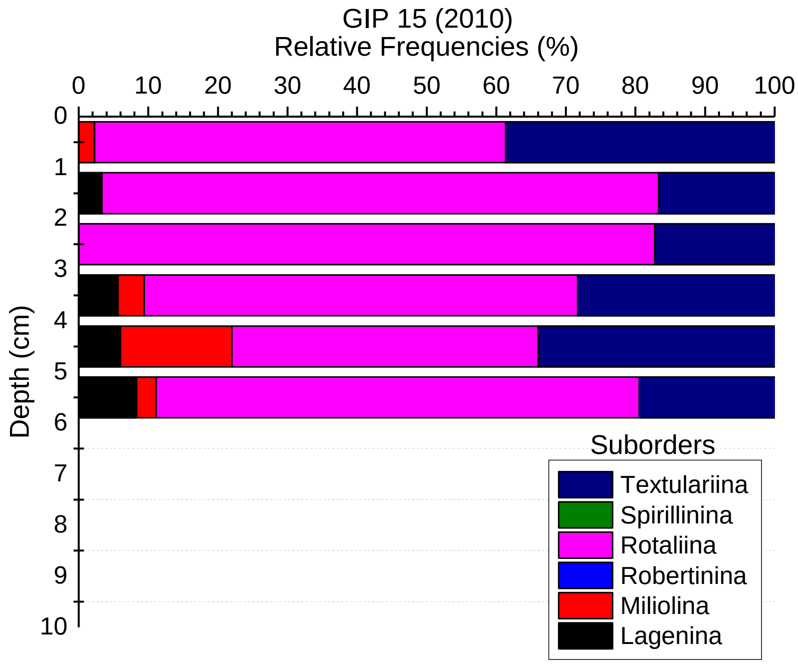


Figure 16. Relative frequency of suborders from GIP 15 downcore samples (2010). None of the downcore samples contain any species from the suborders, Robertinina or Spirillinina. The 0-to1-cm and 2-to-3-cm intervals do not contain any species from the suborder, Lagenina. The 1-to-2-cm interval does not contain any species from the suborder, Miliolina. None of the downcore samples contain any species from the suborders, Robertinina or Spirillinina.

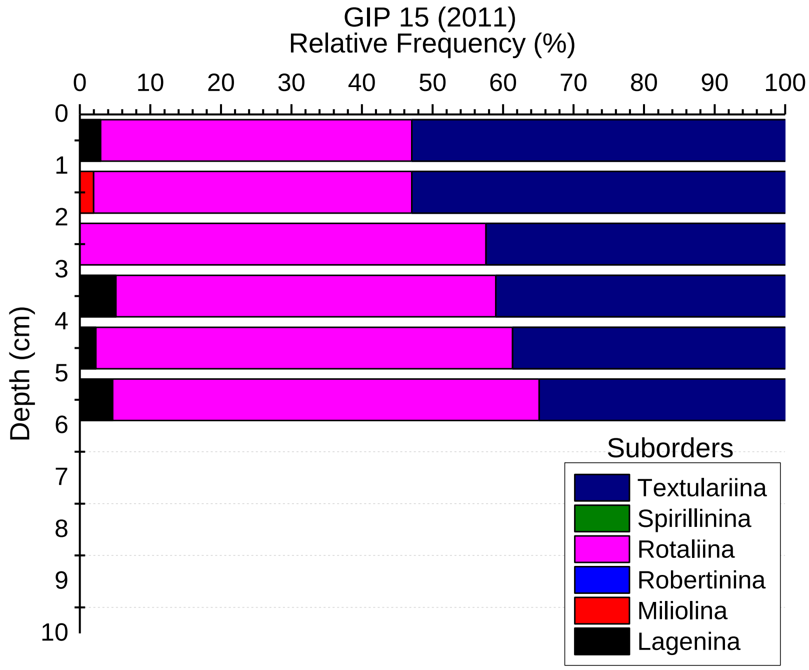


Figure 17. Relative frequency of suborders from GIP 15 downcore samples (2011). None of the downcore samples contain any species from the suborders, Robertinina or Spirillinina. The 1-to-3-cm interval does not contain any species from the suborder, Lagenina. The 0-to-1-cm and 2-to-6-cm intervals do not contain any species from the suborder, Miliolina. None of the downcore samples contain any species from the suborders, Robertinina or Spirillinina.

Species Frequencies

Surface samples. The species with relative frequencies >5% varied between surface samples from both collection years; however, the three pseudo-replicates are more similar in their species content than the other samples. Six species have relative frequencies >5% in the pseudo-replicates (Figures 18a-c). *Cassidulina carinata*, *Epistominella levicula*, and *Trochammina advena* were encountered in all three pseudo-replicates. The taxa from the three pseudo-replicates with relative frequencies <5% range from 61 to 71% of the assemblage.

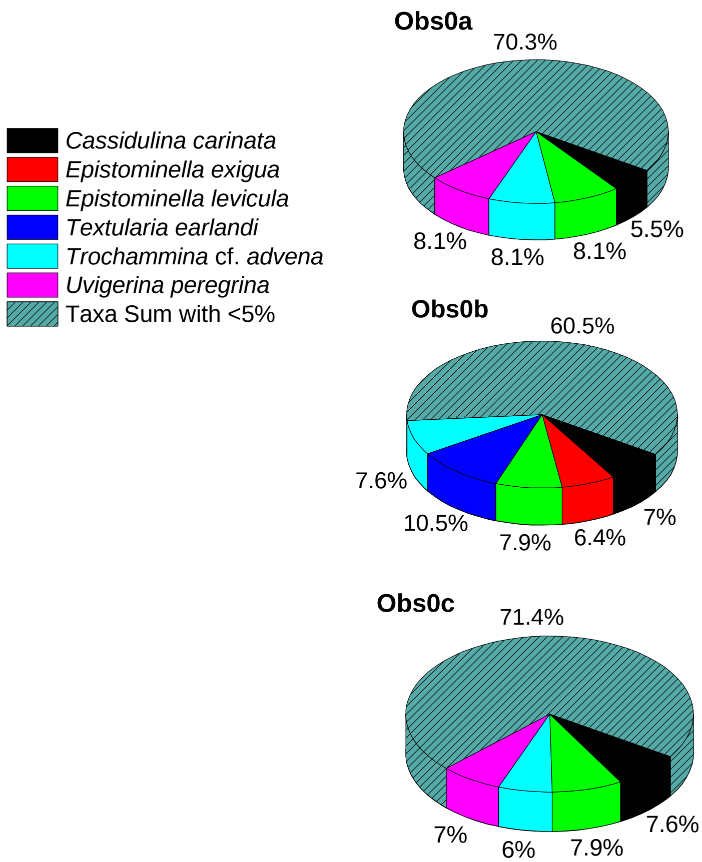


Figure 18. Species with relative frequencies >5% at Obs0. Only four, five, and four species are documented with >5% frequency in samples Obs0a, Obs0b, and Obs0c, respectively.

The 2010 samples contained a range of 3 to 7 species with percentages >5% and the 2011 samples had up to eight species (Figures 19a-f and 20a-e). The surface samples GIP 12 and 15 contained a greater number of species with >5%; however, GIP 16, 17, and 21 had the highest percentages of taxa with relative frequencies <5% in 2010. The surface samples from GIP 16 and 17 in 2011 contained a greater number of taxa with the higher frequencies, and GIP 15 and 25 had the highest percentages of taxa with frequencies <5%. Five species, *Bulimina aculeata*, *Cassidulina carinata*, *Epistominella levicula*, *Textularia earlandi*, and *Trochammina advena*, were found in at least two samples in both collection years. Samples collected from both years had one to two species that occurred at relative frequencies >5% for both years, and the species consisted of *B. aculeata*, *Recurvoides trochamminiforme*, *Spiroplectammina* sp., *T. earlandi*, *T. advena*, and *Uvigerina peregrina*. *Bulimina aculeata* made up nearly 30% of the assemblage at GIP 15 in 2010, and the rest of the surface samples had relative frequencies for that species between 5 and 15% from either year. Species with relative frequencies >5% did not show a trend with respect to [TPAH], except in the case of *B. aculeata*.

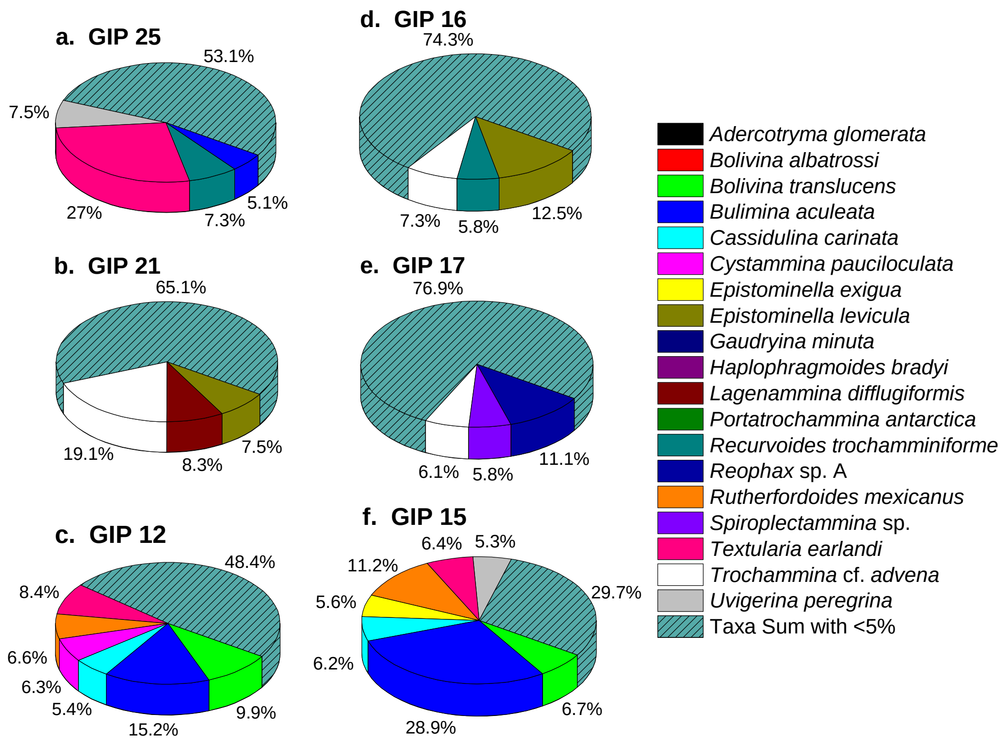


Figure 19. Species with relative frequencies >5% for surface samples (2010). Pie charts are arranged by increasing [TPAH] from a-f. Only three to seven species are documented with >5% frequency within the surface samples.

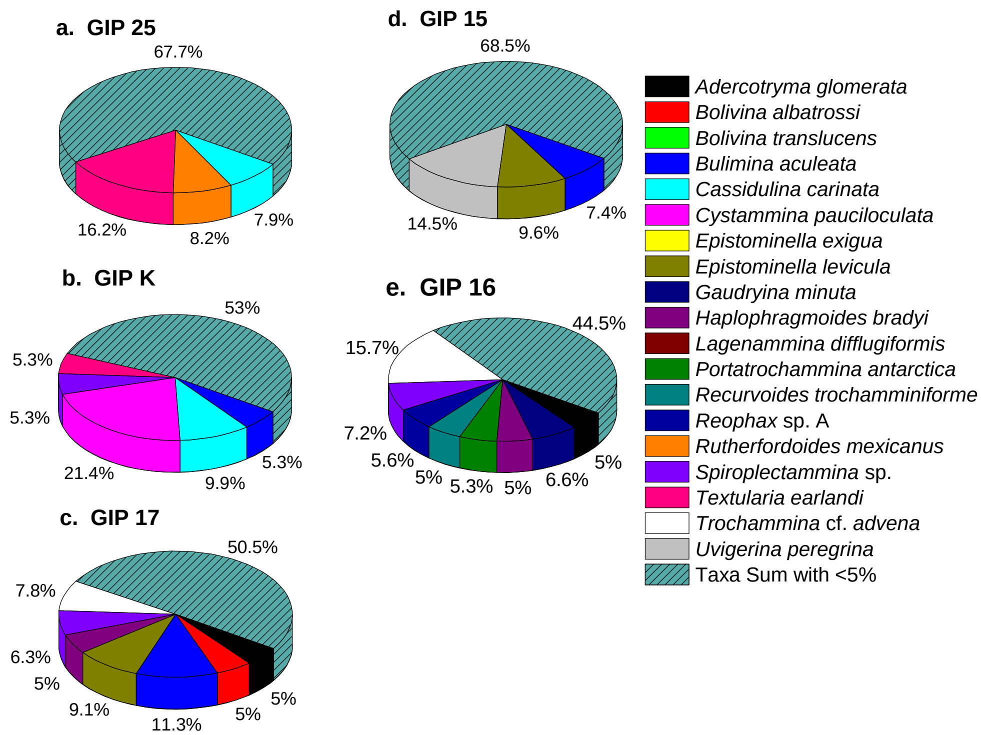


Figure 20. Species with relative frequencies >5% for surface samples (2011). All samples have [TPAH] <1,000 ng/g. Pie charts are arranged by increasing [TPAH] from a-e. Only three to eight species with relative frequencies >5% are documented in the surface samples.

Cores (GIP 25 versus GIP 15). The downcore samples from GIP 15 and 25 have in common seven species that occur at relative frequencies >5% for both years; however, all other taxa and their percentages vary between sites within the collection years. The downcore samples from GIP 25 consisted of 14 and 15 species with relative frequencies >5% in 2010 and 2011, respectively (Figures 21 and 22). *Cassidulina carinata* and *Epistominella levicula* occur in at least five downcore samples at GIP 25 with relative frequencies >5% for both collection years. Additionally, *Spiroplectammina* sp. and *Bolivina minima* also occur at the relative frequencies >5% in 2010 and 2011, respectively. Taxa with relative frequencies <5% are greater by about 1.2% in the 2010 downcore samples in comparison to the samples from 2011 at GIP 25.

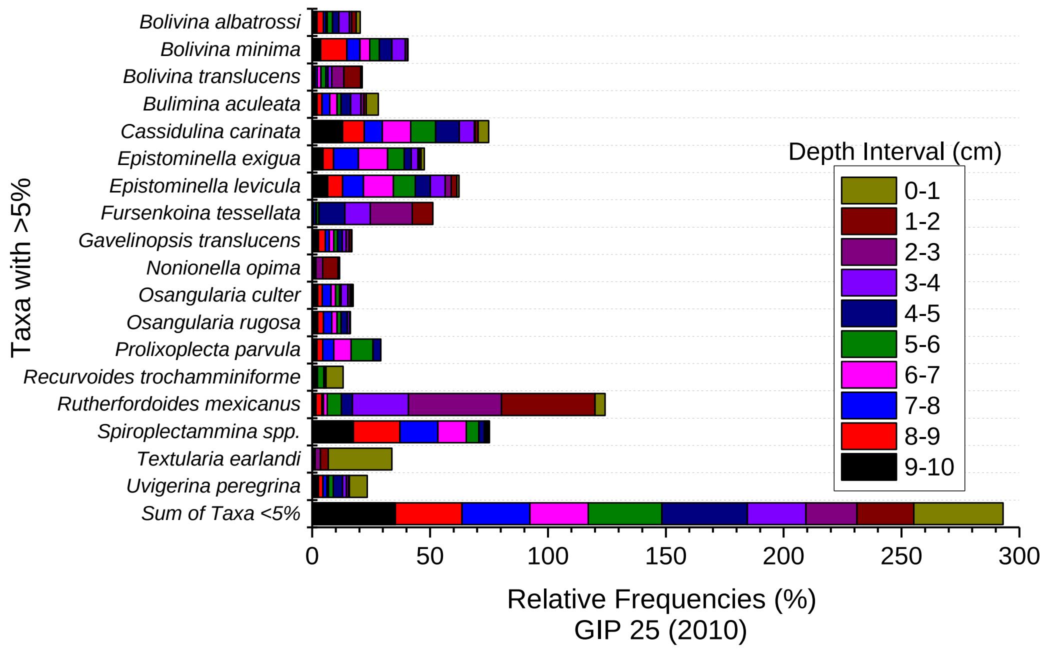


Figure 21. Species with relative frequencies >5% from GIP 25 downcore samples (2010). Eighteen species with relative frequencies >5% are documented at GIP 25. The last row of the chart contains sum of frequencies of taxa with <5% for each of the depth intervals.

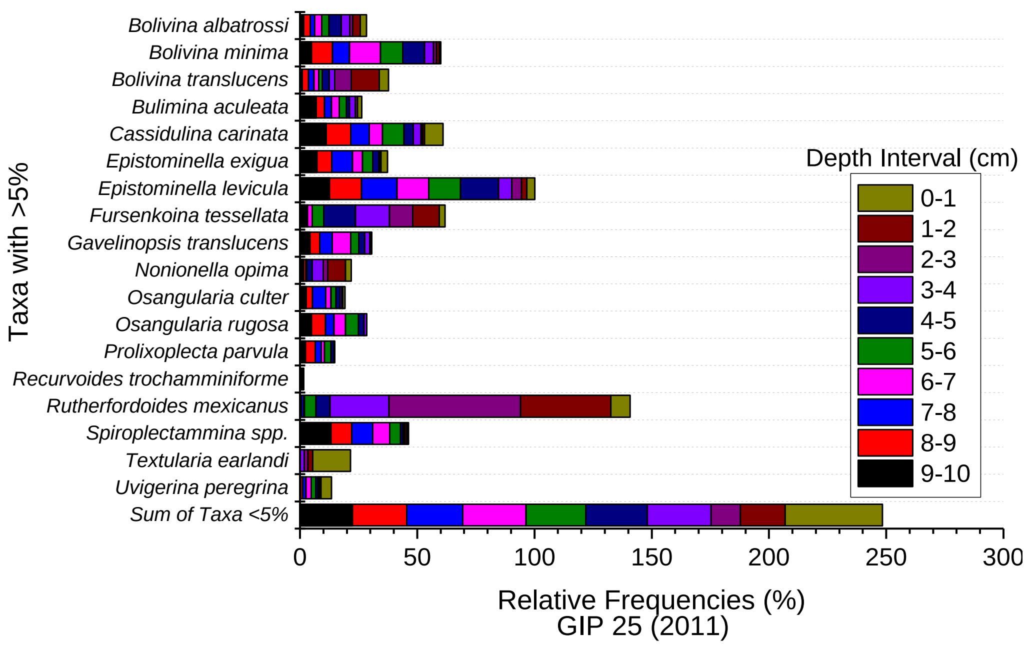


Figure 22. Species with relative frequencies >5% from GIP 25 downcore samples (2011). Eighteen species with relative frequencies >5% are documented at GIP 25. The last row of the chart contains sum of frequencies of taxa with <5% for each of the depth intervals.

The downcore samples from GIP 15 consisted of 9 and 14 species with relative frequencies >5% in 2010 and 2011, respectively (Figures 23 and 24). Three species from GIP 15, *Bulimina aculeata*, *Epistominella levicula*, and *Fursenkoina tessellata*, occur in at least three downcore samples with percentages >5% in 2010. In addition to the three previously mentioned species from 2010, *Rutherfordoides mexicanus* also occurs in at least three downcore samples with percentages >5% in 2011. Taxa with relative frequencies <5% are more numerous in the 2011 samples, especially within the 0-to-2 cm depth interval, where they are two to four times more frequent than in the previous year.

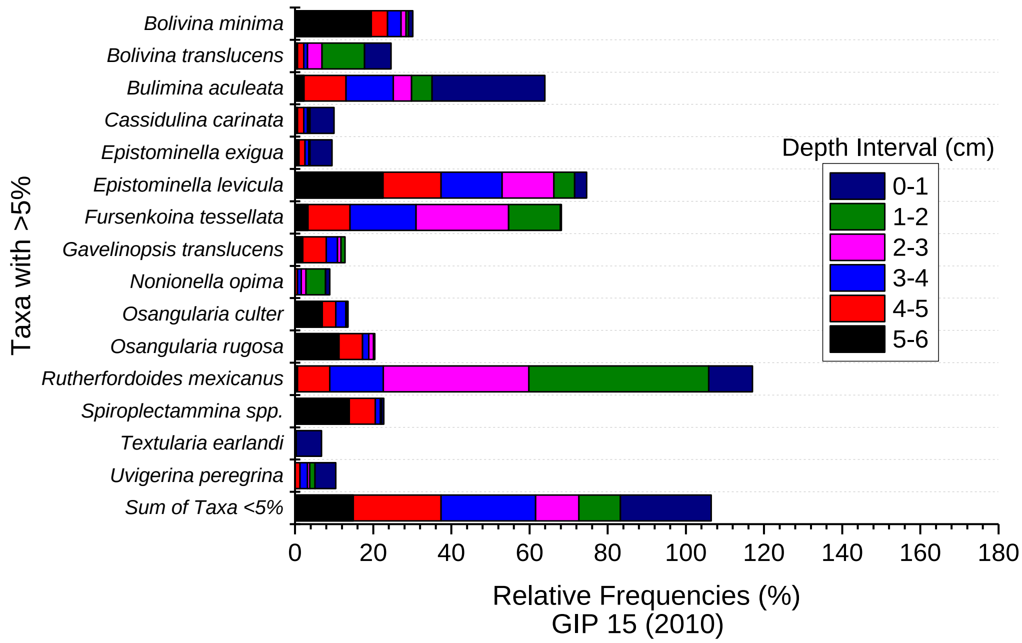


Figure 23. Species with relative frequencies >5% from GIP 15 downcore samples (2010). Fifteen species with relative frequencies >5% are documented at GIP 15. The last row of the chart contains sum of frequencies of taxa with <5% for each of the depth intervals.

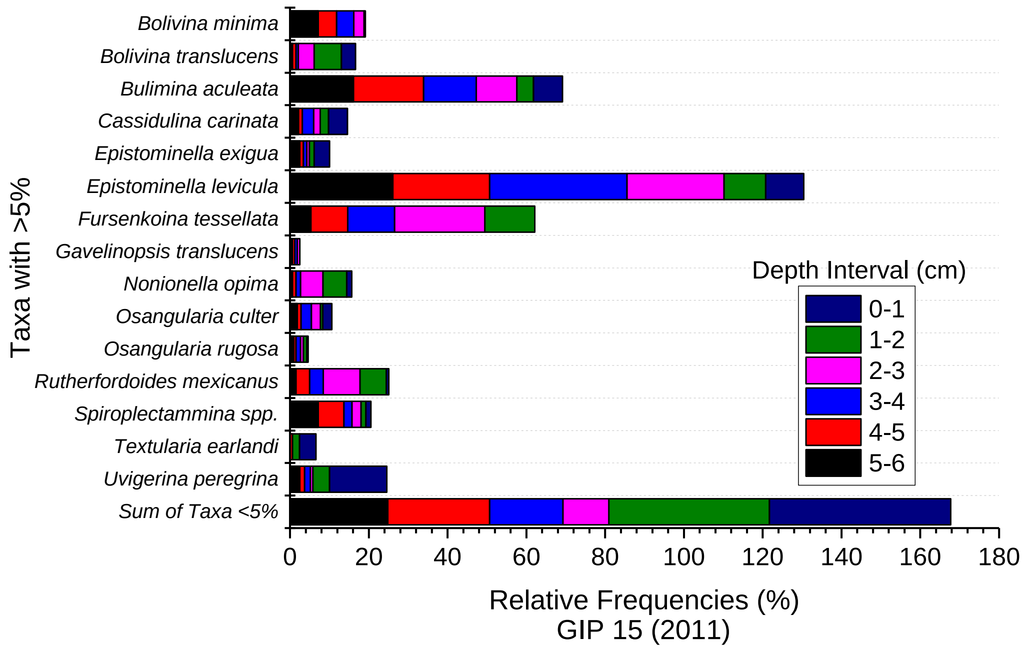


Figure 24. Species with relative frequencies >5% from GIP 15 downcore samples (2011). Fifteen species are documented at GIP 15. The last row of the chart contains the sum of frequencies of taxa with <5% for each of the depth intervals.

Both sites have in common nine species that occur in either collection year with percentages >5%; however, the distribution of these species—as well as species with percentages <5%—vary between site and collection year. GIP 15 (2010) had the fewest species with relative frequencies >5% compared with any other core; however, the number of species in 2011 is similar to that at GIP 25 (2010 and 2011). Five species (*Bulimina aculeata*, *Epistominella levicula*, *Fursenkoina tessellata*, *Rutherfordodies mexicanus*, and *Spiroplectammina* sp.) are found in at least one downcore sample in both of the GIP cores (2010 and 2011) with percentages >5%. The downcore samples at GIP 15 (2010) had the fewest species with percentages <5% compared with any of the other cores.

Although GIP 15 had more species with percentages <5% in 2011 than in 2010, GIP 25 had more species with percentages <5% for both collection years.

Juvenile Distribution

Surface samples. No visible trend between the relative frequencies of juveniles and increasing [TPAH] can be seen in either of the collection years. The juveniles range from 10 to 16% at Obs0, taken in 2012, from 2 to 23% in 2010, and from 9 to 18% in 2011 (Figure 25). Surface samples for GIP 12 and 15 in 2010 have the greatest percentages of juveniles while GIP 21 (2010) has the lowest percentage for either of the collection years. Samples collected in both years (GIP 25, 16, and 17) increase in their juvenile percentages from 2010 to 2011, except in the case of GIP 15.

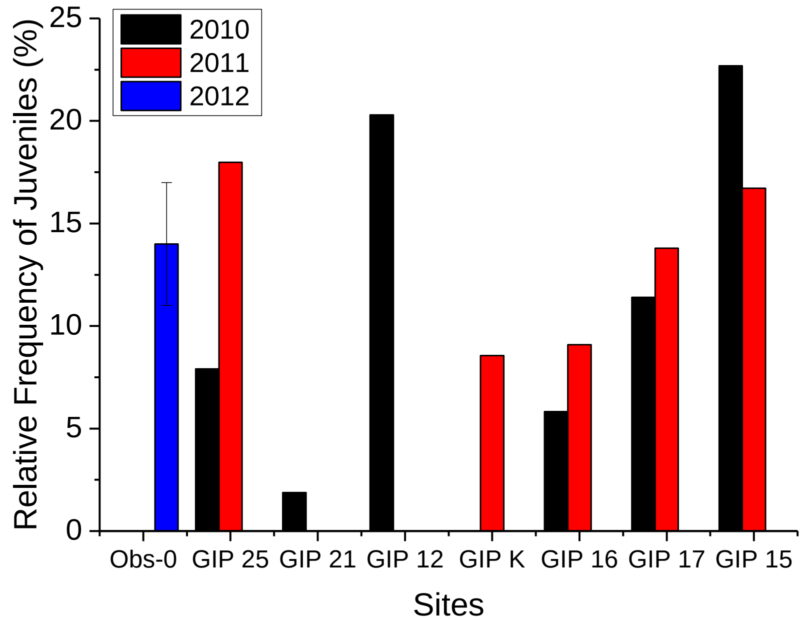


Figure 25. Juvenile distribution for all surface samples. Samples are ordered from left to right by increasing [TPAH]. Obs0 was taken in 2012 and the GIP samples were taken in 2010. GIP 12 and 21 were not sampled in 2011. GIP K was sampled in 2011.

The surface samples consisted of 24 juvenile species; however, only nine species occur in half of those samples from either collection year including the pseudo-replicates. Out of 15 juvenile species, five species (*Bulimina aculeata*, *Cassidulina carinata*, *Gaudryina minuta, Textularia earlandi*, and *Uvigerina peregrina)* are encountered in all three pseudo-replicates (Figure 26). The five species shared among pseudo-replicates vary in their relative frequencies. Twenty species comprise the juveniles present in 2010, seven of which (*Bolivina albatrossi, Bolivina minima, Bolivina translucens, B. aculeata, Rutherfordoides mexicanus, T. earlandi,* and *U. peregrina)* are documented in a least three samples (Figure 27). The surface samples in 2011 are comprised of 16 juvenile species, and five species (*B. alabatrossi, B. minima, B. translucens, C. carinata, G. minuta, R. mexicanus,* and *U. peregrina*) are found in at least three samples

(Figure 28). GIP 21 in 2010 has the lowest number of juvenile species (2) in surface samples where at least six species are documented.

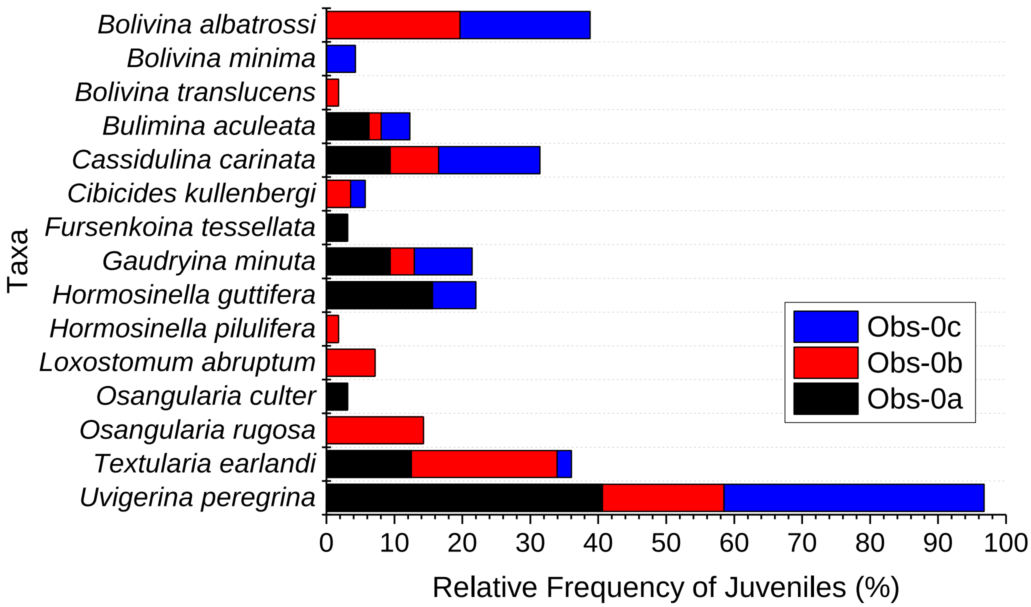


Figure 26. Relative frequency of juveniles present at Obs0. A total of 15 species are documented in the juvenile stage at Obs0. The pseudo-replicates share six juvenile species.

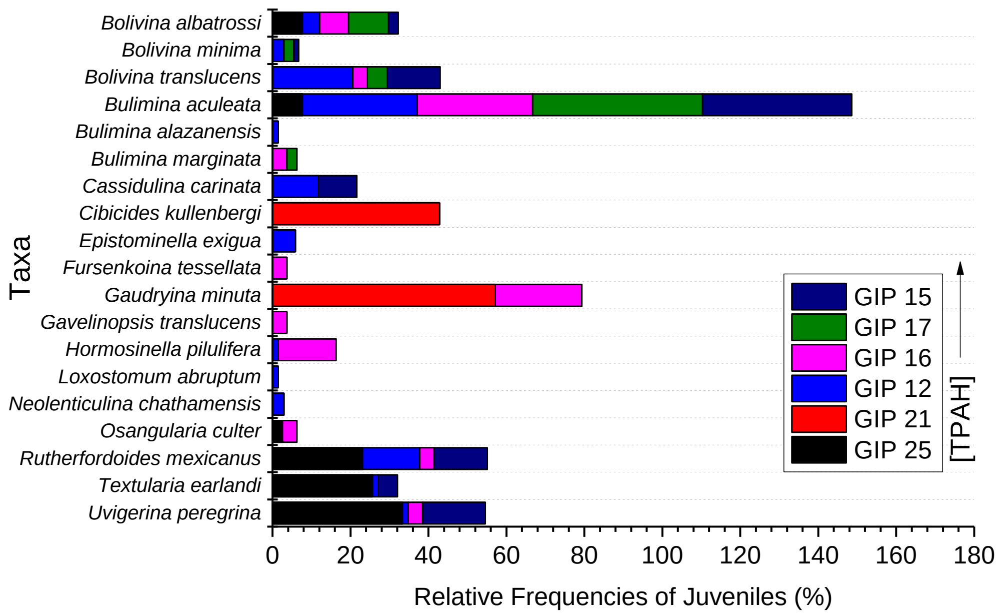


Figure 27. Relative frequency of juveniles present in all surface samples (2010). Samples in the legend are ordered from bottom to top by increasing [TPAH]. A total of 19 species are documented in the juvenile stage in the surface samples.

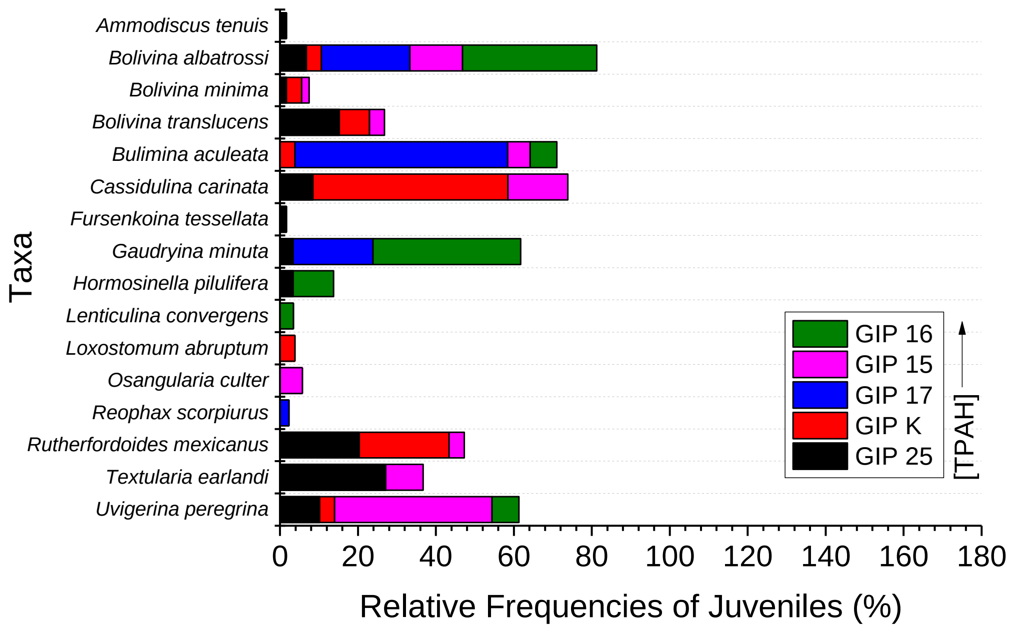


Figure 28. Relative frequency of juveniles present in all surface samples (2011). All samples have [TPAH] <1,000 ng/g (background concentrations) and are ordered by increasing [TPAH] from bottom to top in the legend. A total of 16 species are documented in the juvenile stage in the surface samples.

No trend is visible between the species frequencies of juveniles and increasing [TPAH], except in the case of *Bulimina aculeata*. Most juveniles found in at least three samples show greater frequencies in the samples less contaminated by [TPAH]; however, the juvenile stage of *B. aculeata* has greater frequencies (38 and 44%) in contaminated samples, GIP 15 and 17, respectively. The relative frequency of *B. aculeata* continues to be high (55%) at GIP 17 in 2011; however, the frequency at GIP 15 in 2011 is nearly seven times less than that in 2010. Four juvenile species (*Bolivina albatrossi, Cassidulina carinata, Gaudryina minuta*, and *Uvigerina peregrina*) are documented with relative frequencies >5% in at least two surface samples from the collection years, including the pseudo-replicates.

Cores (GIP 25 versus GIP 15). The overall juvenile percentages are greater in the downcore samples at GIP 25 in 2011 than in the prior year; however, the juvenile assemblage is similar in both years (Figure 29). The GIP 25 samples from 2010 and 2011 contain 19 and 23 species, respectively, in the juvenile stage (Figures 30 and 31). Eight and nine species occur in their juvenile stages in at least five subsurface samples for GIP 25 in 2010 and 2011, respectively. *Bolivina minima*, *Cassidulina carinata, Loxostomum abruptum*, *Rutherfordoides mexicanus*, and *Uvigerina peregrina* are found in at least five downcore samples with relative frequencies >5% at GIP 25 for both years.

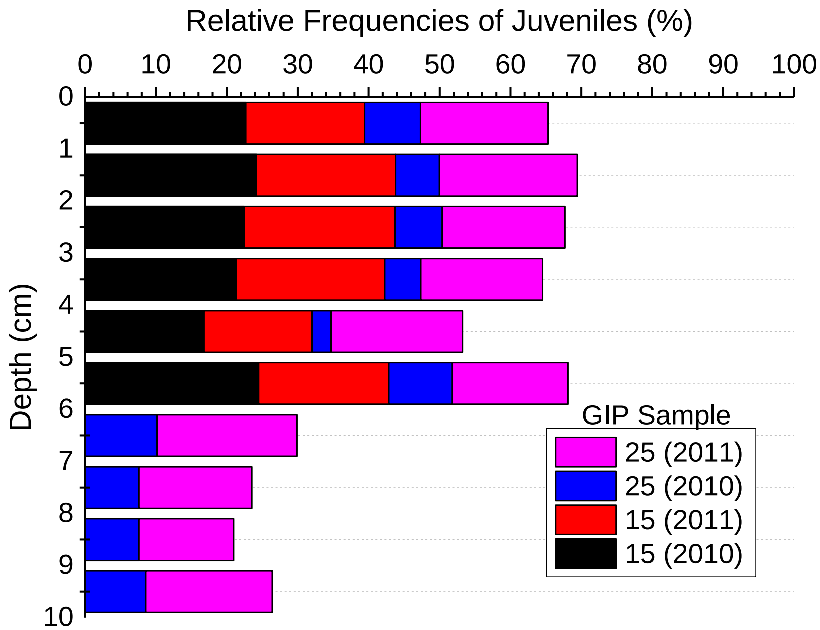


Figure 29. Juvenile distribution for all downcore samples at GIP 25 and 15. The depth of habitation at GIP 15 extended only to 6 cm but lay below 10 cm at GIP 25.

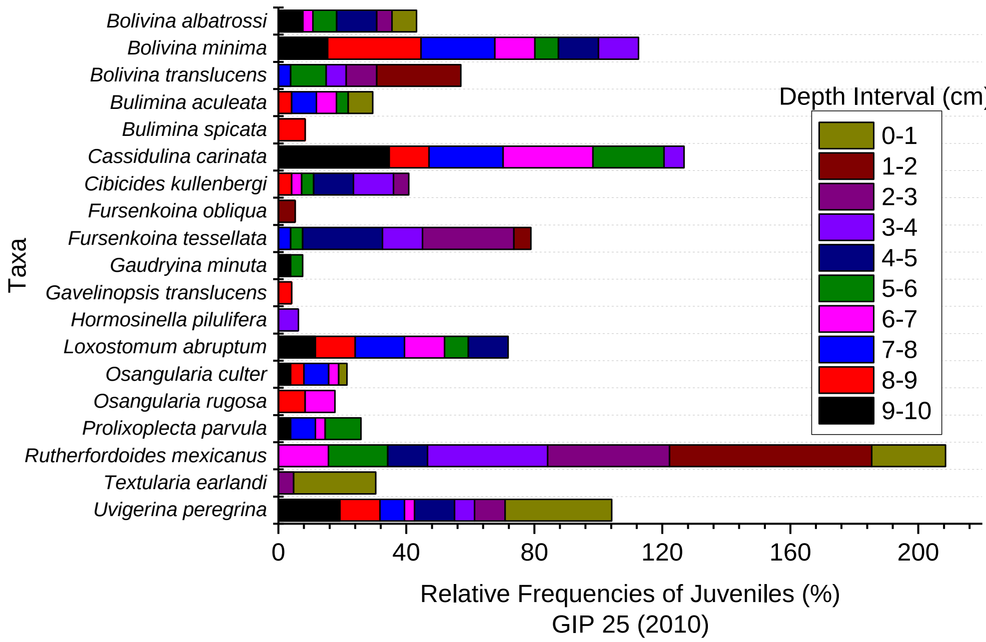


Figure 30. Relative frequency of juveniles in GIP 25 downcore samples (2010). A total of 19 species are documented in the juvenile stage in the downcore samples.

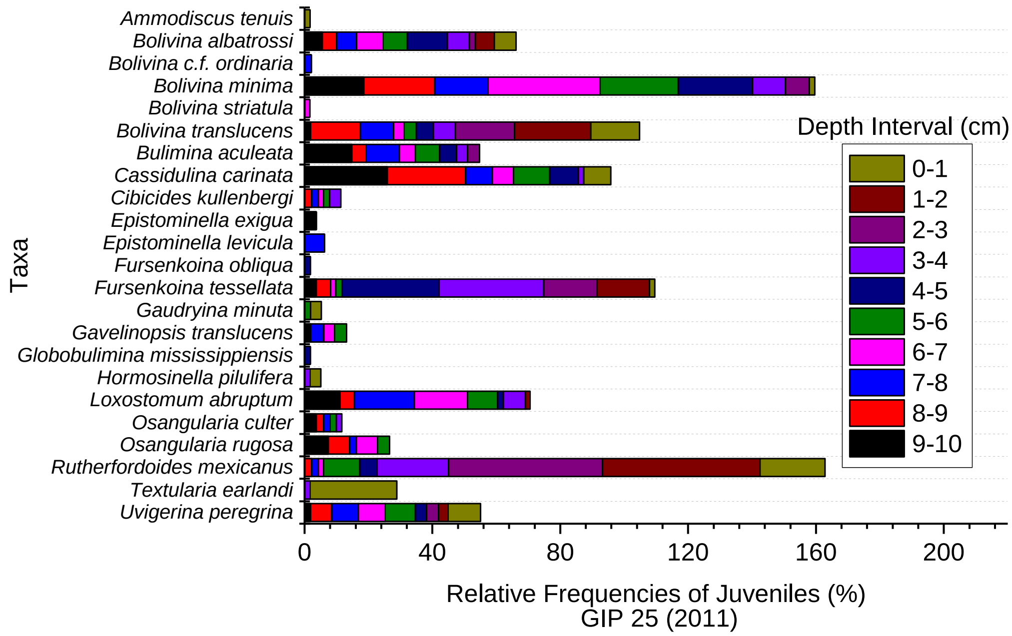


Figure 31. Relative frequency of juveniles in GIP 25 downcore samples (2011). A total of 23 species are documented in the juvenile stage within the downcore samples.

The overall juvenile percentages are similar between collection years at GIP 15; additionally, 14 species are documented in the two years (Figure 29). A total of 17 species are documented in their juvenile stage at GIP 15 for both years (Figures 32 and 33). Seven and nine juvenile species occur in at least three subsurface samples of GIP 15 in 2010 and 2011, respectively. *Bulimina aculeata* and *Rutherfordoides mexicanus* occur at relative frequencies of >5% in at least three downcore samples at GIP 15 for both years.

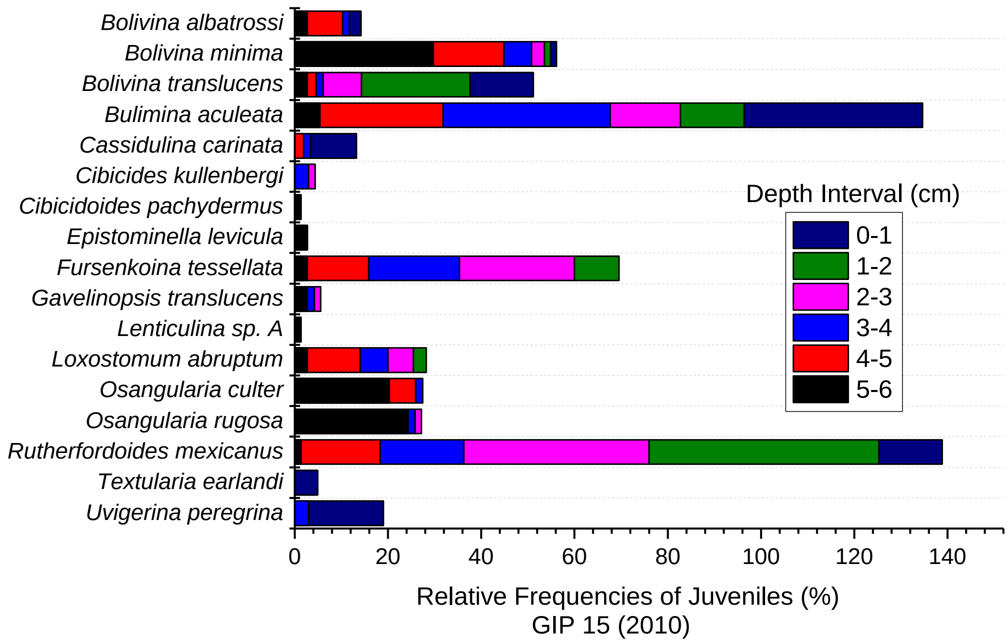


Figure 32. Relative frequency of juveniles present in GIP 15 downcore samples (2010). A total of 17 species are documented in the juvenile stage in the downcore samples.

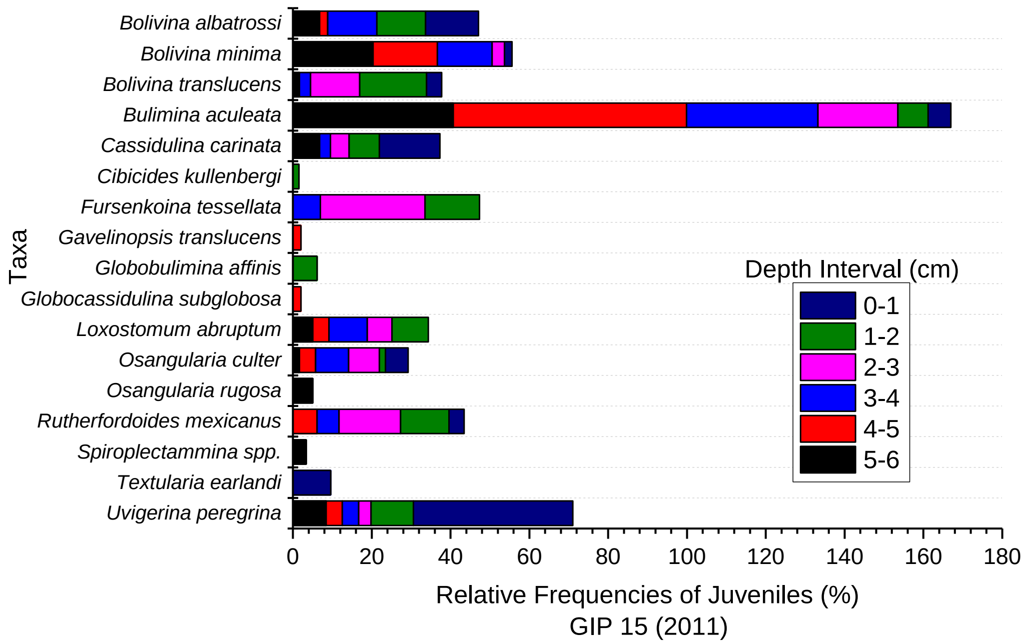


Figure 33. Relative frequency of juveniles in GIP 15 downcore samples (2011). A total of 17 species are documented in the juvenile stage in the downcore samples.

GIP 15 for both collection years and GIP 25 (2011) have similar juvenile abundances downcore; however, GIP 25 from the 2010 collection has much smaller percentages than the other cores. Both sites share 14 species of Foraminifera, but their abundances vary by site and year. Nine of those shared species (*Bolivina albatrossi*, *Bolivina minima*, *Bolivina translucens*, *Bulimina aculeata*, *Cassidulina carinata*, *Fursenkoina tessellata*, *Osangularia rugosa*, *Rutherfordoides mexicanus*, and *Uvigerina peregrina*) have frequencies >5% for both sites and years.

MDS and Q-Mode Cluster Analyses

Surface samples. The MDS and Q-mode cluster analyses, using a coefficient of 11, show two main groups of surface samples and two outliers, and both analyses are in agreement (Figures 34a-c and 35). In the MDS analysis, three dimensions provide the best fit for the surface samples and resulted in a Stress-I value of 0.10, which is a good to fair value (Bartholomew et al., 2008). The MDS biplots and Q-mode cluster show GIP 21 as an outlier; it is the deepest and most distant site from the wellhead. A secondary outlier, GIP K, can also be seen in the plots. The three pseudo-replicates are grouped together in a single cluster, while GIP 16 and 17 from both collection years are grouped in a second cluster. The third cluster consists of GIP 12, 15, and 25 from both collection years. The three pseudo-replicates from the Obs-0 site show more similarity than any other grouping of surface samples.

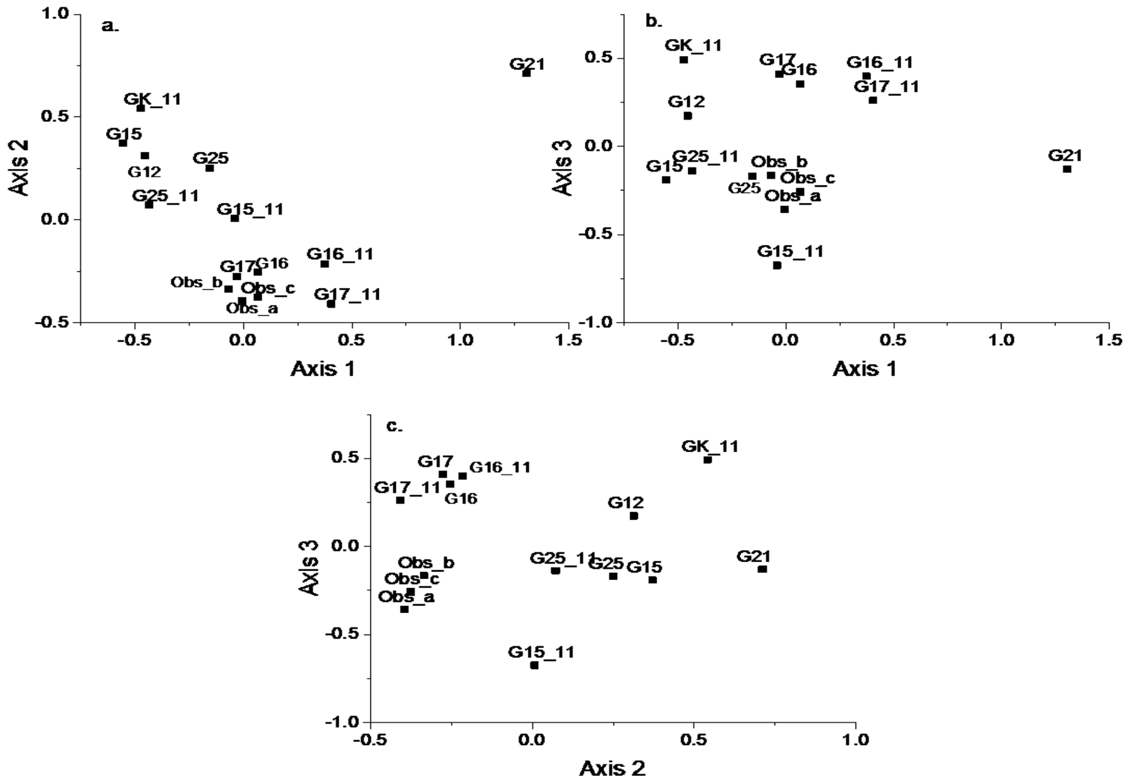


Figure 34. MDS of all surface samples. The MDS was performed using the Bray-Curtis similarity index of the specimen counts for all surface samples. Specimen counts were double square-root transformed prior to analysis. The "G" indicates GIP sites. The "_10" and "_11" indicates the collection year. The stress-I value is 0.10 for the MDS plots.

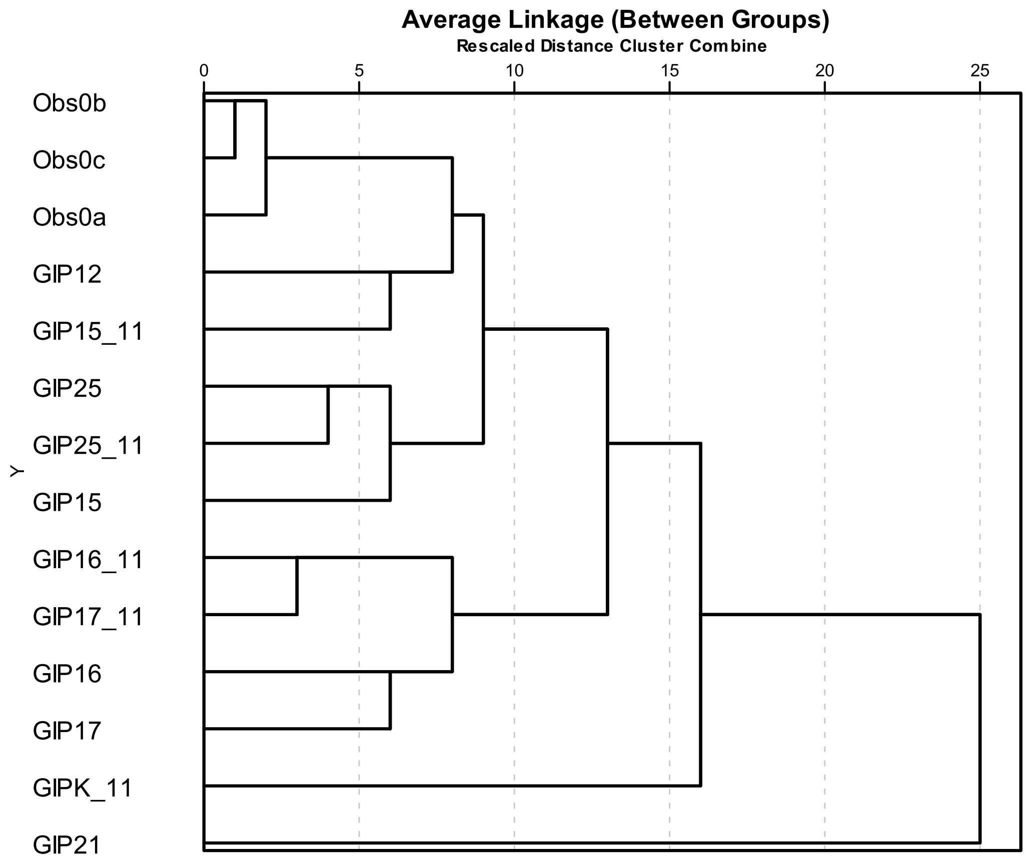


Figure 35. Dendrogram of the Q-mode cluster analysis for all surface samples. The cluster analysis was performed using the Bray-Curtis similarity index of the specimen counts for all surface samples. Specimen counts were double square-root transformed prior to analysis. The "_11" indicates samples from the 2011 collection and all other GIP samples are from 2010. The Obs0 samples are from 2012.

Cores (GIP 25 versus GIP 15). The cluster analysis of samples from cores GIP 25 and 15 shows four major groups of samples using a coefficient of 21 and is in agreement with the MDS analysis (Figures 36a-c and 37). Group A consists of two samples, the surface samples from GIP 25 for both collection years, and the outlier GIP 15 from 2010 (surface sample). Group B consists of the 0 to 2 cm interval from GIP 15 (2011). Group C consists of samples from 2010 at depth intervals 1 to 3 and 1 to 5 cm for GIP 15 and 25, respectively. The samples from 2011 at GIP 25 within the depth interval of 1 to 5 cm are also part of group C. The deepest samples from cores GIP 15 and 25 in both years are clustered in group D. Depth in core is more important for controlling assemblages than environmental differences between GIP sites 15 and 25.

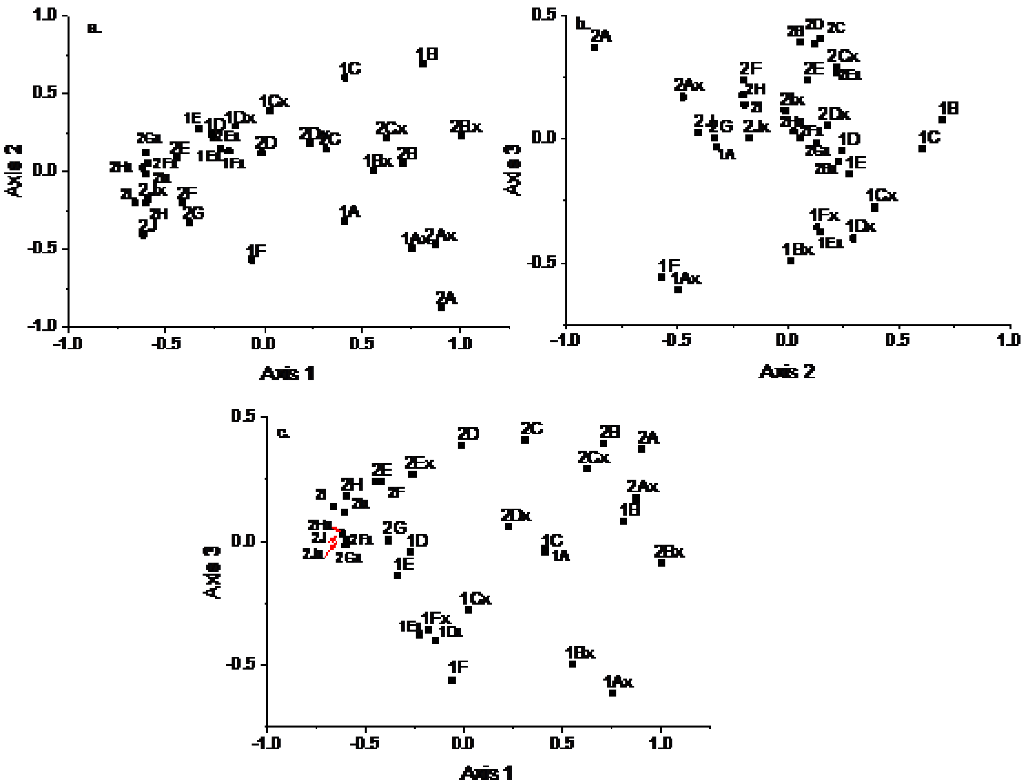


Figure 36. MDS of all downcore samples at GIP 25 and 15. The MDS was performed using the Bray-Curtis similarity index of the specimen counts for all downcore samples. Specimen counts were double square-root transformed prior to analysis. The stress-I value is 0.08 for the MDS plots. The “1” and “2” indicates GIP 15 and 25 samples, respectively. The “x” indicates samples from the 2011 collection. A-J indicate depth interval with A = 0-1 cm, B = 1-2 cm. … J = 9-10 cm.

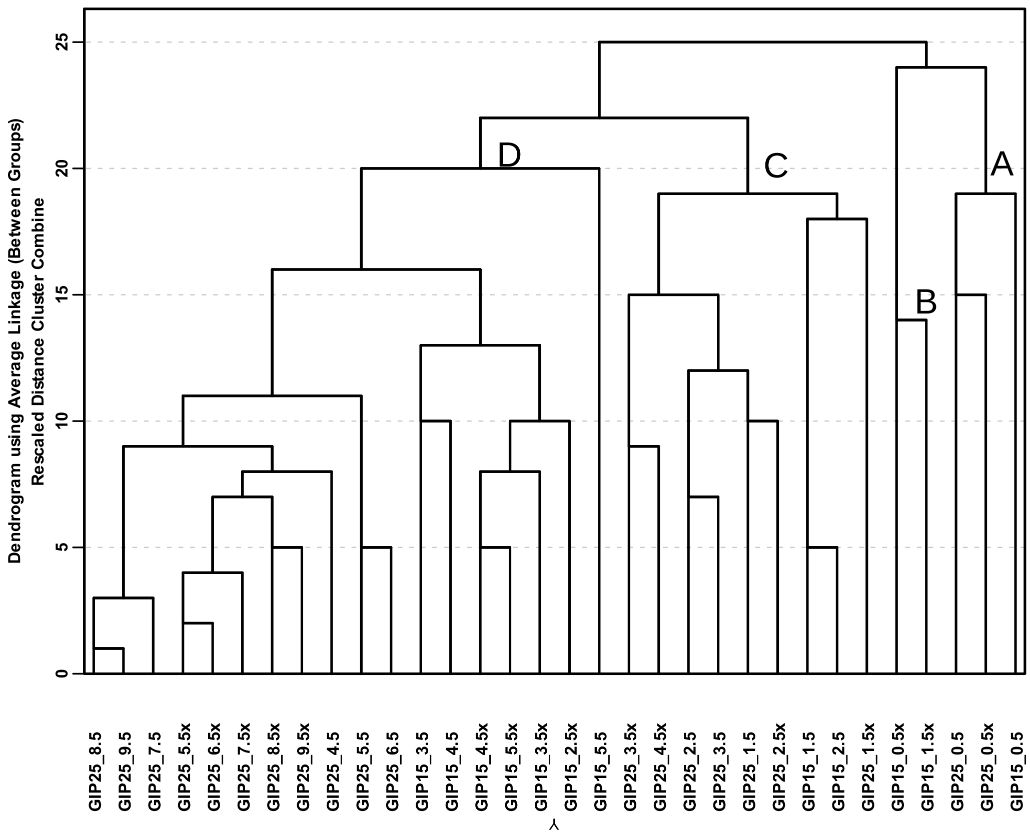


Figure 37. Dendrogram of clusters for all downcore samples. The cluster analysis was performed using the Bray-Curtis similarity index of the specimen counts for all downcore samples. Specimen counts were double square-root transformed prior to analysis. The decimal values indicate mid-interval depths. The “x” indicates samples from the 2011 collection.

MDS Interpretation

Surface samples. All three MDS axes are plotted against all physical and biological variables to find the best linear fit (Figures 38a-c) to guide interpretation. The relative frequency of *Trochammina advena has a strong fit (R^2 = 0.76) with Axis 1,* and *Uvigerina peregrina* has a strong fit (R^2 = 0.66) with Axis 3. Axis 2 shows a strong relationship (R^2 = 0.61) with distance from the periphery of the moderately TPAH impacted footprint defined by Montagna et al. (2013).

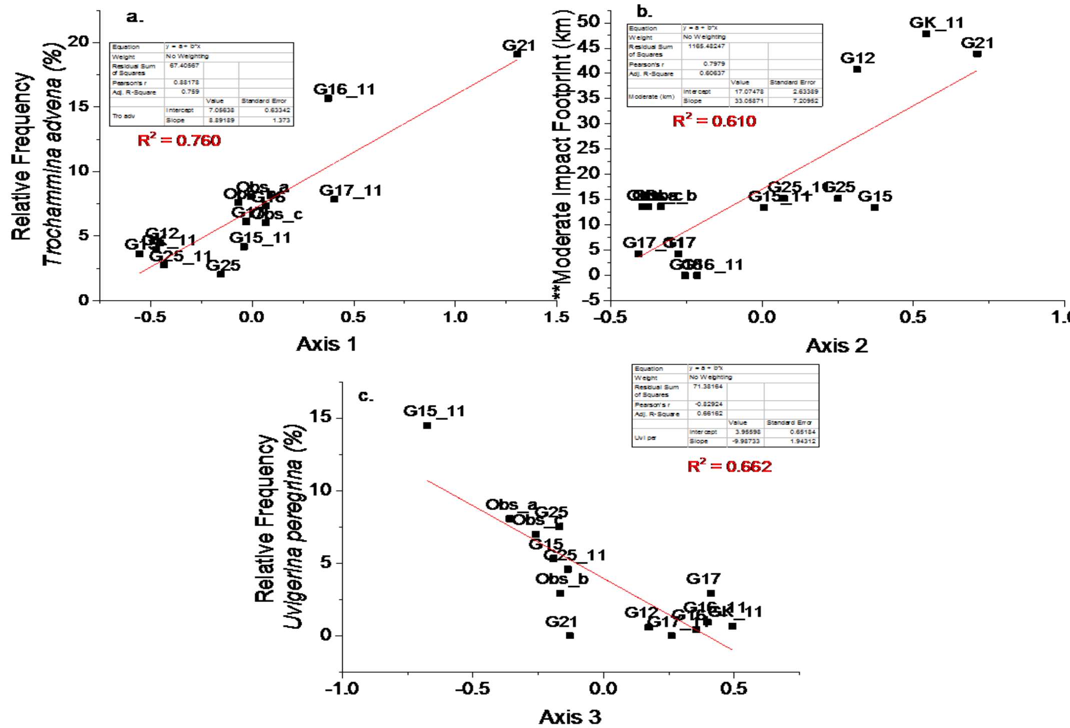


Figure 38. MDS interpretation of the surface samples. Each MDS axis is plotted with the variable that best correlates with it. The linear model is in red with terms and statistics in the associated table. The R^2 is shown in red. The “G” indicates GIP sites. The “_10” and “_11” indicate the collection year.

Cores (GIP 25 versus GIP 15). Three MDS dimensions show the best fit for all downcore samples for GIP 15 and 25 from both years. The MDS analysis has a Stress-I value of 0.08, which falls within the good to fair range (Bartholomew et al., 2008; Figure 39a-c). All physical and biological variables were plotted against each of the axes to find the best linear fit to aid interpretation. The relative frequencies of *Loxostomum abruptum*, *Fursenkoina tessellata*, and *Epistominella levicula* show the strongest fit with the three axes and have R^2 values of 0.56, 0.59, and 0.41, respectively, although variables with higher R^2 values are desirable.

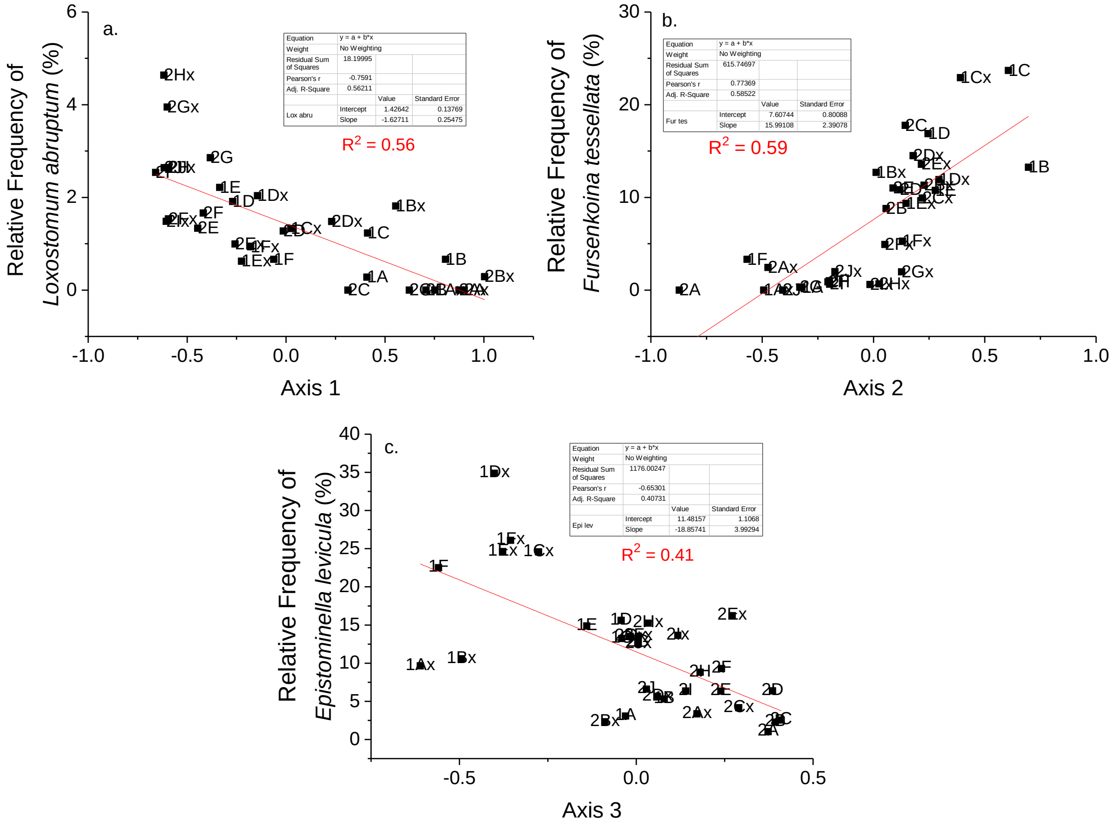
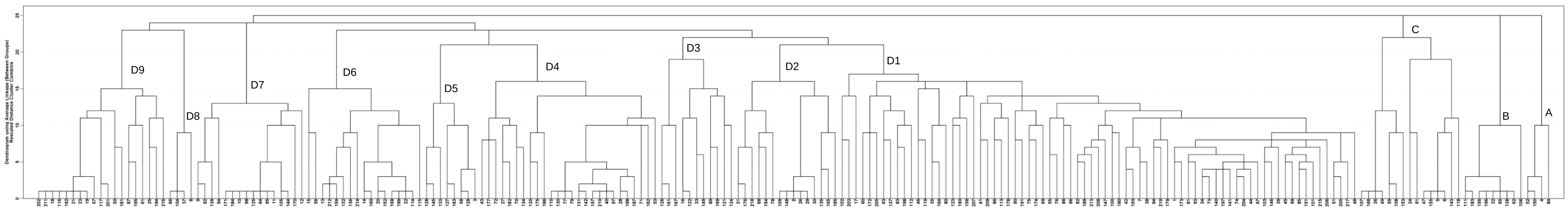


Figure 39. MDS interpretation of the downcore samples at GIP 25 and 15. Each MDS axis is plotted with the variable that best correlates with it. The linear model is in red, with terms and statistics in the associated table. The R^2 is shown in red. The “1” and “2” indicate GIP 15 and 25 samples, respectively. The “x” indicates samples from the 2011 collection.

R-Mode Cluster Analysis of Surface Samples

Four main groups were documented by the R-mode cluster analysis using a coefficient of 25 for separation of groups (Figure 40). The four groups, A, B, C, and D, consist of 4, 9, 15, and 191 species, respectively. Taxa from group A are found in one to two samples from 2011 GIP 15 and 17. Taxa from group B are found in one to two samples from GIP 25 (2010) and Obs0a. Taxa from group C are found in one to three samples from 2010 GIP 16 and 17, 2011 GIP K, 16, and 25, and Obs0b. The relative frequencies of taxa from groups A, B, and C range from 0.3 to 0.8%, 0.2 to 0.6%, and 0.2 to 1.5%, respectively. The taxa from group D are documented within one to 14 samples from all other surface samples with varying relative frequencies.



ID	Taxa-D9
202	*Textulariacea* sp. A
211	*Trochammina squamata*
18	Agglutinated sp. U
116	*Lenticulina peregrina*
192	Rotalid sp. D
21	Agglutinated sp. W
23	Agglutinated sp. X
19	Agglutinated sp. V
57	*Cibicidoides pachydermus*
117	*Lituola lituolinoidea*
201	*Textularia wiesneri*
50	*Buzasina ringens*
181	*Reophax* sp. D
87	*Glomospira gordialis*
195	*Sphaeroidina bulloides*
61	*Cribrostomoides scitulus*
25	Agglutinated sp. Y
194	*Seabrookia earlandi*
216	*Uvigerina auberiana*

ID	Taxa-D8
66	*Cyclammina trullissata*
104	*Ioanella tumidula*
37	*Bolivina lowmani*
8	Agglutinated sp. H

ID	Taxa-D7
9	Agglutinated sp. Hb
92	*Gyroidinoides polius*
139	*Nonionella atlantica*
54	*Chilostomella oolina*
171	*Quinqueloculina lamarckiana*
184	*Reophax* sp. J
10	Agglutinated sp. Kb
98	*Hormosina globulifera*
125	Miliolida sp. J
64	*Cruciloculina triangularis*
95	*Haplophragmoides subinvolutum*
11	Agglutinated sp. Lb
105	*Karrerulina apicularis*
144	*Oridorsalis tenera*
170	*Quinqueloculina bosciana*
12	Agglutinated sp. Mb

ID	Taxa-D6
15	Agglutinated sp. Sb
56	*Cibicides wuellerstorfi*
13	Agglutinated sp. Qb
212	*Trochammina subturbinata*
159	*Pyrgo* c.f. *williamsoni*
132	*Miliolinella antarctica*
136	*Neocrosbyia minuta*
214	*Trochamminoides coronatus*
14	Agglutinated sp. Rb
160	*Pyrgo elongata*
20	Agglutinated sp. Vb
152	*Praeglobobulimina ovata*
168	*Pyrgo* sp. G
199	*Subreophax monile*
22	Agglutinated sp. Wb
114	*Laticarinina pauperata*
115	*Lenticulina convergens*

ID	Taxa-D5
128	Miliolida sp. U
145	*Oridorsalis umbonatus*
133	*Miliolinella californica*
127	Miliolida sp. T
163	*Pyrgo phlegeri*
58	*Cibicidoides robertsonianus*
129	Miliolida sp. V
3	Agglutinated sp. Ab

ID	Taxa-D4
43	*Brizalina subspinescens*
177	*Reophax scorpiurus*
72	*Epistominella decorata*
27	*Alveolophragmium* sp. A
182	*Reophax* sp. E
70	*Dorothia scabra*
134	*Miliolinella oblonga*
120	Miliolida sp. A
175	*Reophax dentaliniformis*
186	*Rhabdammina discreta*
110	Lagenaid sp. D
130	Miliolida sp. W
77	*Evolvocassidulina tenuis*
79	*Fissurina flintiana*
131	Miliolida sp. X
142	*Nonionoides grateloupi*
157	*Pullenia bulloides*
210	*Trochammina* sp. E
40	*Bolivina pusilla*
97	*Hoeglundina elegans*
28	*Ammobaculites filiformis*
188	*Rhabdammina* spp.
187	*Rhabdammina linearis*
71	*Eggerella bradyi*
162	*Pyrgo murrhina*
53	*Cassidulina obtusa*

ID	Taxa-D3
126	Miliolida sp. L
161	*Pyrgo lucernula*
167	*Pyrgo* sp. F
16	Agglutinated sp. T
122	Miliolida sp. C
33	*Anomalinoides mexicana*
149	*Planispirinoides bucculentus placentiformis*
89	*Gyroidina bradyi*
169	*Pyrgoella sphaera*
121	Miliolida sp. B
124	Miliolida sp. I

ID	Taxa-D2
31	*Ammodiscus tenuis*
176	*Reophax hispidulus*
218	*Valvulineria glabra*
68	*Discammina compressa*
154	*Procerolagena gracilis*
78	*Fissurina aradasii*
109	Lagenaid sp. B
148	*Parafissurina kerguelenensis*
2	Agglutinated sp. A
26	Agglutinated sp. Yb
29	*Ammodiscus* sp. A
30	*Ammodiscus* sp. B
135	*Miliolinella warreni*
165	*Pyrgo* sp. B
185	*Reticulophragmium venezuelanum*

ID	Taxa-D1	ID	Taxa-D1 (continued)
102	*Hyperammina friabilis*	147	*Osangularia rugosa*
203	*Triloculina tricarinata*	100	*Hormosinella guttifera*
17	Agglutinated sp. Tb	180	*Reophax sp. B*
60	*Cribrostomoides nitidum*	42	*Bolivina translucens*
172	*Quinqueloculina seminulum*	193	*Rutherfordoides mexicanus*
205	*Trochammina globigeriniformis*	7	Agglutinated sp. G
63	*Cribrostomoides subglobosus*	38	*Bolivina minima*
137	*Neolenticulina chathamensis*	94	*Haplophragmoides kirki*
83	*Globobulimina affinis*	219	*Veleroninoides wiesneri*
198	*Stainforthia complanata*	179	*Reophax* sp. A
112	*Lagenammina difflugiformis*	1	*Adercotryma glomerata*
46	*Bulimina marginata*	173	*Recurvoides trochamminiforme*
119	*Loxostomum abruptum*	81	*Gaudryina minuta*
35	*Bolivina* c.f. *ordinaria*	93	*Haplophragmoides bradyi*
164	*Pyrgo sp. A*	34	*Bolivina albatrossi*
80	*Fursenkoina tessellata*	73	*Epistominella exigua*
123	Miliolida sp. H	140	*Nonionella iridea*
190	*Robertinoides bradyi*	197	*Spiroplectammina* spp.
158	*Pullenia quinqueloba*	141	*Nonionella opima*
207	*Trochammina inflata*	74	*Epistominella levicula*
41	*Bolivina striatula*	204	*Trochammina* c.f. *advena*
209	*Trochammina quadriloba*	44	*Bulimina aculeata*
86	*Globotextularia* sp. A	67	*Cystammina pauciloculata*
113	*Lagenammina tubulata*	103	*Hyperammina* spp.
178	*Reophax scotti*	146	*Osangularia culter*
90	*Gyroidina orbicularis*	39	*Bolivina paula*
191	Rotalid sp. A	45	*Bulimina alazanensis*
75	*Epistominella vitrea*	99	*Hormosinella distans*
174	*Reophax agglutinatus*	85	*Globocassidulina subglobosa*
69	*Discorbis bulbosa*	151	*Portatrochammina antarctica*
55	*Cibicides kullenbergi*	101	*Hormosinella pilulifera*
76	*Eponides regularis*	215	*Usbekistania charoides*
88	*Glomospira irregularis*	206	*Trochammina globulosa*
96	*Haynesina germanica*	51	*Cassidulina carinata*
82	*Gavelinopsis translucens*	200	*Textularia earlandi*
189	*Rhizammina indivisa*	217	*Uvigerina peregrina*
213	*Trochammina tasmanica*	48	*Bulimina spicata*
208	*Trochammina japonica*		

ID	Taxa-C
107	*Lagena* sp. B
166	*Pyrgo* sp. C
36	*Bolivina lanceolata*
49	*Buliminella bassendorfensis*
59	*Cornuspira involvens*
108	Lagenaid sp. A
153	*Praeglobobulimina ovula*
24	Agglutinated sp. Xb
91	*Gyroidinoides altiformis*
47	*Bulimina* sp. D
155	*Prolixoplecta parvula*
5	Agglutinated sp. D
6	Agglutinated sp. Eb
143	*Oolina ovum*
118	*Lituotuba lituiformis*

ID	Taxa-B
111	Lagenaid sp. E
183	*Reophax* sp. G
156	*Pseudosolenia wiesneri*
196	*Spiroloculina* sp. A
32	*Ammolagena clavata*
65	*Cyclammina cancellata*
138	*Neolenticulina variabilis*
62	*Cribrostomoides* sp. B
106	*Lagena hispidula*

ID	Taxa-A
52	*Cassidulina laevigata*
150	*Plectina apicularis*
4	Agglutinated sp. Bb
84	*Globobulimina mississippiensis*

Figure 40. Dendogram of the R-mode cluster of all surface samples. The cluster analysis was performed using Bray-Curtis similarity index of the specimen counts which were double square-root transformed prior to analysis. A total of 219 species from the 14 surface samples are documented in the dendogram.

Foraminiferal Diversity Measures

S Index

Surface samples. The median of the S index among the surface samples are slightly similar between years with a median of 74 species embraced by 25th and 75th percentiles of 52 and 83 species in 2010, a median of 63 species embraced by 25th and 75th percentiles of 56 and 57 species in 2011, and a median of 65 species embraced by 25th and 75th percentiles of 61 and 70 species for the pseudo-replicates (Figure 41 and Tables 7 and 8). The variability in the S index is greater in the samples from the 2010 collection than in the samples from 2011 and the three pseudo-replicates.

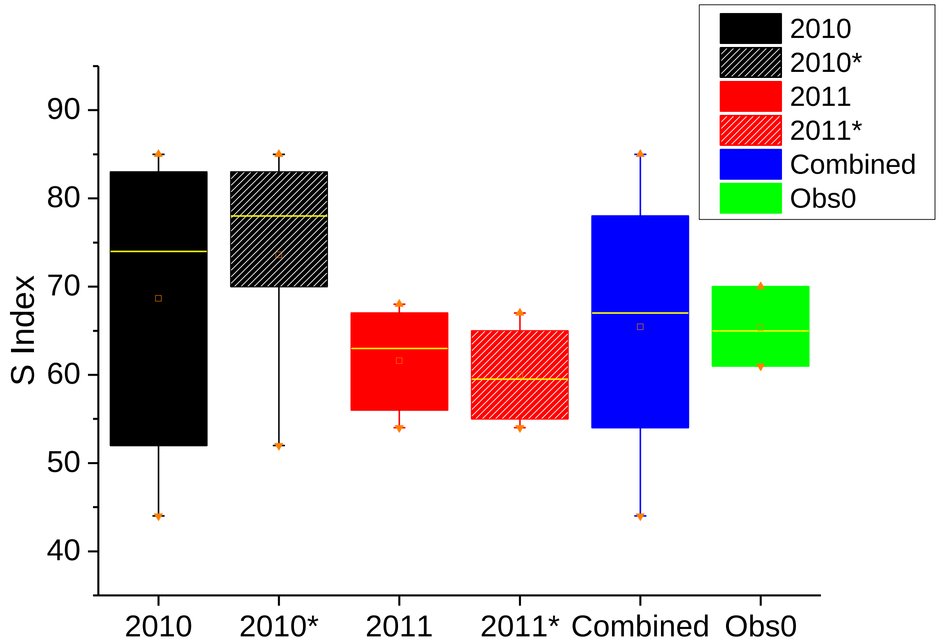


Figure 41. Whisker plot of number of species versus sites. The * in the legend and x-axis indicates removal of GIP 15. The top and bottom of the colored boxes are the 25th and 75th percentiles. The yellow line, open orange box, and filled orange triangle indicate median, mean, and1st/99th percentiles, respectively. The capped, vertical bars extending from the boxes indicate maximum and minimum values. The 2010 and 2011 groups contain six and five surface samples, respectively. The combined group contains a total 14 surface samples. The Obs0 group contains three pseudo-replicates.

Table 7

Diversity Indices for All Surface Samples

Sample	Species Richness	H'	D	E	J
GIP 12_10	52	3.19	0.06	0.47	0.81
GIP 15_10	44	2.77	0.12	0.36	0.73
GIP 16_10	85	3.76	0.04	0.50	0.85

Table 7 (continued).

Sample	Species Richness	H’	D	E	J
GIP 17_10	78	3.76	0.03	0.55	0.86
GIP 21_10	70	3.48	0.06	0.46	0.82
GIP 25_10	83	3.28	0.09	0.32	0.74
GIP K_11	54	3.16	0.07	0.44	0.79
GIP 15_11	68	3.45	0.05	0.46	0.82
GIP 16_11	56	3.31	0.05	0.49	0.82
GIP 17_11	67	3.52	0.04	0.51	0.84
GIP 25_11	63	3.49	0.05	0.52	0.84
Obs0a_12	65	3.61	0.04	0.57	0.86
Obs0b_12	61	3.47	0.04	0.53	0.84
Obs0c_12	70	3.63	0.03	0.54	0.86

Note. Samples from 2010, 2011, and 2012 are indicted by “_10,” “_11,” and “_12,” respectively.

Table 8

Measures of Central Tendency for S Index

Group	Median	25%	75%
Surface Samples (2010)	74	52	83
Surface Samples (2011)	63	56	57
Pseudo-Replicates (Obs0)	65	61	70
GIP 25’s Downcore (2010)	49	47	57
GIP 25’s Downcore (2011)	48	44	55
GIP 15’s Downcore (2010)	40	30	50
GIP 15’s Downcore (2011)	44	39	51

Note. Medians and percentiles are in units of number of species.

The Obs0b sample has fewer species (61) than the other two pseudo-replicates (Figure 42a). The S index ranges from 44 to 85 species in the surface samples from 2010, the lowest being from GIP 15 (Figure 43a). GIP K and 16 have the lowest S index in 2011 with 54 and 56 species, respectively (Figure 44a). GIP 25 decreases in the S index from 83 species in 2010 to 63 species in 2011. The two samples with the highest specimen counts (>400 specimens; GIP 16 and 25 from 2010) have the greatest S index compared with any other surface sample from either of the two collection years.

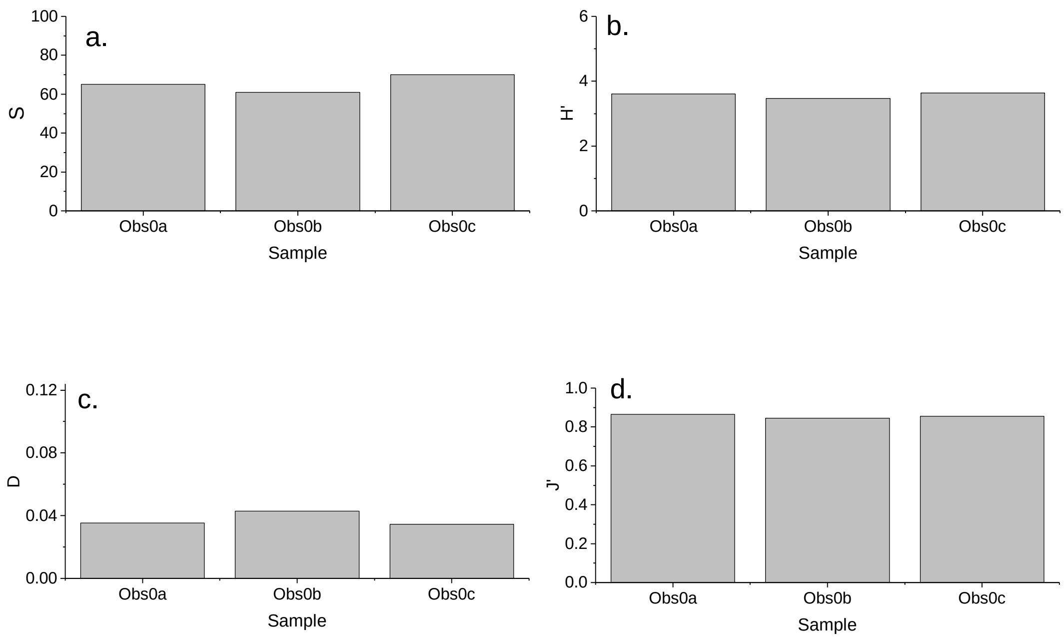


Figure 42. Diversity indices for Obs0. Higher diversities are indicated by higher values of S (a) and H' (b) and lower values of D (c). High values of the J (d) index indicate greater equitability.

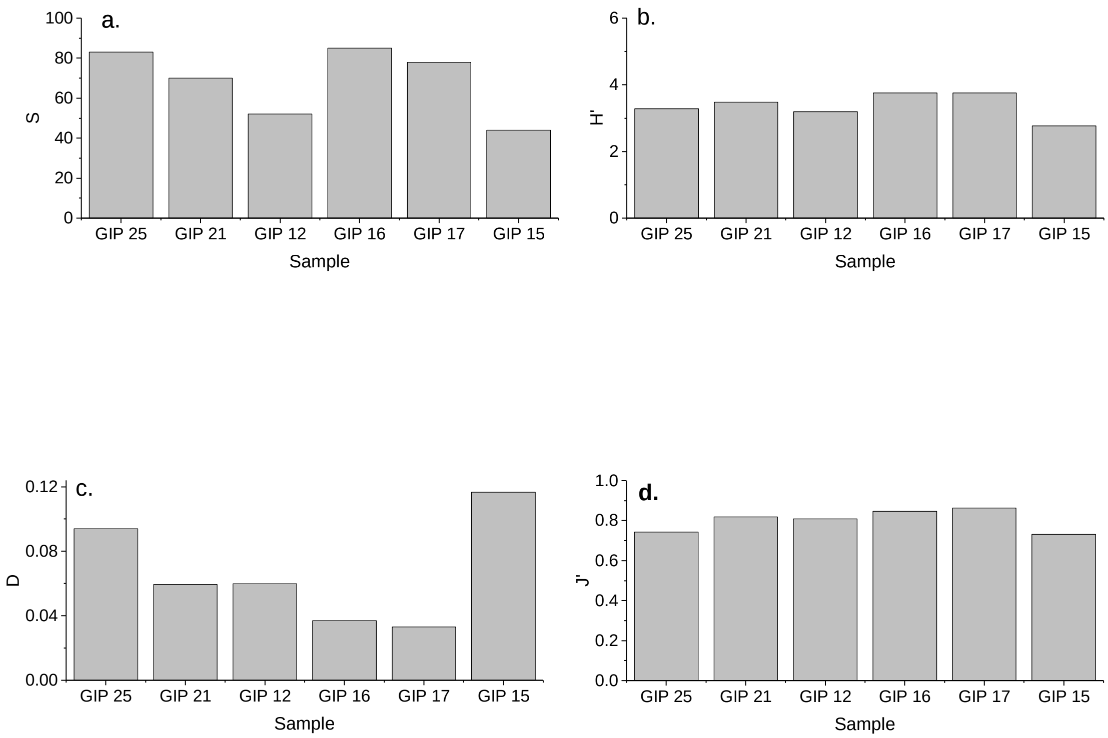


Figure 43. Diversity indices for all surface samples (2010). Samples are ordered from left to right by increasing [TPAH]. Higher diversities are indicated by higher values of S (a) and H’ (b) and lower values of D (c). High values of the J’ (d) index indicate greater equitability.

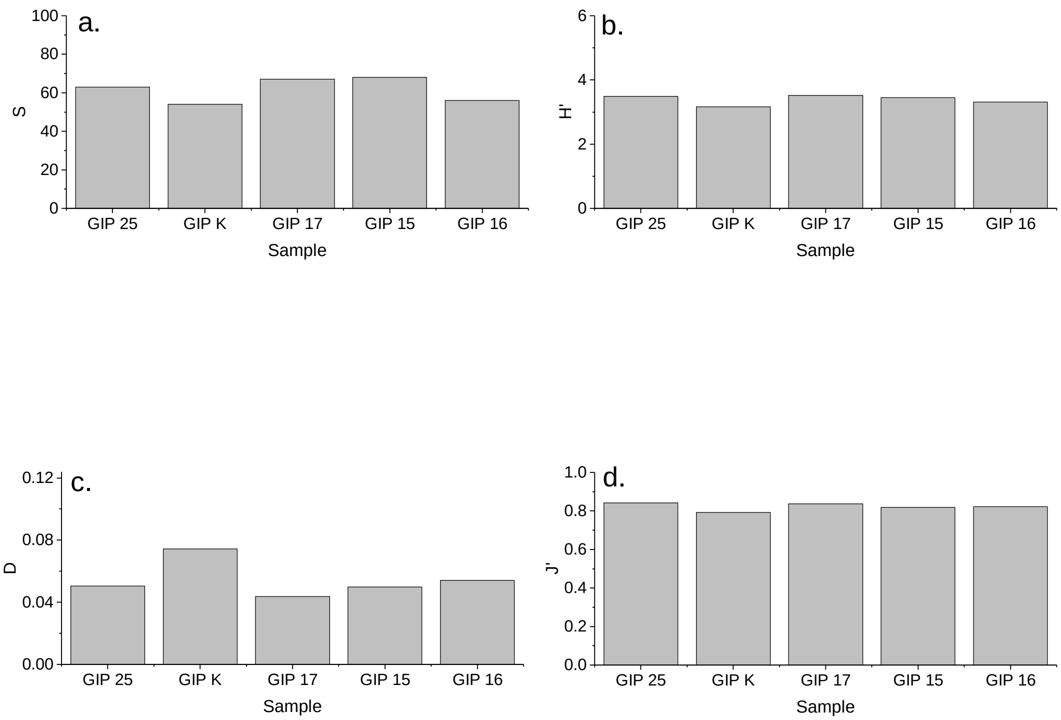


Figure 44. Diversity indices for all surface samples (2011). All samples have [TPAH] <1,000 ng/g (background concentrations) and are ordered from left to right by increasing [TPAH]. Higher diversities are indicated by higher values of S (a) and H' (b) and lower values of D (c). High values of the J' (d) index indicate greater equitability.

The H' and J diversity indices follow the same trend as the S index, whereas the D index trends oppositely with the S index among all the surface samples in both years (Figures 42b-e, 43b-e, 44b-e, and 45-46 and Tables 9-11); hence they will not be described in any further detail.

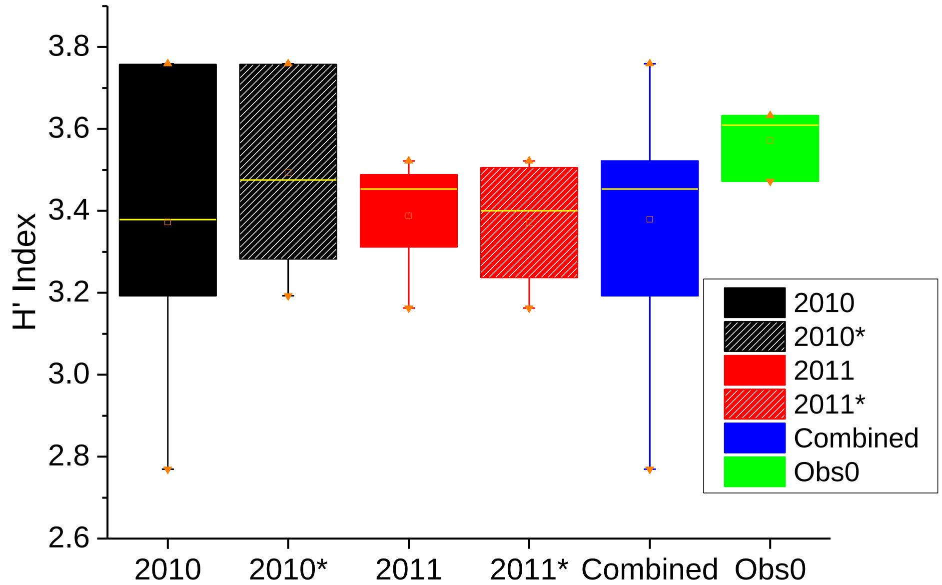


Figure 45. Whisker plot of H' index versus sites. The * in the legend and x-axis indicates removal of GIP 15. The top and bottom of the colored boxes are the 25th and 75th percentiles. The yellow line, open orange box, and filled orange triangle indicate median, mean, and1st/99th percentiles, respectively. The capped, vertical bars extending from the boxes indicate maximum and minimum values. The 2010 and 2011 groups contain six and five surface samples, respectively. The combined group contains a total 14 surface samples. The Obs0 group contains three pseudo-replicates.

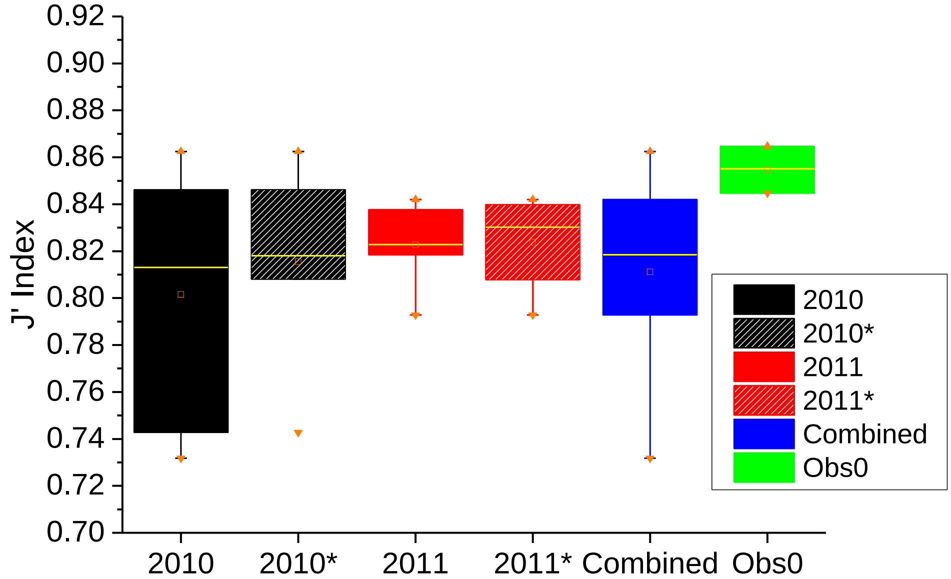


Figure 46. Whisker plot of J' index versus sites. The * in the legend and x-axis indicates removal of GIP 15. The top and bottom of the colored boxes are the 25th and 75th percentiles. The yellow line, open orange box, and filled orange triangle indicate median, mean, and 1st/99th percentiles, respectively. The capped, vertical bars extending from the boxes indicate maximum and minimum values. The 2010 and 2011 groups contain six and five surface samples, respectively. The combined group contains a total 14 surface samples. The Obs0 group contains three pseudo-*replicates.*

Table 9

Measures of Central Tendency for H' Index

Group	Median	25%	75%
Surface Samples (2010)	3.38	3.19	3.76
Surface Samples (2011)	3.48	3.28	3.76
Pseudo-Replicates (Obs0)	3.61	3.47	3.63
GIP 25's Downcore (2010)	3.12	2.99	3.29

Table 9 (continued).

Group	Median	25%	75%
GIP 25’s Downcore (2011)	3.09	3.03	3.22
GIP 15’s Downcore (2010)	2.63	2.02	2.91
GIP 15’s Downcore (2011)	2.80	2.54	3.31

Table 10

Measures of Central Tendency for D Index

Group	Average	Standard Deviation
Surface Samples (2010)	0.07	0.03
Surface Samples (2011)	0.05	0.01
Pseudo-Replicates (Obs0)	0.04	0.01
GIP 25’s Downcore (2010)	0.10	0.05
GIP 25’s Downcore (2011)	0.10	0.10
GIP 15’s Downcore (2010)	0.12	0.05
GIP 15’s Downcore (2011)	0.10	0.04

Table 11

Measures of Central Tendency for J’ Index

Group	Median	25%	75%
Surface Samples (2010)	0.81	0.74	0.85
Surface Samples (2011)	0.82	0.82	0.84

Table 11 (continued).

Group	Median	25%	75%
Pseudo-Replicates (Obs0)	0.86	0.84	0.86
GIP 25's Downcore (2010)	0.79	0.74	0.82
GIP 25's Downcore (2011)	0.80	0.76	0.82
GIP 15's Downcore (2010)	0.71	0.59	0.73
GIP 15's Downcore (2011)	0.74	0.71	0.82

Cores (GIP 25 versus GIP 15). The medians of the S index for the control site (GIP 25) between collection years are not notably different with a median of 49 species embraced by 25th and 75th percentiles of 47 and 57 species in 2010 and a median of 48 species embraced by 25th and 75th percentiles of 44 and 55 species in 2011 (Figure 47, Tables 8 and 12). The 2010 surface sample is most diverse, with 83 species, and all sample depths below are less diverse ranging from 45 to 60 species (Figure 48a). The samples between 1 and 6 cm stay stable between 46 and 57 species, but the S index decreases to 45 species at 6 to 7 cm. Samples below 7 cm increase in the S index to 57 species at the last depth interval at GIP 25 in 2010. The 2011 surface sample at GIP 25 has 63 species and sharply decreases to 39 species at 2 to 3 cm (Figure 49a). A sharp increase in the S index, a subsurface maximum of 60 species, occurs at 3 to 4 cm. The samples below 4 cm decrease again and the sample from 6 to 7 cm contains 42 species. The S index increases from 44 to 48 species in the last few depth intervals in the 2011 GIP 25 core.

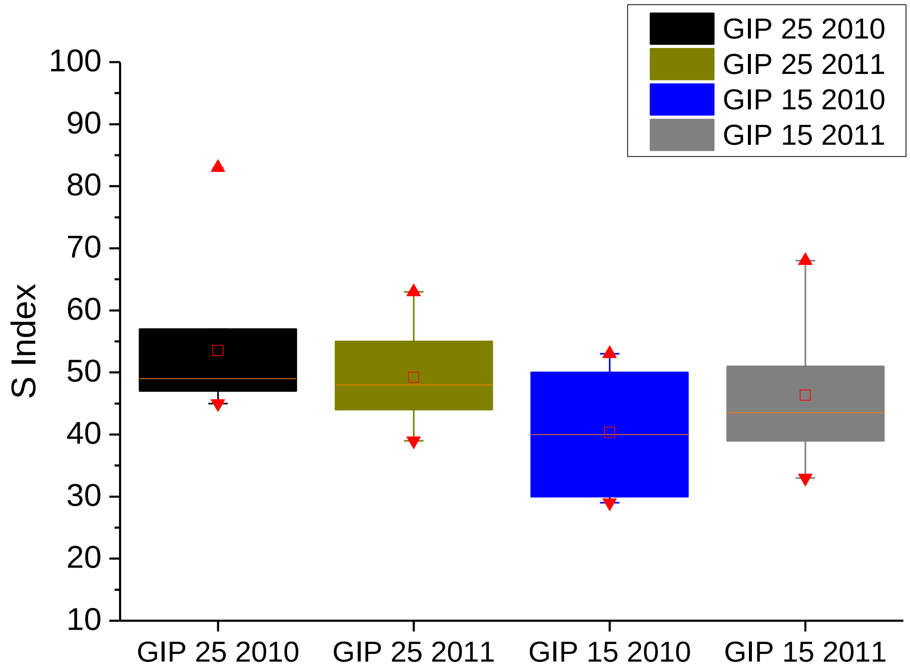


Figure 47. Whisker plot of the S index in composited downcore samples at GIP 25 and 15. The base and top of the colored boxes mark the 25th and 75th percentiles. Orange line, open red box, and filled red triangle indicate median, mean, and 1st/99th percentiles, respectively. The capped vertical lines extending from the boxes indicate maximum and minimum values. Ten and six downcore samples are included in each of the GIP 25 and 15 groups, respectively.

Table 12

Diversity Indices for GIP 25's Downcore Samples

Sample	Species Richness	H'	D	E	J
GIP 25_10 (0-1 cm)	83	3.28	0.09	0.32	0.74
GIP 25_10 (1-2 cm)	46	2.56	0.18	0.28	0.67
GIP 25_10 (2-3 cm)	47	2.54	0.19	0.27	0.66
GIP 25_10 (3-4 cm)	50	3.04	0.09	0.42	0.78
GIP 25_10 (4-5 cm)	54	3.37	0.04	0.54	0.84
GIP 25_10 (5-6 cm)	57	3.34	0.05	0.50	0.83

Table 12 (continued).

Sample	Species Richness	H'	D	E	J
GIP 25_10 (6-7 cm)	45	2.99	0.07	0.44	0.79
GIP 25_10 (7-8 cm)	48	3.16	0.06	0.49	0.82
GIP 25_10 (8-9 cm)	48	3.08	0.07	0.45	0.80
GIP 25_10 (9-10 cm)	57	3.29	0.06	0.47	0.81
GIP 25_11 (0-1 cm)	63	3.49	0.05	0.52	0.84
GIP 25_11 (1-2 cm)	44	2.41	0.19	0.25	0.64
GIP 25_11 (2-3 cm)	39	1.97	0.33	0.18	0.54
GIP 25_11 (3-4 cm)	60	3.11	0.10	0.38	0.76
GIP 25_11 (4-5 cm)	55	3.22	0.07	0.45	0.80
GIP 25_11 (5-6 cm)	48	3.24	0.05	0.53	0.84
GIP 25_11 (6-7 cm)	42	3.06	0.06	0.51	0.82
GIP 25_11 (7-8 cm)	44	3.07	0.06	0.49	0.81
GIP 25_11 (8-9 cm)	49	3.12	0.06	0.46	0.80
GIP 25_11 (9-10 cm)	48	3.03	0.07	0.43	0.78

Note. Samples from 2010 and 2011 are indicated by "_10," and "_11," respectively.

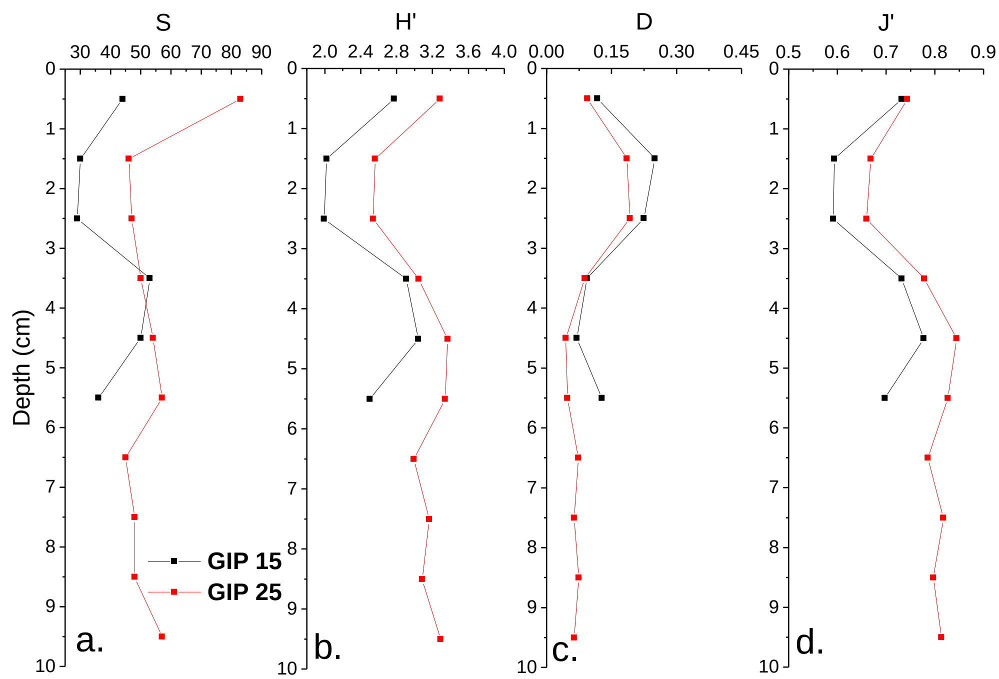


Figure 48. Diversity indices for downcore samples at GIP 25 and 15 (2010). Higher diversities are indicated by higher values of S (a) and H' (b) and lower values of D (c). High values of the J' (d) index indicate greater equitability. The DOH of GIP 15 extends to only 6 cm.

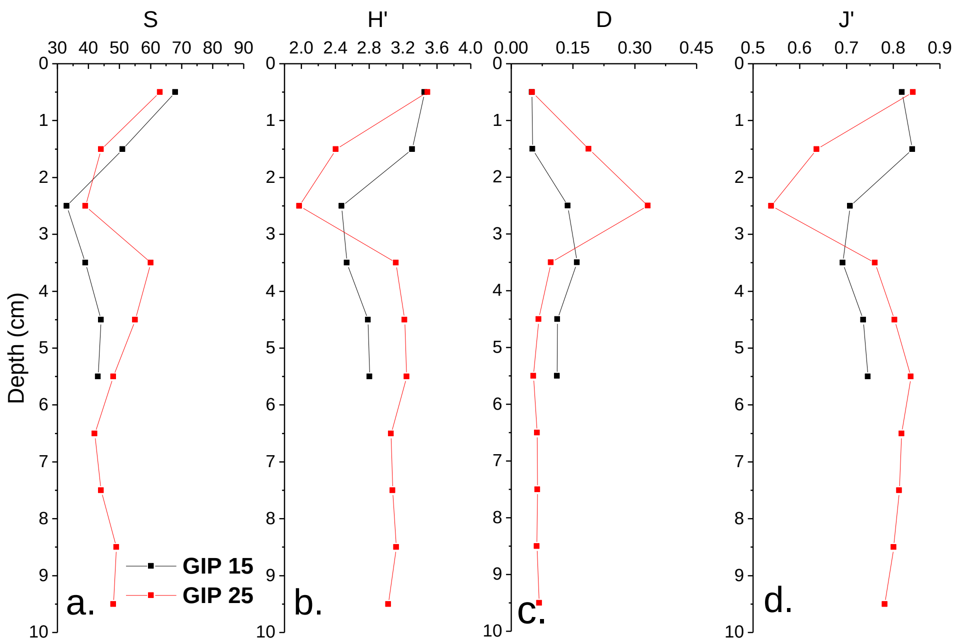


Figure 49. Diversity indices for downcore samples at GIP 25 and 15 (2011). Higher diversities are indicated by higher values of S (a) and H' (b) and lower values of D (c). High values of the J' (d) index indicate greater equitability. The DOH of GIP 15 extends to only 6 cm.

The medians of the S index for the heavily-oiled site (GIP 15) between collection years are slightly different with a median of 40 species and 25th/75th percentiles of 30/50 species in 2010 and a median of 44 species and 25th/75th percentiles of 39/51 species in 2011 (Figure 47,Tables 8 and 13). The S index in the 2010 GIP 15 core is 44 species at the surface (Figure 48a), decreases to a minimum of 30 and 29 at 1 and 3 cm, and increases sharply to 53 and 50 species at 3-4 and 4-5 cm, respectively. The deepest interval (5 to 6 cm), which is at least 4 cm shallower than the DOH at the 2010 GIP 15 site, decreases in the S index to 36 species. In 2011, the S index of the GIP 15 surface sample is high at 68 species, decreases sharply to 51 species at 2 to 3 cm, 33 species at 3 to 4 cm (Figure 49a), and below remains relatively stable between 39 and 44 species.

Table 13

Diversity Indices for GIP 15's Downcore Samples

Sample	Species Richness	H'	D	E	J
GIP 15_10 (0-1 cm)	44	2.77	0.12	0.36	0.73
GIP 15_10 (1-2 cm)	30	2.02	0.25	0.25	0.59
GIP 15_10 (2-3 cm)	29	1.99	0.22	0.25	0.59
GIP 15_10 (3-4 cm)	53	2.91	0.09	0.34	0.73
GIP 15_10 (4-5 cm)	50	3.04	0.07	0.42	0.78
GIP 15_10 (5-6 cm)	36	2.50	0.13	0.34	0.70
GIP 15_11 (0-1 cm)	68	3.45	0.05	0.46	0.82
GIP 15_11 (1-2 cm)	51	3.31	0.05	0.54	0.84
GIP 15_11 (2-3 cm)	33	2.47	0.14	0.36	0.71
GIP 15_11 (3-4 cm)	39	2.54	0.16	0.32	0.69
GIP 15_11 (4-5 cm)	44	2.78	0.11	0.37	0.74
GIP 15_11 (5-6 cm)	43	2.81	0.11	0.38	0.75

Note. Samples from 2010 and 2011 are indicated by "_10," and "_11," respectively.

The overall S index at GIP 25 is higher than at GIP 15 for both collection years, except in the case of the top 2 cm where the S index is similar between the sites in 2011. The S index decreases from 2010 to 2011 within the surface sample at GIP 25 from 83 to 63 species, while an increase occurs for the surface sample of the heavily oiled site from 44 to 68 species. A greater S index is found in the 2010 downcore samples at GIP 25 than at GIP 15; however, two depth intervals, 3-4 and 4-5 cm, have a similar S index of about 50 for both sites. The S index is quite similar between sites within the range of 0 to 3 cm with 30 to 70 species in the samples from 2011. The maximum S index occurs for GIP 15 in

2010 with 53 species at 3-4 cm, and two maximums occurs in 2011 at GIP 25 for depth intervals 0-1 and 3-4 cm of 63 and 60 species, respectively.

The H’ and J diversity indices trend similarly with species riches and the D index trends oppositely to the S index downcore at GIP sites 15 and 25 for both years (Figures 48b-e, 49b-e, and 50-51 and Tables 9-11); hence they will not be described in any further detail.

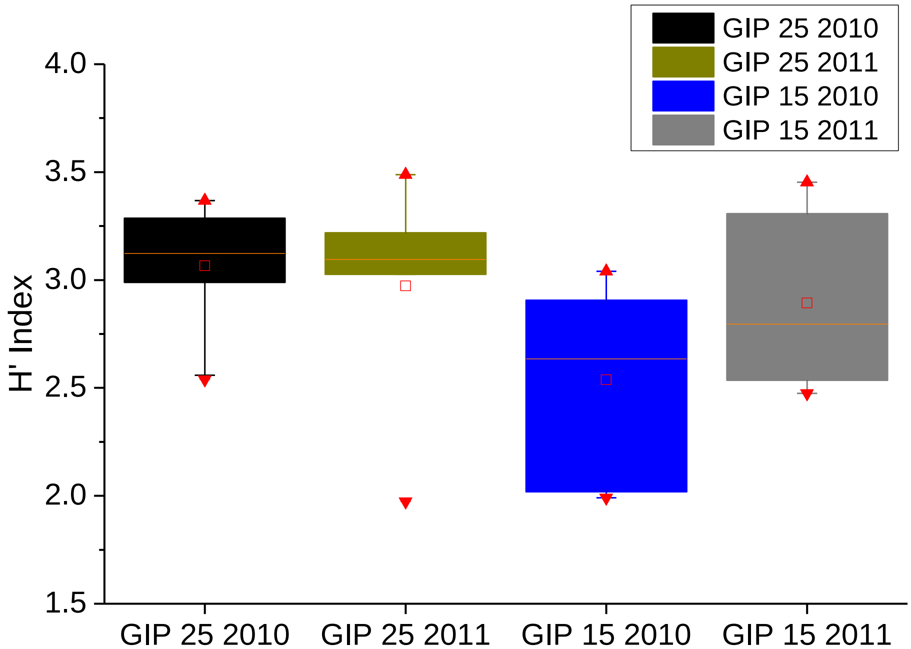


Figure 50. Whisker plot of H' index in composited downcore samples at GIP 25 and 15. The base and top of the colored boxes mark the 25th and 75th percentiles. Orange line, open red box, and filled red triangle indicate median, mean, and1st/99th percentiles, respectively. The capped vertical lines extending from the boxes indicate maximum and minimum values. Ten and six downcore samples are included in each of the GIP 25 and 15 groups, respectively.

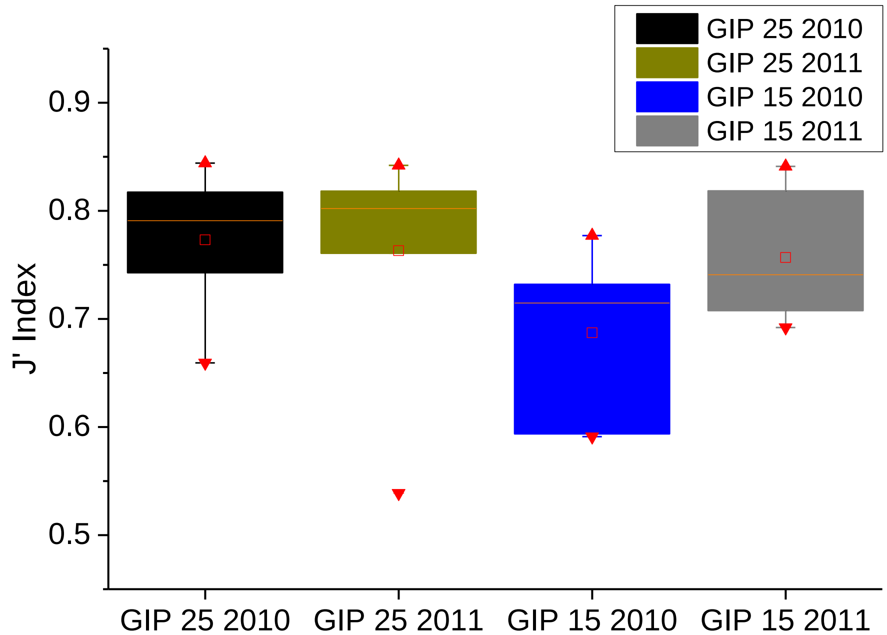


Figure 51. *Whisker* plot of J' index in composited downcore samples at GIP 25 and 15. The base and top of the colored boxes mark the 25th and 75th percentiles. Orange line, open red box, and filled red triangle indicate median, mean, and 1st/99th percentiles, respectively. The capped vertical lines extending from the boxes indicate maximum and minimum values. Ten and six downcore samples are included in each of the GIP 25 and 15 groups, respectively.

Foraminiferal Opportunistic and/or Stress Tolerant Species

Bulimina aculeata, a species documented in previous studies as stress tolerant and/or opportunistic in stressed environments, was recorded in the GIP samples (Alve, 1995; Mojtahid et al., 2006; and Denoyelle et al., 2010). *Bulimina aculeata* comprises nearly 30% of the benthic assemblage in the surface sample at GIP 15 in 2010, but the abundance is substantially less (5%) at GIP 25. In 2010, *Bulimina aculeata* is less frequent in the rest of the downcore samples at GIP 15 (range: 2 to 12%) and at the 2010 GIP 25 site (range: 1 to 5%). Furthermore, the juvenile stage of *B. aculeata* comprises nearly 40% of the juveniles present in the surface sample at GIP 15 and only 8% at GIP 25 in 2010.

The percentages of *Bulimina aculeata* (adult) in the 2011 surface samples decreased notably at GIP 15 (7%) and slightly at GIP 25 (2%). The juvenile stage of *B. aculeata* also decreases substantially in the surface sample at GIP 15 (6%) and was not present at GIP 25 in 2011. The downcore samples are not notably different from the 2010 samples at either site (GIP 15: 4 to 18%; GIP 25: 0 to 7%)

In addition to *Bulimina aculeata*, *Uvigerina peregrina* has also been documented as stress tolerant (Mojtahid et al., 2006 and Denoyelle et al., 2010) and has been documented in the GIP samples. The surface sample at GIP 15 increases in abundance of adult *U. peregrina* between collection years from 5 to 15%; however, frequencies of *U. peregrina* at GIP 25 are not notably different between collection years (2010: 8%, 2011: 5%). The frequency of adult *U. peregrina* downcore is also not particularly different between sites and collection years [GIP 15: 2010 (0 to 2%), 2011 (1 to 5%); GIP 25: 2010 (0 to 4%), 2011 (0 to 8%)]. However, the juvenile stage of *U. peregrina* is apparently different between sites and collection years. GIP 15 increases in juvenile abundance of *U. peregrina* between collection years (2010: 16%; 2011: 40%), while GIP 25 decreased (2010: 33%, 2011: 10%).

CHAPTER IV

DISCUSSION

Examining the Hypotheses

Hypothesis 1. The hypothesis is that the heavily contaminated site, GIP 15, had lower density, standing stock, and diversity in comparison with the uncontaminated site, GIP 25. The surface density at GIP 15 was four and two times higher than at GIP 25 in 2010 and 2011, respectively. The standing stock at GIP 15 was higher than that at GIP 25 in 2010; however, the following year the sites had similar standing stocks. The higher density and standing stock at GIP 15 are a possible indication of hypertrophy in 2010 followed by partial recovery in 2011, at least with respect to standing stock.

All diversity indices (S, H', D, and J') indicated higher diversity in the downcore samples at GIP 25 than at GIP 15 for both collection years. The downcore samples at GIP 25 have similarly high diversity in both years, but downcore samples at GIP 15 increased in diversity from the previous year. These trends suggest the occurrence of hypertrophy at GIP 15 in 2010 followed by partial recovery the following year. Although the results are not consistent with the hypothesis, the elevated density and standing stock at the heavily oiled site are consistent with hypertrophy as a secondary response to heavy contamination.

Hypothesis 2. The hypothesis states that the uncontaminated site (GIP 25) had a deeper DOH in comparison with the heavily contaminated site (GIP 15). The DOH was nearly two times deeper at GIP 25 than at GIP 15 for both collection years. Additionally, the DOH was possibly deeper than 10 cm at GIP 25 for both collection years because the 95th percentile of the foraminiferal population was not reached by the bottom of the sampled interval. The shallow DOH at GIP 15 is consistent with hypertrophy at the site in 2010, according to Brunner et al.'s (2013) modification of Alve's (1995) model (Figure 1). Although signs of recovery at GIP 15 in 2011 are documented by density and diversity values, the DOH did not show any noticeable difference between collection years.

Hypothesis 3. The hypothesis states that the heavily contaminated site (GIP 15) had dominant (opportunistic) species different from the uncontaminated site (GIP 25). Two species known to be opportunistic were important at the GIP sites: *Bulimina aculeata* and *Uvigerina peregrina*. Adult and juvenile *Bulimina aculeata* had higher frequencies at GIP 15 (adult: 30%, juvenile: 40%) than at GIP 25 (adult: 5%, juvenile: 8%) in surface samples of 2010. The frequencies of *B. aculeata* decreased substantially at GIP 15 (adult: 7%, juvenile: 6%) and only slightly at GIP 25 (adult: 2%, juvenile: 0%) in surface samples of 2011. In contrast, frequencies of adult *B. aculeata* downcore at GIP 25 (2010 range: 1 to 5%, 2011 range: 0 to 7%) and 15 (2010 range: 2 to 12%, 2011 range: 4 to 18%) were only slightly different between sites and similar between collection years.

Adult and juvenile *Uvigerina peregrina,* the second opportunistic species of interest, differed in frequency between sites and collection years. The frequencies of adult *U. peregrina* for the surface samples at GIP 25 were similar between collection years (2010: 8%, 2011: 5%). However, frequencies at GIP 15 were quite different between years (2010: 5%, 2011: 15%). Juvenile *U. peregrina* in the surface interval also increased substantially at GIP 15 between collection years (2010: 16%; 2011: 40%), whereas frequency decreased at GIP 25 (2010: 33%, 2011: 10%). Downcore, however, the frequency of adult *U. peregrina* was similar between sites and collection years [GIP 15: 2010 (0 to 2%), 2011 (1 to 5%); GIP 25: 2010 (0 to 4%), 2011 (0 to 8%)]. Abundance of juvenile *U. peregrina* in the downcore samples decreased at GIP 25 (2010 range: 0 to 13%, 2011 range: 0 to 9%) and increased at GIP 15 (2010 range: 0 to 3%, 2011 range: 3 to 11%) between collection years.

The abundance of *Bulimina aculeata* in both the adult and juvenile forms does fully support the hypothesis between GIP 25 and 15. However, the frequency of adult *Uvigerina peregrina* does not increase with increasing [TPAH], and therefore does not fully support the hypothesis. However, juvenile *U. peregrina* does have elevated percentages at GIP 15 a year after the spill when percentages of *B. aculeata* have decreased, suggesting succession as seen in recovery from stressful, low-oxygen conditions (i.e., Kurbjeweit et al., 2000). The high percentages of *B. aculeata* provide additional support that GIP 15 possibly underwent hypertrophy in 2010 and some degree of recovery in 2011.

Hypothesis 4. The hypothesis is that contaminated sites had a difference in assemblage structure in comparison with the uncontaminated sites [e.g., low abundance of juveniles and agglutinated species (suborder: Textulariina)]. Juvenile abundance in the surface samples does not support the hypothesis. In 2010, one of the least and the most contaminated sites [GIP 12 (uncontaminated) and 15 (heavily contaminated)] both had the highest relative frequencies of juveniles of any other sample from either collection year; additionally, the percentages in these two samples were quite similar. Juveniles in the downcore samples at the 2010 GIP 25 site were much lower in frequency than juveniles at the 2011 GIP 25 site. Juveniles were lower in the downcore samples in both years at GIP 15 compared with GIP 25, consistent with contamination at GIP 15. In contradiction, juveniles in the two moderately oiled surface samples (GIP 16, and 17) increased in frequency from 2010 to 2011. Hence, the hypothesis is unsupported among surface samples but supported in subsurface samples at the heavily contaminated site.

Although GIP 15 (2010) has a lower abundance of Textulariina (agglutinated species) than the other GIP surface sites, the difference in abundance between contaminated and uncontaminated samples is small in both the 2010 and 2011 collections. All downcore samples at the highly oiled site (GIP 15) in 2010 had far greater percentages of Rotaliina (calcareous) than any surface and downcore sample in either of the collection years; however, the 0-to-2-cm interval at GIP 15 from 2011 was dominated by Textulariina. The results fail to determine whether Textulariina abundance was greater at uncontaminated sites than at contaminated sites. Rather, the high frequencies of Rotaliina compared to Textulariina in the downcores samples at GIP 15 (2010) could be attributed to the greater delicacy and susceptibility of agglutinated species to chemical and/or biological degradation (Goldstein and Barker, 1988; Goldstein and Watkins, 1999; Berkeley et al., 2007).

Hypothesis 5. The hypothesis stated that the 2011 surface samples should show signs of recovery (i.e., increase in diversity and density), if the sites had been stressed in 2010. The overall species diversity as well as diversity within the two dominant suborders in the surface samples at the contaminated sites (GIP 15, 16, and 17) decreased with increasing [TPAH] in 2010. However, the signs of recovery expressed as increases in density and diversity from 2010 to 2011 are ambiguous. In terms of specimen density, GIP 17 increased from 2010 to 2011; however, the opposite occurred slightly at GIP 16 and dramatically at GIP 15. The diversity indices of the surface sample at GIP 15 increased from 2010 to 2011 but decreased slightly at GIP 16 and did not change at GIP 17. Hence, density and diversity trends at GIP 16 and 17 do not fully support the hypothesis. However, GIP 15 does show signs of recovery based on the increase in diversity from 2010 to 2011.

Hypothesis 6. The hypothesis is that the variability between the three pseudo-replicates from Obs0 was lower than that between oiled and un-oiled samples. The three pseudo-replicates from Obs0 have more similarity in assemblages and diversity values than any other surface sample collected in 2010 and 2011. The similarity is further supported by the MDS and cluster analyses of assemblages in the surface samples. The similarity of assemblages between the pseudo-replicates is an indication that despite the reported patchy distribution of foraminifera on the sea floor (Jorissen et al., 1995; Jannink et al., 1998; Fontanier et al., 2003; Schröder-Adams and Van Rooyen, 2011), assemblages within a single site seem to be more similar than assemblages from surrounding sites in the bathyal depths of the northeastern Gulf of Mexico.

Comparisons to Other's Work

Foraminiferal densities. The specimen densities at the GIP sites were compared to previous studies to determine whether using a smaller sieve size captures a better representation of the living assemblage. The surface samples and the downcore samples (0-3 cm) from all collection years were compared against available data from studies in the northern GOM near the GIP sites to determine similarities between specimen densities. All samples collected between 2010 and 2012, within the 0 to 3-cm interval, range in density from approximately 200 to 2,200 specimens/10 cm^3. Past studies (Robinson et al., 2004; Bernhard et al., 2008) in the northern GOM recorded the living assemblage and the total assemblage (Lobegeier and Sen Gupta, 2008; Sen Gupta et al., 2009) at densities far less than 200 specimens/10 cm^3 (median: 10.4 specimens/10 cm^3) within the top 3 cm. The density of the live foraminifera at the GIP sites is nearly 400 times greater than that reported by these studies. Although these past studies differed in their methodologies in comparison to the current study, the main difference was in their use of a larger sieve size (> 63 µm). Therefore, it is suggestive that the use of a smaller sieve size (45 µm) has yielded a greater proportion of the living assemblage and permits an interpretation more representative of the population.

Species distributions. Species distributions were reviewed from other studies to determine any similarities with the GIP sites. Because studies (e.g., Poag, 1981) divide the GOM into eastern and western assemblages of Foraminifera, only sites nearest the GIP sites were compared for species distributions. Many of the species encountered in the studies of Parker (1954), Robinson et al. (2004), Bernhard et al. (2008), and Sen Gupta et al. (2009) with frequencies >5% also occurred in the GIP sites but at lower frequencies. Eight species (*Bolivina albatrossi*, *Bolivina translucens, Bulimina aculeata, Cassidulina carinata, Fursenkoina tessellata, Lagenammina difflugiformis*, *Portatrochammina antarctica,* and *Uvigerina peregrina*) from the GIP sites also occurred at frequencies > 5% in the living assemblages of Parker (1954), Robinson et al. (2004), and/or Sen Gupta et al. (2009). Furthermore, the suborders found in the GIP sites are consistent with reports from all these mentioned studies in addition to Denne and Sen Gupta (1991).

The GIP abundances of the opportunistic species *Bulimina aculeata* and *Uvigerina peregrina* were compared to Parker's (1954) abundances to determine whether these species frequent the northeastern GOM. *Bolivina aculeata* and *U. peregrina* have not only shown tolerance of stressed environments, but in particular have strong correlations to high organic matter input and low oxygen levels (Fontanier et al., 2002; Sarka and Sen Gupta, 2009; Mendes et al., 2012). In the northern GOM, the only study that had high frequencies of these two species was that of Parker (1954) but her frequencies were from the total assemblage (live plus dead specimens). Frequencies of *B. aculeata* in Parker's (1954) transects II, III, V, and VI were 16% at two sites and are similar to the frequencies at GIP 12 (2010: 11%) and GIP 17 (2011: 15%); however, none of her sites have as high a percentage as GIP 15 (30%) in 2010. Three of Parker's (1954) sites also had high frequencies of *U. peregrina* (site 8: 15%; site 33: 16%; and site 38: 28%), but GIP 15 (2011) was the only sample in this study that had a similar frequency of 15%. The two sites from Parker's (1954) study with the high frequencies of *B. aculeata* are near GIP 15 (10 km southeast of Parker's site 33) and GIP 17 (9 km northeast from Parker's site 35). However, the two sites (sites 8 and 38) from Parker's (1954) study that had similar frequencies of *U. peregrina* are 135 km west and 154 km southeast, respectively, of GIP 15.

Density and diversity at the GIP sites were compared to density and diversity at sites that also tabulated microforaminifera—though outside the GOM (Kurbjeweit et al., 2000; Nozawa et al., 2006)—to determine 1) whether density and diversity would be similar to this study and 2) if density and diversity would be notably higher than in conventional studies that have used the >63 µm fraction. The study done by Kurbjeweit et al. (2000) in the Arabian Sea found similar diversities (S index: 75 to 96 species, H': 3.05 to 3.46) in the living assemblages (> 30 µm) at three bathyal, surface samples (1,900 to 2,200 m). One of the three bathyal sites from Kurbjeweit et al.'s (2000) study documented a density of 620 specimens/10 cm^2 which fell in range of the current study's density values. However, the density values of the other two bathyal sites were slightly less than those of the current study (210-250 specimens/10 cm^2; Kurbjeweit et al., 2000). Nozawa et al. (2006) also found similar diversities (S index: 41 to 65 species, H': 3.42 to 3.69) in the living assemblages (> 32 µm) in samples from abyssal depths (4,100 to 4,200 m) in the eastern Equatorial Pacific. One replicate from each of the three sites from Nozawa et al.'s (2006) study had a density value within range of the current study (362-835 specimens/10 cm^2), whereas the other replicates noticeably fell below the current study's density range (133-207 specimens/10 cm^2). The studies by Robinson et al. (2004) and Bernhard et al. (2008) used the >63 µm fraction and had an S index between 1 and 32 species; furthermore, their H' indices were distinctly less (<1.0) than the GIP samples. Sen Gupta et al. (2009) had 20 to 114 species (>63 µm) in their samples from Desoto and Mississippi Canyons. The studies by Robinson et al. (2004), Bernhard et al. (2008), and Sen Gupta et al. (2009) documented density values <17, 75, and 174 specimens/10 cm^3, respectively. In conclusion, the distinctly higher density and diversity of this work are comparable to those of Kurbjeweit et al. (2000) and Nozawa et al. (2006) and suggest that inclusion of the microforaminifera (30-65 µm) provides a better representation of the population.

Assemblage comparisons. The GIP sites were compared with Poag's (1981) biofacies study in order to determine whether all GIP and Obs0 sites are within the same biofacies. Poag's (1981) biofacies study was chosen because it integrated results from Dignes (1978), Parker (1954), and several other studies that defined benthic biofacies in the eastern GOM and proposed more refined biofacies than those of Culver and Buzas (1983). If any of the GIP samples are from differing biofacies, then the dissimilarities among site assemblages could not be considered the effects of the DWH oil spill. Conversely, dissimilarities among assemblages at GIP sites that fell within a single biofacies could be considered the effects of the contamination.

Most of the GIP sites are within Poag's (1981) *Bulimina* biofacies, except two samples (GIP 21 and K), which are located at boundaries with other biofacies. Poag (1981) reviewed the studies focusing in the entire GOM and interpreted the data into biofacies based on the most abundant genus from samples processed by past studies. Based on his interpretations, GIP 15, 16, 17, 25, and Obs0 are located within Poag's (1981) *Bulimina* biofacies. Upon closer examination of the site locations in Poag's (1981) biofacies map, GIP 12 and K are located near the boundary between the *Brizalina, Bulimina*, and *Glomospira* biofacies. GIP K, which lies consistently at the outer margin of groupings in the Q-mode cluster and MDS analyses, might be slightly different from the other GIP samples because it is located closer to the *Brizalina*, *Bulimina*, and *Glomospira* biofacies than is GIP 12, although the two sites are only 8 km apart. The deepest site (GIP 21), a distinct outlier in the Q-mode cluster and MDS analyses, is located within Poag's (1981) boundary between *Bulimina and Nuttallides* biofacies. Finally, a caveate—though GIP 16 and 17 consistently form a subgroup within a larger cluster, the cause remains unclear. The cause may be attributable to the moderate oil contamination they both suffer, but they could also be naturally different as they are the deepest samples within the MDS and cluster groupings and the deepest within Poag's *Bulimina* biofacies.

Comparison of Foraminiferal Trends with Macrofaunal Trends

Density. Densities of Foraminifera and macrofauna are compared in all surface samples to determine trends with [TPAH] (Rom, 2011; Briggs, personal communication, 2014). Although foraminiferal density does not vary with [TPAH], macrofaunal density decreases with increasing [TPAH] when GIP 15 is disregarded (Figure 52). GIP 15 has anomalously high density for both groups in 2010. The 2011 samples show an increase in macrofaunal density for the moderately oiled site GIP 17, and nearly the same for moderately oiled site GIP 16 (Figure 53). Foraminiferal density remains relatively high only at GIP 17 in 2011.

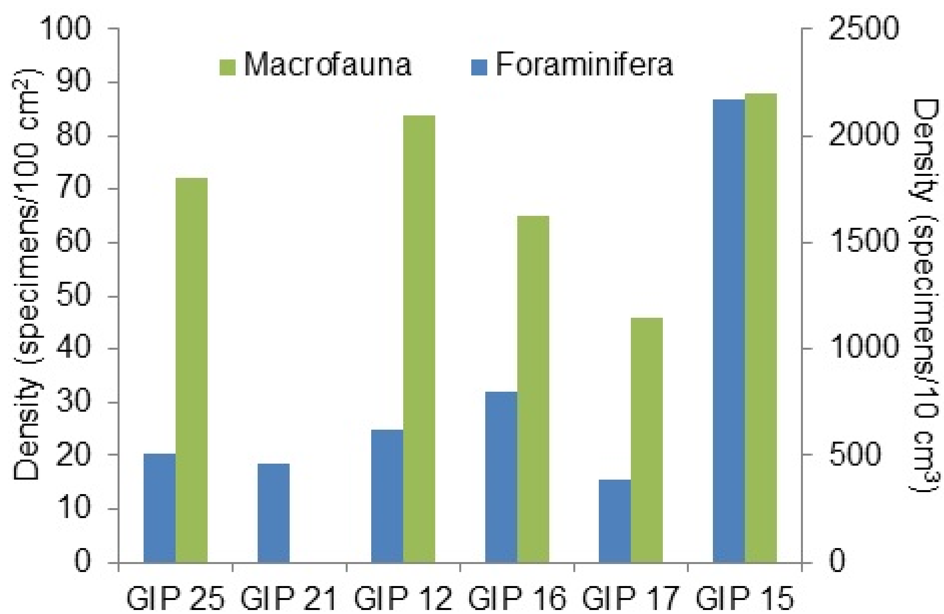


Figure 52. Specimen density trends of Foraminifera and macrofauna (2010). Samples are ordered from left to right by increasing [TPAH]. Macrofaunal and foraminiferal densities are on the left and right axes, respectively.

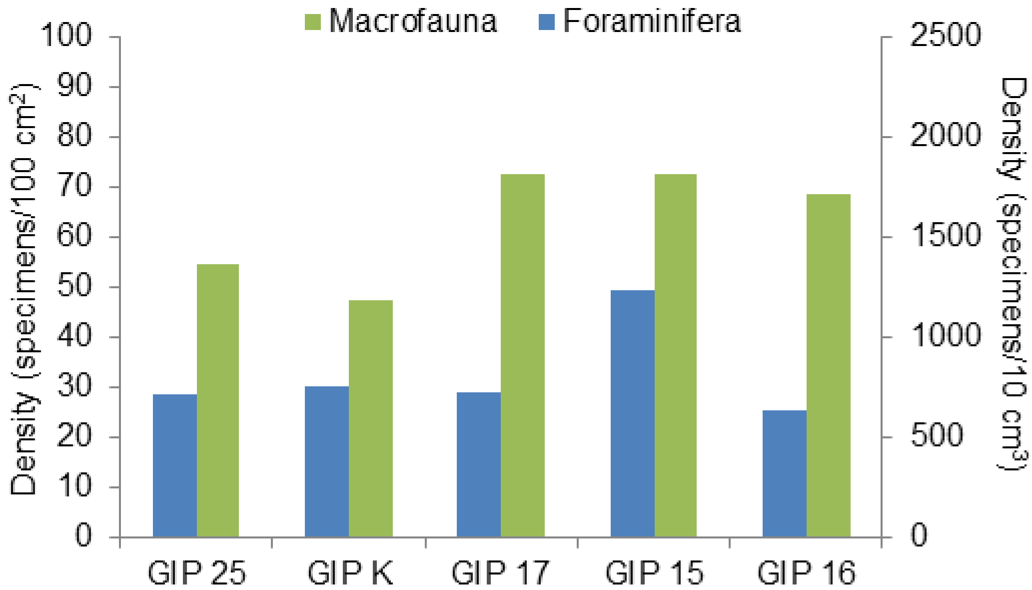


Figure 53. Specimen density trends of Foraminifera and macrofauna (2011). All samples have [TPAH] <1,000 ng/g (background concentrations) and are ordered from left to right by increasing [TPAH]. Macrofaunal and foraminiferal densities are on the left and right axes, respectively.

SR index. The SR index of Foraminifera and macrofauna are compared in all surface samples to determine any trends with [TPAH] (Rom, 2011; Briggs, personal communication, 2014). The number of species is greatest at GIP 15 for the macrofauna (11.0) and at GIP 16 for the Foraminifera (13.7) in 2010. Conversely, the lowest SR index for macrofauna is found at GIP 16 and for the Foraminifera at GIP 15 (Figure 54). The SR index shows no visible trend in either of the groups of organisms with increasing [TPAH] in 2010. In 2011, GIP 15 has the greatest SR index for both the macrofauna (12.5) and the Foraminifera (11.7; Figure 55). GIP K has the lowest abundance of species for macrofauna (6.4) and Foraminifera (9.3) in 2011. The surface samples from 2011 fall within background levels of [TPAH] and show a similar trend in the SR index for both groups of organisms.

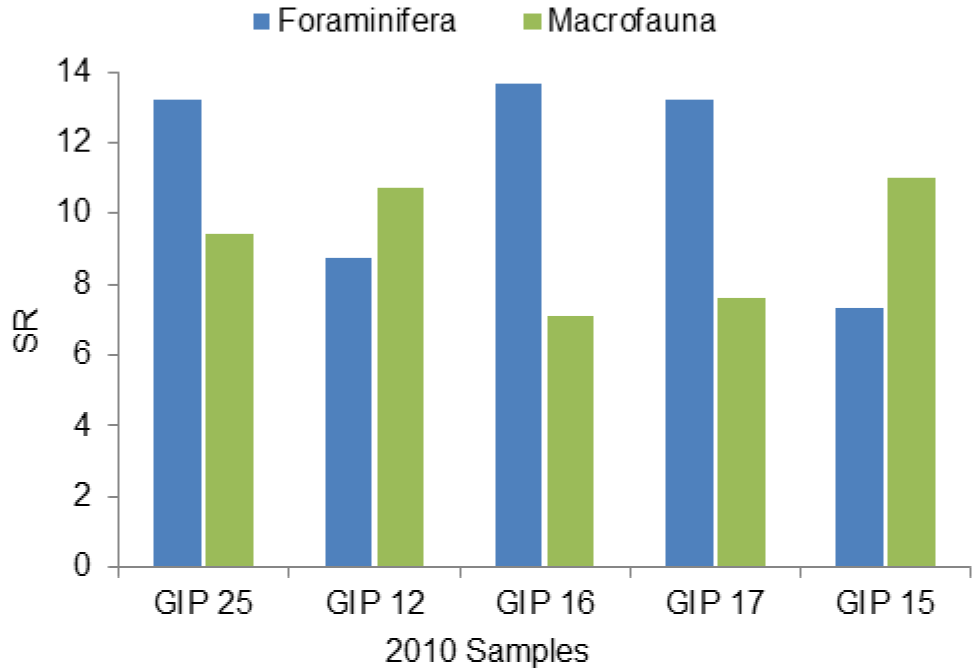


Figure 54. SR index trends of Foraminifera and macrofauna (2010). Samples are ordered from left to right by increasing [TPAH]. Foraminiferal and macrofaunal SR index values are on a single axis.

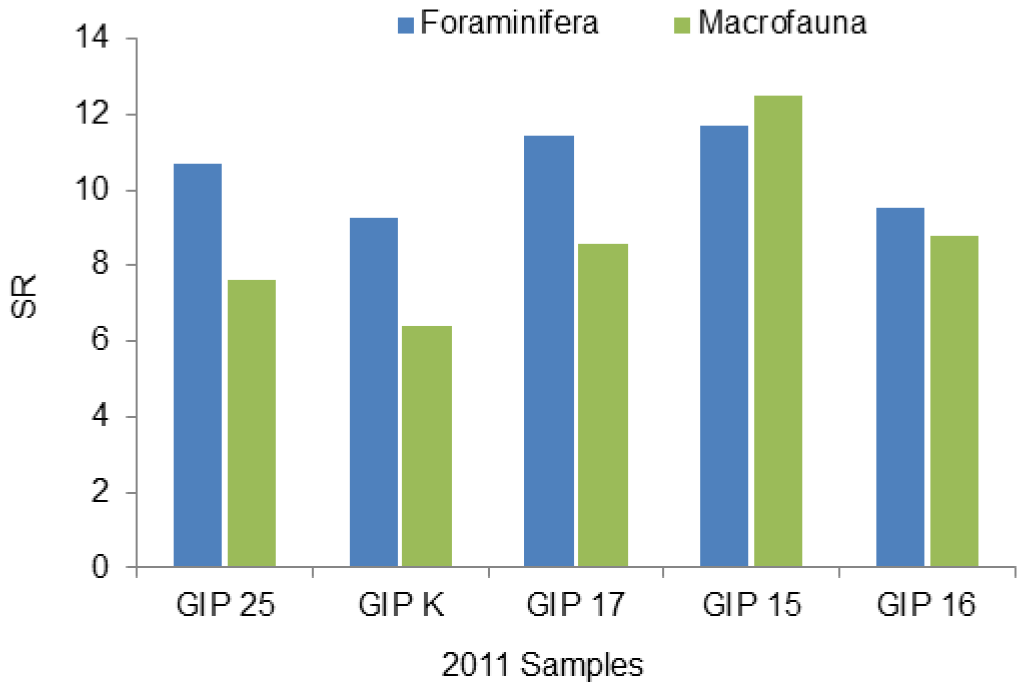


Figure 55. SR index trends of Foraminifera and macrofauna (2011). All samples have [TPAH] <1,000 ng/g (background concentrations) and are ordered from left to right by increasing [TPAH]. Foraminiferal and macrofaunal SR index values are on a single axis.

Indices of H', 1-D, and J'. The diversity indices of H', D (recalculated as 1-D to compare similarly with the trend in Shannon's diversity), and J' do show a decreasing trend in the macrofauna and an increasing trend in the Foraminifera with increasing [TPAH] with the exception of GIP 15 in 2010; however, they both have similar trends the following year (Figures 56-61). GIP 15 (2010) shows the highest diversity (H') for the macrofauna (3.67) and the lowest diversity for the Foraminifera (2.77). Furthermore, GIP 16 and 17 (2010) have the highest and lowest values of H' for the Foraminifera (GIP 16 and 17: 3.76) and the macrofauna (GIP 16: 3.03, GIP 17: 2.97), respectively. The indices of 1-D and J' in 2010 for both groups of organisms follow the same trend as the H' index. The

H’, 1-D, and J’ diversity indices trend similarly with the SR index for both groups of organisms in the 2011 surface samples.

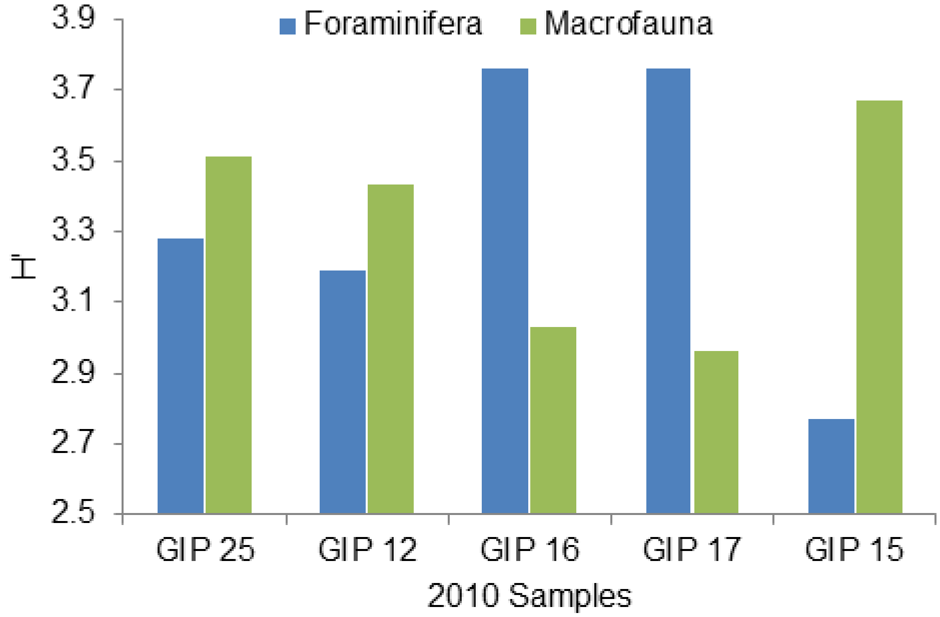


Figure 56. H’ index trends of Foraminifera and macrofauna (2010). Samples are ordered from left to right by increasing [TPAH].

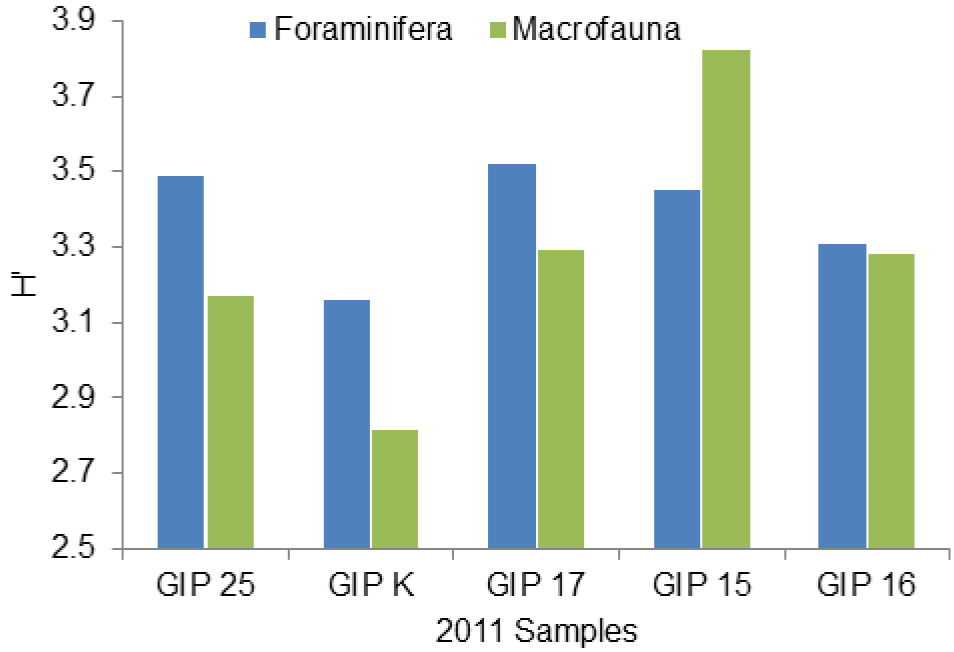


Figure 57. H' index trends of Foraminifera and macrofauna (2011). All samples have [TPAH] <1,000 ng/g (background concentrations) and are ordered from left to right by increasing [TPAH].

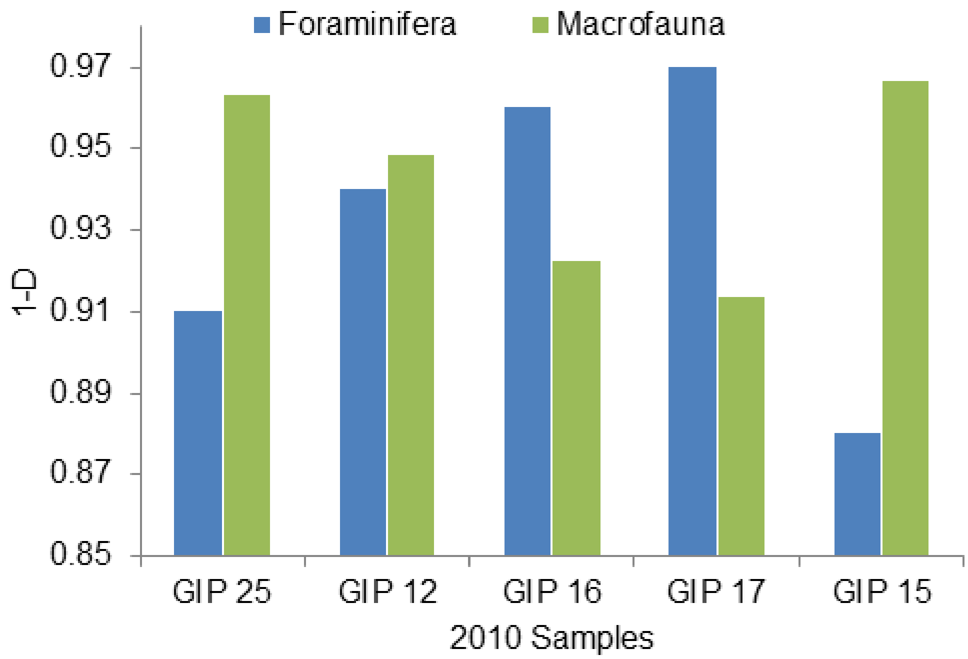


Figure 58. 1-D index trends of Foraminifera and macrofauna (2010). Samples are ordered from left to right by increasing [TPAH].

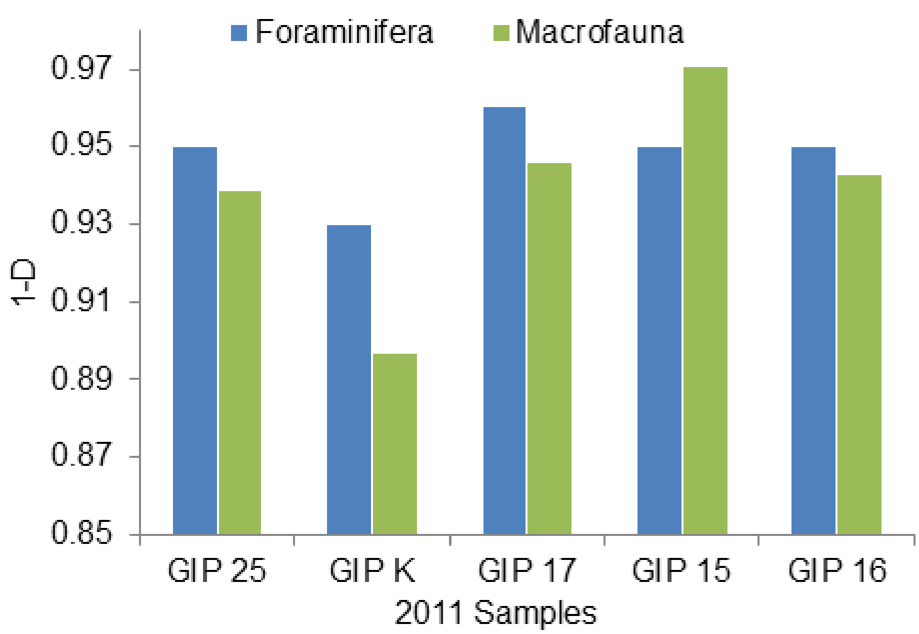


Figure 59. 1-D index trends of Foraminifera and macrofauna (2011). All samples have [TPAH] <1,000 ng/g (background concentrations) and are ordered from left to right by increasing [TPAH].

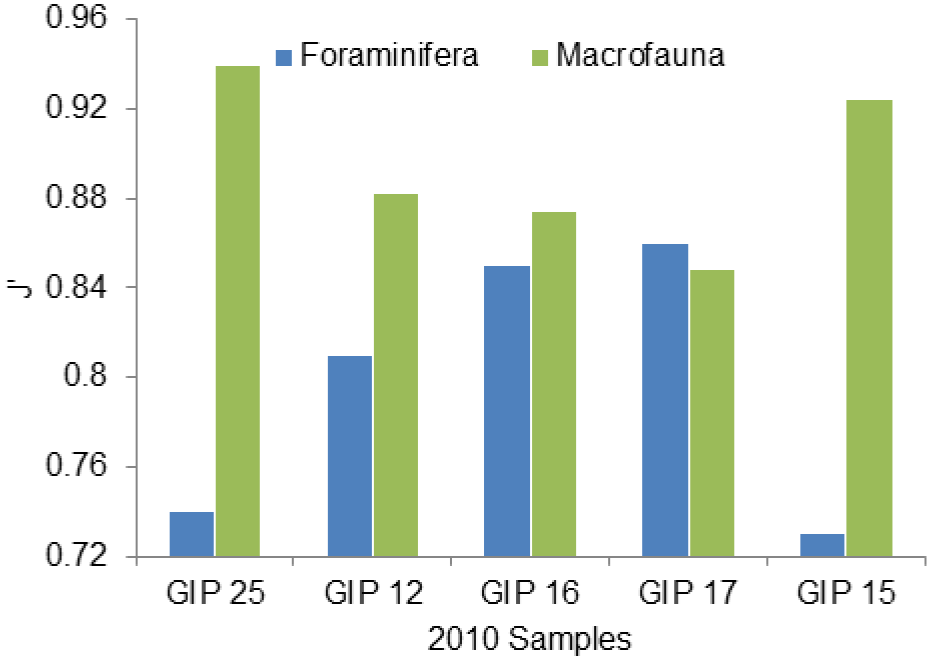


Figure 60. J' index trends of Foraminifera and macrofauna (2010). Samples are ordered from left to right by increasing [TPAH].

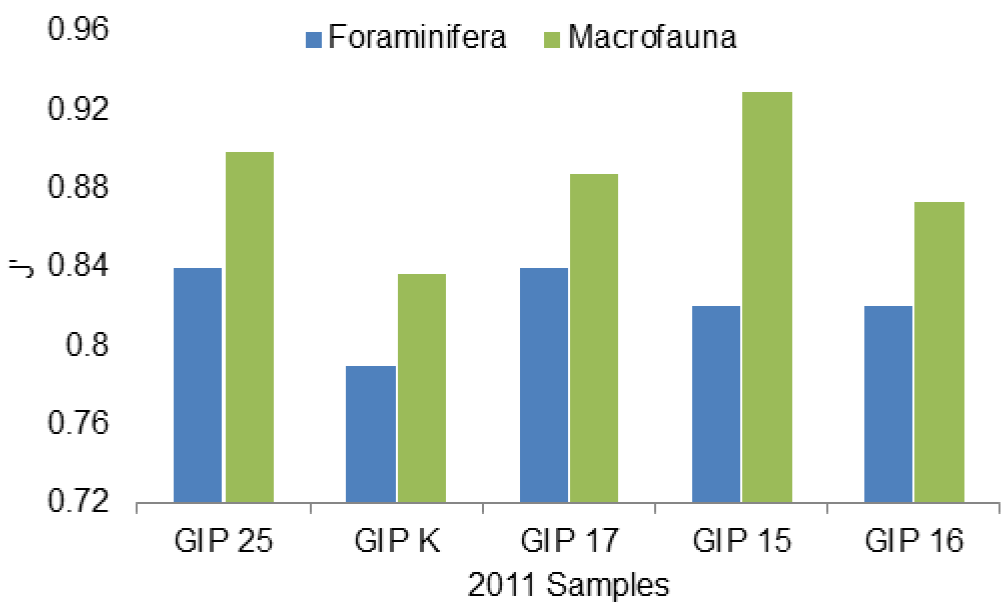


Figure 61. J' index trends of Foraminifera and macrofauna (2011). All samples have [TPAH] <1,000 ng/g (background concentrations) and are ordered from left to right by increasing [TPAH].

Opportunists. The opportunistic and stress-tolerant species of the Foraminifera and macrofauna from GIP 15 and 25 also were also compared to determine trends among sites (Briggs, personal communication, 2014). The macrofaunal opportunists are divided into classic and associated opportunistic species. The classic opportunists consist of polychaetes within the families of Capitellidae and Spionidae. In contrast to the classic opportunists, the associated opportunists are more abundant and diverse and consist of polychaetes, bivalves, and one holothurian found in transitory organic enrichment environments (*sensu* Pearson and Rosenberg, 1978). The opportunistic and stress-tolerant species of the Foraminifera include *Bulimina aculeata* and *Uvigerina peregrina*. There is no trend in abundance of classic opportunists (macrofauna) or foraminiferal opportunists with increasing [TPAH] in the 2010 samples; however, *B. aculeata* is elevated in abundance at GIP 15 (Figure 62). The abundance of macrofaunal associated opportunists does decrease with increasing [TPAH].

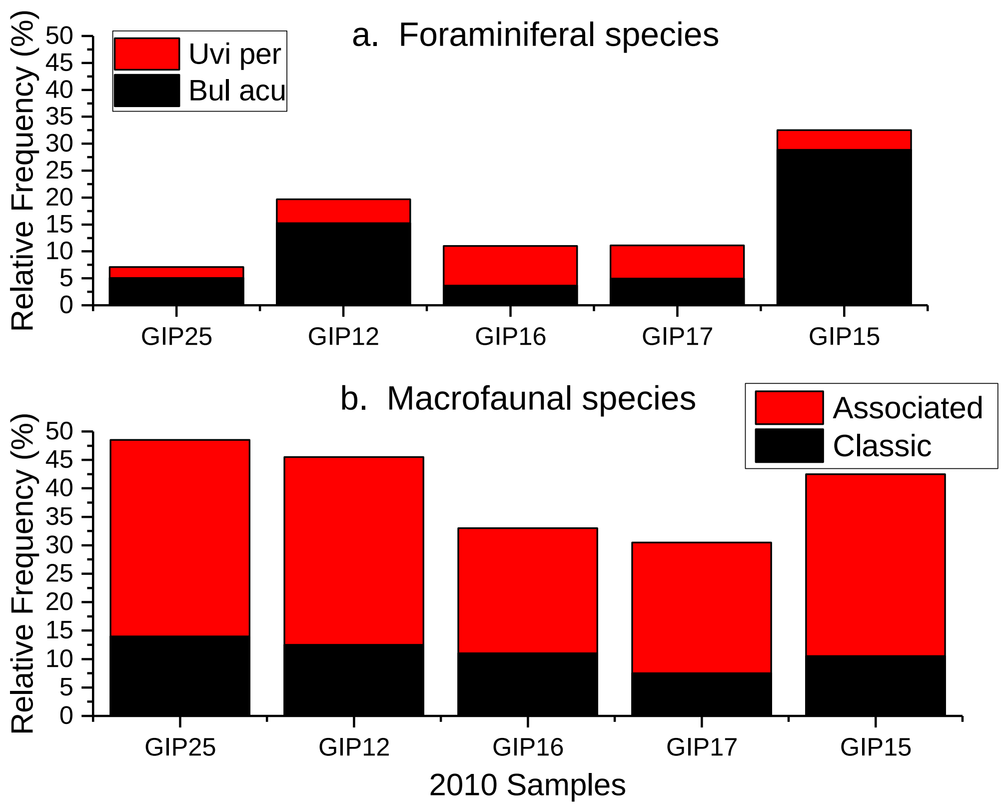


Figure 62. Opportunistic species trends of Foraminifera and macrofauna (2010). Samples and are ordered from left to right by increasing [TPAH]. The top portion (a) consists of foraminiferal species: Bulimina aculeata (Bul acu) and Uvigerina peregrina (Uvi per). The bottom portion (b) includes species from the macrofaunal group. Classic species include polychaetes from the families of Capitellidae and Spionidae. Associated species include polychaetes, bivalves, and a holothurian.

The samples from 2011 have [TPAH] <1,000 ng/g, and they have no visible trend in the foraminiferal opportunists with increasing [TPAH] (Figure 63). Additionally, no trend is visible in regard to the abundances of macrofaunal associated or classic opportunists with increasing [TPAH] in 2011. All opportunists for the Foraminifera and macrofauna decrease from 2010 to 2011 at GIP 25. GIP 15 and 16 have similar abundances of classic and associated macrofaunal opportunists between years, but they have a decrease in *B. aculeata* and an increase in *U. peregrina*. GIP 17 has somewhat similar abundances of macrofaunal opportunists between years, but the site has an increase in *B. aculeata* and a decrease in *U. peregrina*. The classification of macrofaunal opportunistic species is not necessarily defined by [TPAH], but traditionally by other factors such as organic enrichment and low oxygen (Pearson and Rosenberg, 1978).

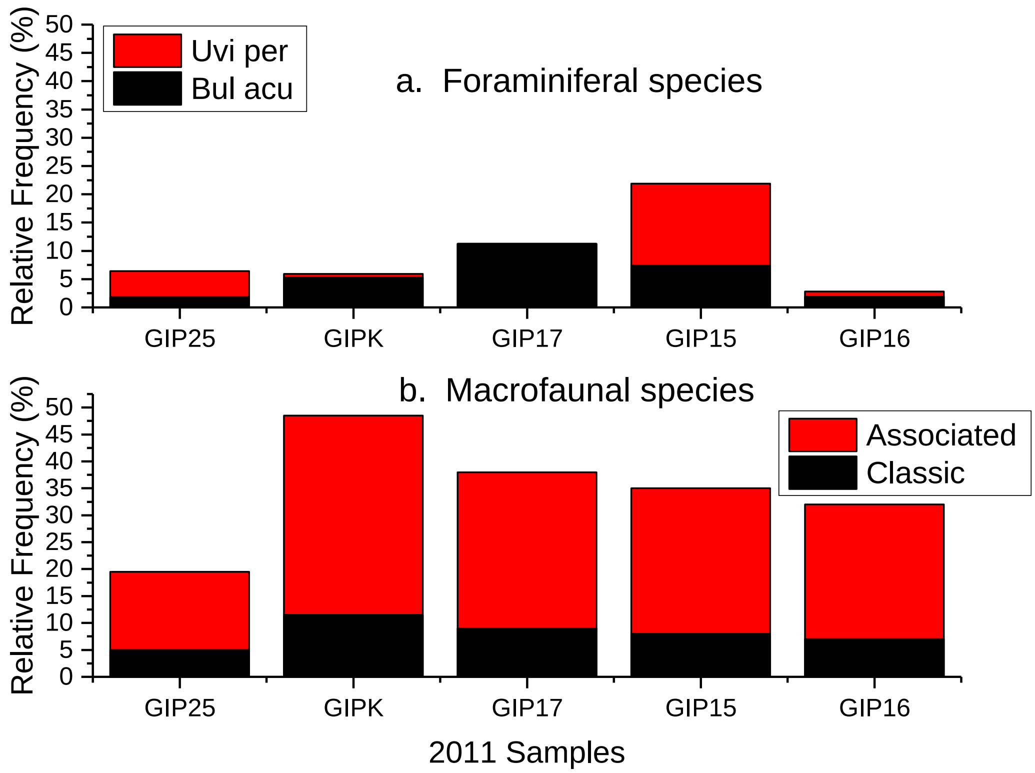


Figure 63. Opportunistic species trends of Foraminifera and macrofauna (2011). All samples have [TPAH] <1,000 ng/g (background concentrations) and are ordered from left to right by increasing [TPAH]. The top portion (a) consists of foraminiferal species: Bulimina aculeata (Bul acu) and Uvigerina peregrina (Uvi per). The bottom portion (b) includes species from the macrofaunal group. Classic species include polychaetes from the families of Capitellidae and Spionidae. Associated species include polychaetes, bivalves, and a holothurian.

Conclusion

1. The GIP 15 site from 2010 showed characteristics of a hypertrophic zone based on the shallow depth of habitation, high standing stock, high abundance of *Bulimina aculeata*, high densities, and low diversities. Additionally, the high abundance of the macrofauna further supported hypertrophy at the site in 2010. Although the depth of habitation remained unchanged at GIP 15 between 2010 and 2011, signs of recovery were indicated by a reversal of the decrease in density and standing stock approaching normal values, and an increase in diversity.

2. The species (*Bulimina aculeata)* that made up nearly 30% of the assemblage at GIP 15 in 2010 was documented at two of Parker's (1954) sites with a frequency of 15%. Although, *B. aculeata* was documented in other studies at lower percentages, this opportunistic species tolerated the high [TPAH] at GIP 15 in 2010 and was able to survive even in the juvenile stage as demonstrated by the high juvenile abundance.

3. The juveniles present within contaminated and uncontaminated sites from 2010 showed no notable difference in abundance. *Bulimina aculeata* contributed a large portion to the juvenile abundance in a few of the sites.

4. The three pseudo-replicates from Obs0 showed more similarity than any other surface sample collected in either of the collection years based on the MDS analysis. The similarity between the pseudo-replicates was further confirmed by their assemblages and diversity values, and the Q-mode cluster analysis. The tentative implication is that though foraminiferal assemblages are known to be patchy in all measures, they vary more among sites than within sites

so that the differences among sites shown in this study may be used to differentiate between stressed and unstressed populations.

5. Despite the differences in sieve size used and documented density and diversity values, the species encountered at the GIP sites were consistent with those previously documented by Parker (1954), Denne and Sen Gupta (1991), Robinson et al. (2004), Bernhard et al. (2008), Lobegeier and Sen Gupta (2008), and Sen Gupta et al. (2009). Additionally, several species that were documented at frequencies > 5% in the GIP sites were also encountered at similar frequencies in the living assemblages of the studies mentioned.

6. For the most part, the macrofauna and Foraminifera showed opposing trends in density and diversity in 2010. Furthermore, GIP 15 (2010) showed a clear distinction from the other surface samples in both the macrofauna and Foraminifera with its elevated densities. The samples in 2011 showed similar trends in all the diversity indices for both groups of organisms.

7. The assemblages from GIP 12, 15, 16, 17, 25, and Obs0 fall within Poag's (1981) *Bulimina* biofacies. GIP K seems to be located along the boundary of the *Brizalina*, *Bulimina*, and *Glomospira* biofacies and is consistent with its marginal placement in the Q-mode cluster and MDS analyses. GIP 21 is part of a deeper assemblage and is located within the boundary of Poag's (1981) *Bulimina* and *Nuttallides* biofacies, an interpretation that is also consistent with its outlier placement in the Q-mode cluster and MDS analyses.

8. The foraminiferal population in the >45 µm size fraction at the GIP sites was substantially larger than populations reported in studies that used a >63 or

>74 µm size fraction. Specifically, the use of a smaller sieve size produced nearly 400 times the density and higher diversity than reported previously in the northern GOM, and these values of density and diversity are comparable to past studies (i.e., Kurbjeweit et al., 2000; Nozawa et al., 2006) that included the microforaminiferal population.

APPENDIX A

TAXONOMIC NOTES

Order FORAMINIFERIDA Eichwald, 1830
Suborder TEXTULARIINA Delage and Hérouard, 1869
Superfamily AMMODISCACEA Reuss, 1862
Family AMMODISCIDAE Reuss, 1862
Subfamily AMMODISCINAE Reuss, 1862
Genus *Ammodiscus* Reuss, 1862

Ammodiscus tenuis (Brady)
Trochammina tenuis Brady, 1881; *figure in* Brady, H.B., 1884, vol. 9, pl. 38, figs. 4-60.
Notes: The juvenile stage of this species is documented in at least one sample.

Subfamily AMMOVERTELLININAE Saidova, 1981
Genus *Glomospira* Rzehak, 1885

Glomospira gordialis (Jones and Parker)
Trochammina squamata Jones and Parker var. *gordialis* Jones and Parker, 1860, vol. 16, pp. 304.

Glomospira irregularis (Grzybowski)
Ammodiscus irregularis Grzybowski, 1898, vol. 33, pp. 285, pl. 11, figs. 2-3.

Subfamily TOLYPAMMININAE Cushman, 1928
Genus *Ammolagena* Eimer and Fickert, 1899

Ammolagena clavata (Jones and Parker)
Trochammina irregularis (d'Orbigny) var. *clavata* Jones and Parker, 1860, vol. 16, pp. 304.

Subfamily USBEKISTANIINAE Vyalov, 1968
Genus *Usbekistania* Suleymanov, 1960

Uskekistania charoides (Jones and Parker)
Trochammina squamata Jones and Parker var. *charoides* Jones and Parker, 1860, vol. 16, pp. 304.

Superfamily ASTRORHIZACEA Brady, 1881
Family RHABDAMMINIDAE Brady, 1884
Subfamily RHABDAMMININAE Brady, 1884
Genus *Rhabdammina* Sars, 1869

Rhabdammina discrete Brady
Rhabdammina discrete Brady, 1881, pp. 48, pl. 22, figs. 7-9.

Rhabdammina linearis Brady
Rhabdammina linearis Brady, 1879, vol. 19, pp. 37, pl. 3, figs. 10-11.

Genus *Rhizammina* Brady, 1879

Rhizammina indivisa Brady
Rhizammina *indivisa* Brady, 1884, vol. 9, pp. 277, pl. 29, figs. 5-7.

Family SACCAMMINIDAE Brady, 1884
Subfamily SACCAMMININAE Brady, 1884
Genus *Lagenammina* Rhumbler, 1911

Lagenammina difflugiformis (Brady)
Reophax difflugiformis Brady, 1879, vol. 19, pp. 51, pl. 4, figs. 3a-b.

Lagenammina tubulata (Rhumbler)
Saccammina tubulata Rhumbler, 1931; pp. 82, pl. 23, fig. a.

Superfamily ATAXOPHRAGMIACEA Schwager, 1877
Family GLOBOTEXTULARIIDAE Cushman, 1927
Subfamily GLOBOTEXTULARIINAE Cushman, 1927
Genus *Globotextularia* Eimer and Fickert, 1899

Superfamily CYCLOLINACEA Loeblich and Tappan, 1964
Family CYCLAMMINIDAE Marie, 1941
Subfamily ALVEOLOPHRAGMIINAE Saidova, 1981
Genus *Alveolophragmium* Stschedrina, 1936

Alveolophragmium subglobosum (Cushman)
Haplophragmoides subglobosum Cushman, 1910, no. 71, pp. 105, fig. 163.

Genus *Reticulophragmium* Maync, 1955

Reticulophragmium venezuelanum (Maync)
Alveolophragmium venezuelanum Maync, 1952, vol. 3, pp. 142, pl. 26, figs. 1-8.

Superfamily HAPLOPHRAGMIACEA Eimer and Fickert, 1899
Family AMMOSPHAEROIDINIDAE Cushman, 1927
Subfamily AMMOSPHAEROIDININAE Cushman, 1927
Genus *Adercotryma* Loeblich and Tappan, 1952

Adercotryma glomerata (Brady)
Lituola glomerata Brady, 1878, ser. 5, vol. 1, pp. 433, pl. 20, figs. 1a-c.

Genus *Cystammina* Neumayr, 1889

Cystammina pauciloculata (Brady)
Trochammina pauciloculata Brady, 1879, vol. 19, pp. 58, pl. 5, figs. 13-14.
Notes: The species is found at relative frequencies of >10% in at least one sample and is shown in Figures 5a-b in Appendix F. Figures shown are from sample GIP 16 (0-1 cm) from 2011.

Subfamily RECURVOIDINAE Alekseychik-Mitskevich, 1973
Genus *Recurvoides* Earland, 1934

Recurvoides trochamminiforme Höglund
Recurvoides trochamminiforme Höglund, 1947, pp. 149, pl. 11, figs. 7-8.

Superfamily HIPPOCREPINACEA Rhumber, 1895
Family HIPPOCREPINIDAE Rhumbler, 1895
Subfamily HYPERAMMININAE Eimer and Fickert, 1899
Genus *Hyperammina* Brady, 1878

Hyperammina friabilis Brady
Hyperammina friabilis Brady, 1884, vol. 9, pp. 258, pl. 23, figs. 1-6.

Superfamily HORMOSINACEA Haeckel, 1894
Family HORMOSINIDAE Haeckel, 1894
Subfamily HORMOSININAE Haeckel, 1894
Genus *Hormosina* Brady, 1879

Hormosina globulifera Brady
Hormosina globulifera Brady, 1879, vol. 19, pp. 60, pl. 4, figs. 4-5.

Hormosina pilulifera (Brady)
Reophax pilulifera Brady, 1884, vol. 9, pp. 292, pl. 30, figs. 18-20.
Notes: The juvenile stage of this species is documented in at least one sample.

Subfamily REOPHACINAE Cushman, 1910
Genus *Hormosinella* Stchedrina, 1969

Hormosinella distans (Brady)
Lituola distans Brady, 1881, vol. 21, pp. 50*; figure in* Brady, 1884, vol. 9, pl. 32, figs. 18-22.

Hormosinella guttifera (Brady)
Lituola guttifera Brady, 1881, vol. 21, pp. 49; *figure in* Brady, 1884, vol. 9, pl. 32, figs. 10-15.
Notes: The juvenile stage of this species is documented in at least one sample.

Genus *Reophax* de Montfort, 1808

Notes: Specimens of *Reophax* sp. A are found at relative frequencies of >10% in at least one sample and is shown in Figures 10a-b in Appendix F. Figures shown are from sample GIP 16 (0-1 cm) from 2010.

Reophax agglutinatus Cushman
Reophax agglutinatus Cushman, 1913, no. 1973, vol. 44, pp. 637, pl. 79, fig. 6.

Reophax dentaliniformis Brady
Reophax dentaliniformis Brady, 1881; *figure in* Brady, H.B., 1884, vol. 21, pp. 49, pl. 30, figs. 21-22.

Reophax hispidulus Cushman
Reophax hispidulus Cushman, 1920, no. 104, pp. 24, pl. 5, fig. 7.

Reophax scorpiurus de Montfort
Reophax scorpiurus Denys de Montfort, 1808, tome 1, pp. 331; *figure in* Soldani, 1789, pp. 162, fig. K.

Reophax scottii Chaster
Reophax scottii Chaster, 1892, pp. 57, pl. 1, fig. 1.
Notes: The juvenile stage of this species is documented in at least one sample.

Genus *Subreophax* Saidova, 1975

Subreophax monile (Brady)
Trochammina monile Brady, 1881, vol. 21, pp. 52; *figure in* Brady, 1884, vol. 9, pl. 39, figs. 10-13.

Superfamily LITUOLACEA de Blainville, 1827
Family DISCAMMINIDAE Mikhalevich, 1980
Genus *Discammina* Lacroix, 1932

Discammina compressa (Goës)
Lituolina irregularis (Römer) var. *compressa* Goës, 1882, no. 4, pp. 141, pl. 12, figs. 421-423.

Family HAPLOPHRAGMOIDIDAE Maync, 1952
Genus *Buzasina* Loeblich and Tappan, 1985

Buzasina ringens (Brady)
Trochammina ringens Brady, 1879, vol. 19, pp. 57, pl. 5, fig. 12.

Genus *Cribrostomoides* Cushman, 1910

Cribrostomoides nitidum (Goës)
Haplophragmium nitidum Goës, 1896, vol. 29, pp. 30, pl. 3, figs. 8-9.

Cribrostomoides scitulus (Brady)
Lituola scitulum Brady, 1881, vol. 21, pp. 50, pl. 34, figs. 11-13.

Cribrostomoides subglobosus (Cushman)
Haplophragmoides subglobosum Cushman, 1910, no. 71, pp. 105, figs. 162-164.

Genus *Haplophragmoides* Cushman, 1910

Haplophragmoides bradyi (Robertson)
Trochammina bradyi Robertson, 1891, ser. 6, vol. 7, pp. 388.

Haplophragmoides kirki Wickenden
Haplophragmoides kirki Wickenden, 1932, ser. 3, vol. 26, pp. 85, pl. 1, figs. 1a-c.

Haplophragmoides subinvolutum Cushman and McCulloch
Haplophragmoides subinvolutum Cushman and McCulloch, 1939, vol. 6, pp. 83, pl. 7, figs. 3-5.

Genus *Veleroninoides* Saidova, 1981

Veleroninoides wiesneri (Parr)
Labrospira wiesneri Parr, 1950, ser. B., vol. 5, pp. 272, pl. 4, figs. 25-26.

Family LITUOLIDAE de Blainville, 1827
Subfamily AMMOMARGINULININAE Podobina, 1978
Genus *Ammobaculites* Cushman, 1910

Ammobaculites filiformis (Earland)
Ammobaculites agglutinans (d'Orbigny) var. *filiformis* Earland, 1934, vol. 10, pp. 92, pl. 3, figs. 11-13.

Subfamily LITUOLINAE de Blainville, 1827
Genus *Lituola* Lamarck, 1804

Lituola lituolinoidea (Goës)
Haplophragmium lituolinoideum Goës, 1896, vol. 29, pp. 32, pl. 3, figs. 17-20.

Family LITUOTUBIDAE Loeblich and Tappan, 1984
Genus *Lituotuba* Rhumbler, 1895

Lituotuba lituiformis (Brady)
Trochammina lituiformis Brady, 1879, vol. 19, pp. 59, pl. 5, fig. 16.

Genus *Trochamminoides* Cushman, 1910

Trochamminoides coronatus (Brady)

Trochammina coronatus Brady, 1878, vol. 19, pp. 58, pl. 5, fig. 15.

Superfamily LOFTUSIACEA Brady, 1884
Family CYCLAMMINIDAE Marie, 1941
Subfamily CYCLAMMININAE Marie, 1941
Genus *Cyclammina* Brady, 1879

Cyclammina cancellata Brady
Cyclammina cancellata Brady, 1879; *figure in* Brady, H.B., 1884, vol. 19, pp. 62, pl. 37, figs. 8-15.

Cyclammina trullissata (Brady)
Trochammina trullissata Brady, 1879, vol. 19, pp. 56, pl. 5, figs. 10-11.

Superfamily SPRIOPLECTAMMINACEA Cushman, 1927
Family SPIROPLECTAMMINIDAE Cushman, 1927
Subfamily SPIROPLECTAMMININAE Cushman, 1927
Genus *Spiroplectammina* Cushman, 1927

Notes: Specimens of *Spiroplectammina* sp. are found at relative frequencies of >10% in at least one sample and is shown in Figures 12a-b in Appendix F. Figures shown are from sample GIP 17 (0-1 cm) from 2010. The juvenile stage of this species is documented in at least one sample.

Superfamily TEXTULARIACEA Ehrenberg, 1838
Family EGGERELLIDAE Cushman, 1937
Subfamily DOROTHIINAE Balakhmatova, 1972
Genus *Dorothia* Plummer, 1931

Dorothia scabra (Brady)
Gaudryina scabra Brady, 1884, vol. 9, pp. 381, pl. 46, fig. 7.

Subfamily EGGERELLINAE Cushman, 1937
Genus *Eggerella* Cushman, 1935

Eggerella bradyi (Cushman)
Gaudryina bradyi Cushman, 1911, no. 71, pp. 67, figs. 107a-c.

Family TEXTULARIIDAE Ehrenberg, 1838
Subfamily TEXTULARIINAE Ehrenberg, 1838
Genus *Textularia* Defrance, 1824

Textularia earlandi Parker
Textularia earlandi Parker, 1952, vol. 106, no. 10, pp. 458.

Notes: The species is found at relative frequencies of >10% in at least one sample and is shown in Figures 13a-b in Appendix F. Figures shown are from sample GIP 25 (0-1 cm) from 2011. The juvenile stage of this species is documented in at least one sample.

Textularia wiesneri Earland

Textularia wiesneri Earland, 1933, vol. 7, pp. 95, pl. 3, fig. 18-19.

Superfamily TROCHAMMINACEA Schwager, 1877
Family TROCHAMMINIDAE Schwager, 1877
Subfamily TROCHAMMININAE Schwager, 1877
Genus *Portatrochammina* Echols, 1971

Portatrochammina antarctica (Parr)

Trochammina antarctica Parr, 1950, ser. B, vol. 5, pp. 280, pl. 5, figs. 2-4.

Genus *Trochammina* Parker and Jones, 1859

Trochammina advena Cushman

Trochammina advena Cushman, 1922, vol. 17, no. 311, pp. 20, pl. 1, figs. 2-4.

Notes: The species is found at relative frequencies of >10% in at least one sample and is shown in Figures 14a-b in Appendix F. Figures shown are from sample GIP 17 (0-1 cm) from 2011. The species has a strong fit with Axis 1 of the MDS analysis (surface samples).

Trochammina globigeriniformis (Parker and Jones)

Lituola nautiloidea Lamark *var. globigeriniformis* Parker and Jones, 1865, vol. 155, pp. 407, pl. 15, figs. 46-47.

Trochammina globulosa Cushman

Trochammina globulosa Cushman, 1920, pp. 77, pl. 16, figs. 3-4.

Trochammina inflata (Montagu)

Nautilus inflata Montagu, 1808, pp. 81, pl. 18, fig. 3.

Trochammina japonica Ishiwada

Trochammina japonica Ishiwada, 1950, vol. 1, no. 4, pp. 190, figs. 2a-c.

Trochammina quadriloba (Höglund)

Trochammina pusilla Höglund, 1947, pp. 201, pl. 17, fig. 4.

Trochammina squamata Jones and Parker

Trochammina squamata Jones and Parker, 1860, vol. 16, pp. 304.

Trochammina subturbinata Cushman

Trochammina subturbinata Cushman, 1920, pp. 81, pl. 16, figs. 7-8.

Trochammina tasmanica Parr

Trochammina tasmanica Parr, 1950, pp. 279, pl. 5, fig. 8.

Superfamily VERNEUILINACEA Cushman, 1911
Family PROLIXOPLECTIDAE Loeblich and Tappan, 1985
Genus *Karrerulina* Finlay, 1940

Karrerulina apicularis (Cushman)
Gaudryina apicularis Cushman, 1911, no. 71, pp. 70, figs. 110a-c.

Genus *Plectina* Marsson, 1878

Plectina apicularis (Cushman)
Gaudryina apicularis Cushman, 1911, no. 71, pp. 79, fig. 110.

Genus *Prolixoplecta* Loeblich and Tappan, 1985

Prolixoplecta parvula (Cushman)
Textularia parvula Cushman, 1922, no. 104, pp. 11, pl. 6, figs. 1-2.
Notes: The juvenile stage of this species is documented in at least one sample.

Family VERNEUILINOIDINAE Suleymanov, 1973
Subfamily VERNEUILININAE Cushman, 1911
Genus *Gaudryina* d'Orbigny, 1839

Gaudryina minuta Earland
Gaudryina minuta Earland, 1934, pp. 121, pl. 5, figs. 45-46.
Notes: The juvenile stage of this species is documented in at least one sample.

Suborder SPIRILLININA Hohenegger and Piller, 1975
Family SPIRILLINIDAE Reuss and Fritsch, 1861
Genus *Spirillina* Ehrenberg, 1843

Spirillina vivipara Ehrenberg
Spirillina vivipara Ehrenberg, 1841, pp. 422, pl. 7, fig. 41.

Suborder MILIOLINA Delage and Hérouard, 1896
Superfamily CORNUSPIRACEA Schultze, 1854
Family CORNUSPIRIDAE Schultze, 1854
Subfamily CORNUSPIRINAE Schultze, 1854
Genus *Cornuspira* Schultze, 1854

Cornuspira involvens (Reuss)
Operculina involvens Reuss, 1850, pp. 370, pl. 46, fig. 20.

Superfamily MILIOLACEA Ehrenberg, 1839
Family HAUERINIDAE Schwager, 1876
Subfamily HAUERININAE Schwager, 1876
Genus *Quinqueloculina* d'Orbigny, 1826

Quinqueloculina bosciana d'Orbigny
Quinqueloculina bosciana d'Orbigny, 1839, vol. 8, pp. 191, pl. 11, figs. 22-24.

Quinqueloculina lamarckiana d'Orbigny
Quinqueloculina lamarckiana d'Orbigny, 1839, vol. 8, pp. 189, pl. 11, figs. 14-15.

Quinqueloculina seminulum (Linné)
Serpula seminulum Linné, 1758, tome 1, pp. 786, pp. 19, pl. 2, fig. 1a-c.

Subfamily MILIOLINELLINAE Vella, 1957
Genus *Biloculinella* Wiesner, 1931

Biloculinella irregularis (d'Orbigny)
Biloculina irregularis d'Orbigny, 1839, vol. 5, pt. 5, pp. 67, pl. 8, figs. 20-21.

Genus *Cruciloculina* d'Orbigny, 1839

Cruciloculina triangularis d'Orbigny
Cruciloculina triangularis d'Orbigny, 1839, tome 5, pp. 72, pl. 9, figs. 11-12.

Genus *Miliolinella* Wiesner, 1931

Miliolinella antarctica Kennett
Miliolinella antarctica Kennett, 1967, vol 18, pp. 133-134, pl. 11, figs. 1-3.

Miliolinella californica Rhumbler
Miliolinella californica Rhumbler, 1936, heft 1, pp. 215; *figure in* Cushman and Valentine, 1930, pl. 4, figs. 4a-c.

Miliolinella oblonga (Montagu)
Vermiculum oblongum Montagu, 1803, pp. 522, pl. 14, fig. 9.

Miliolinella warreni Anderson
Miliolinella warreni Anderson, 1961, no. 35, pp. 37, pl. 7, fig. 4.

Genus *Pyrgo* Defrance, 1824

Pyrgo elongata (d'Orbigny)
Biloculina elongata d'Orbigny, 1826, ser. 1, tome 7, pp. 298; *figure in* Parker, Jones, and Brady, 1826, ser. 4, vol. 8, pl. 8, fig. 6.

Pyrgo lucernula (Schwager)
Biloculina lucernula Schwager, 1866, pp. 202, pl. 4, figs. 14a-c, 17a-b.

Pyrgo murrhina (Schwager)

Biloculina murrhina Schwager, 1866, vol. 2, pp. 203, pl. 4, figs. 15a-c.

Pyrgo phlegeri Anderson
Pyrgo phlegeri Anderson, 1961, no. 35, pp. 38, pl. 8, figs. 1-2.

Pyrgo williamsoni (Silvestri)
Biloculina williamsoni Silvestri, 1923, tomo 76, pp. 73, pl. 6, figs. 169-170.

Genus *Pyrgoella* Cushman and White, 1936

Pyrgoella sphaera (d'Orbigny)
Biloculina sphaera d'Orbigny, 1839, tome 5, pp. 66, pl. 8, figs. 13-16.

Genus *Triloculina* d'Orbigny, 1826

Triloculina tricarinata d'Orbigny
Triloculina tricarinata d'Orbigny, 1826, ser. 1, tome 7, pp. 299; *figure in* Parker, Jones, and Brady, 1865, vol. 16, ser. 3, pl. 1, fig. 8.

Family SPIROLOCULINIDAE Wiesner, 1920
Genus *Planispirinoides* Parr, 1950

Planispirinoides bucculentus placentiformis (Brady)
Miliolina bucculenta H.B. Brady var. *placentiformis* Brady, 1884, vol. 9, pp. 171, pl. 4, figs. 1-2.

Genus *Spiroloculina* d'Orbigny, 1826

Suborder LAGENINA Delage and Hérouard, 1896
Superfamily NODOSARIACEA Ehrenberg, 1838
Family ELLIPSOLAGENIDAE Silvestri, 1923
Subfamily ELLIPSOLAGENINAE Silvestri, 1923
Genus *Fissurina* Reuss, 1850

Fissurina aradasii Seguenza
Fissurina aradasii Seguenza, 1862, pp. 59, pl. 1, fig. 59.

Fissurina fissa (Heron-Allen and Earland)
Lagena marginata (Montagu) var. *Fissa* Heron-Allen and Earland, 1922, vol. 6, no. 2, pp. 157, pl. 5, figs. 24-25.

Fissurina flintiana (Cushman)
Lagena flintiana Cushman, 1923, no. 104, pp. 18, pl. 3, figs. 11-13.

Fissurina incomposita (Patterson and Pettis)
Lagenosolenia incomposita Patterson and Pettis, 1986, vol. 16, no. 1, pp. 74.

Subfamily PARAFISSURININAE Jones, 1984
Genus *Parafissurina* Parr, 1947

Parafissurina kerguelenensis (Parr)
Fissurina kerguelenensis Parr, 1950, ser. B, vol. 5, pp. 305, pl. 8, fig. 7.

Parafissurina lateralis (Cushman)
Lagena lateralis Cushman, 1913, no. 71, pp. 9, pl. 1, figs. 1a-d.

Genus *Pseudosolenina* Jones, 1984

Pseudosolenina wiesneri (Barker)
Fissurina wiesneri Barker, 1960; *figure in* Jones, 1994, pl. 59, fig. 23

Subfamily OOLININAE Loeblich and Tappan, 1961
Genus *Oolina* d'Orbigny, 1839

Oolina ovum Ehrenberg
Oolina ovum Ehrenberg, 1843, pp. 166.

Family GLANDULININAE Reuss, 1860
Subfamily SEABROOKIINAE Cushman, 1927
Genus *Seabrookia* Brady, 1890

Seabrookia earlandi (Wright)
Seabrookia earlandi Wright, 1891, ser. 3, vol. 1, no. 4, pp. 477, pl. 20, figs. 6-7.

Family LAGENIDAE Reuss, 1862
Genus *Lagena* Walker and Jacob, 1798

Lagena hispidula Cushman
Lagena hispidula Cushman, 1913, no. 71, pp. 14, pl. 5, figs. 2-3.

Genus *Procerolagena* Puri, 1954

Procerolagena gracilis (Williamson)
Lagena gracilis Williamson, 1848, ser. 2, vol. 1, pp. 13, pl. 1, fig. 5.

Family NODOSARIIDAE Ehrenberg, 1838
Subfamily NODOSARIINAE Ehrenberg, 1838
Genus *Pandaglandulina* Loeblich and Tappan, 1955

Pandaglandulina dinapolii Loeblich and Tappan
Pandaglandulina dinapolii Loeblich and Tappan, 1955, vol. 126, no. 3, pp. 7, pl. 1, figs. 12-16.

Family VAGINULINIDAE Reuss, 1860
Subfamily LENTICULININAE Chapman, Parr, and Collins, 1934
Genus *Lenticulina* Lamarck, 1804

Notes: The juvenile stage of *Lenticulina* sp. A is documented in at least one sample.

Lenticulina convergens (Bornemann)
Cristellaria convergens Bornemann, 1855, heft 2, pp. 327, pl. 13, figs. 16-17.

Notes: The juvenile stage of this species is documented in at least one sample.

Lenticulina gibba (d'Orbigny)
Cristellaria gibba d'Orbigny, 1839, vol. 8, pp. 40, pl. 7, figs. 20-21.

Lenticulina peregrina (Schwager)
Cristellaria peregrina Schwager, 1866, pp. 245, pl. 7, fig. 89.

Genus *Neolenticulina* McCulloch, 1977

Neolenticulina chathamensis McCulloch
Neolenticulina chathamensis McCulloch, 1977, pp. 8, pl. 94, figs. 11-12.

Notes: The juvenile stage of this species is documented in at least one sample.

Neolenticulina variabilis (Reuss)
Cristellaria variabilis Reuss, 1850, pp. 369, pl. 46, fig. 15-16.

Suborder ROBERTININA Loeblich and Tappan, 1984
Superfamily CERATOBULIMINACEA Cushman, 1927
Family EPISTOMINIDAE Wedekind, 1937
Subfamily EPISTOMININAE Wedeind, 1937
Genus *Hoeglundina* Brotzen 1948

Hoeglundina elegans (d'Orbigny)
Rotalia elegans d'Orbigny, 1826, ser. 1, tome 7, pp. 276; *figure in* Parker, Jones, and Brady, 1871, ser. 4, vol. 8, pl. 12, fig. 142.

Superfamily CONORBOIDACEA Thalmann, 1952
Family ROBERTINIDAE Reuss, 1850
Subfamily ALLIATININAE McGowran, 1966
Genus *Robertinoides* Höglund, 1947

Robertinoides bradyi (Cushman and Parker)
Robertina bradyi Cushman and Parker, 1936, vol. 12, pp. 99, pl. 16, fig. 9.

Suborder ROTALIINA Delage and Hérouard, 1896

Superfamily BOLIVINACEA Glaessner, 1937
Family BOLVINIDAE Glaessner, 1937
Genus *Bolivina* d'Orbigny, 1839

Bolivina albatrossi Cushman
Bolivina albatrossi Cushman, 1922, no. 104, pp. 31, pl. 6, fig. 4.
Notes: The juvenile stage of this species is documented in at least one sample.

Bolivina barbata Phleger and Parker
Bolivina barbata Phleger and Parker, 1951, no. 46, pp. 13, pl. 6, figs. 12-13.

Bolivina lanceolata Parker
Bolivina lanceolata Parker, 1954, no. 10, vol. 111, pp. 514, pl. 7, figs. 17-20.

Bolivina lowmani Phleger and Parker
Bolivina lowmani Phleger and Parker, 1951, no. 46, pp. 13, pl. 6, figs. 20-21.

Bolivina minima Phleger and Parker
Bolivina minima Phleger and Parker, 1951, no. 46, pp. 14, pl. 6, figs. 22, 25; pl. 7, figs. 1-2.
Notes: The species is found at relative frequencies of >10% in at least one sample and is shown in Figures 1a-b in Appendix F. Figures shown are from sample GIP 15 (5-6 cm) from 2010. The juvenile stage of this species is documented in at least one sample.

Bolivina ordinaria Phleger and Parker
Bolivina ordinaria Phleger and Parker, 1952; *figure in* Phleger and Parker, 1951, pl. 7, figs. 4-6.
Notes: The juvenile stage of this species is documented in at least one sample.

Bolivina paula Cushman and Cahill
Bolivina paula Cushman and Cahill, 1932, no. 9, pp. 84, pl. 12, fig. 6.

Bolivina pusilla Schwager
Bolivina pusilla Schwager, 1866, pp. 254, pl. 7, fig. 101.

Bolivina striatula Cushman
Bolivina striatula Cushman, 1922, vol. 17, pp. 27, pl. 3, fig. 10.
Notes: The juvenile stage of this species is documented in at least one sample.

Bolivina subaenariensis var. *mexicana* Cushman
Bolivina subaenariensis Cushman var. *mexicana* Cushman, 1922, no. 104, pp. 47, pl. 8, fig. 1.

Bolivina translucens Phleger and Parker
Bolivina translucens Phleger and Parker, 1951, no. 46, pp. 15, pl. 7, figs. 13-14.

Notes: The species is found at relative frequencies of >10% in at least one sample and is shown in Figures 2a-b in Appendix F. Figures shown are from sample GIP 25 (1-2 cm) from 2011. The juvenile stage of this species is documented in at least one sample.

Genus *Brizalina* Costa, 1856

Brizalina subspinescens (Cushman)
Bolivina subspinescens Cushman, 1922, no. 104, pp. 48, pl. 7, fig. 5.

Superfamily BULIMINACEA Jones, 1875
Family BULMINELLIDAE Hofker, 1951
Genus *Buliminella* Cushman, 1911

Buliminella bassendorfensis Cushman and Parker
Buliminella bassendorfensis Cushman and Parker, 1937, vol. 13, pp. 40, pl. 4, fig. 13.

Family BULMINIDAE Jones, 1875
Genus *Bulimina* d'Orbigny, 1826

Bulimina aculeata d'Orbigny
Bulimina aculeata d'Orbigny, 1826, ser. 1, tome 7, pp. 269; *figure in* Parker, Jones, and Brady, 1871, ser. 4, vol. 8, pl. 11, fig. 128.
Notes: The species is found at relative frequencies of >10% in at least one sample and is shown in Figures 3a-b in Appendix F. Figures shown are from sample GIP 16 (0-1 cm) from 2010. The species has been previously documented as opportunistic and/or stress tolerant (Mojtahid et al., 2006; Denoyelle et al., 2010). The surface sample for GIP 15 had the highest relative frequency than any other sample. The juvenile stage of this species is documented in at least one sample. Juveniles of both *B. aculeata* and *B. marginata* are indistinguishable in their juvenile stages; thus, juveniles were documented as *B. aculeata* unless a clear distinction to *B. marginata* was observed (Filipsson et al., 2010).

Bulimina alazanensis Cushman
Bulimina alazanensis Cushman, 1927, vol. 1, pp. 161, pl. 25, fig. 4.
Notes: The juvenile stage of this species is documented in at least one sample.

Bulimina marginata d'Orbigny
Bulimina marginata d'Orbigny, 1826, ser. 1, tome 7, pp. 269, pl. 12, figs. 10-12.
Notes: The juvenile stage of this species is documented in at least one sample.

Bulimina spicata Phleger and Parker
Bulimina spicata Phleger and Parker, 1951, no. 46, pp. 16, pl. 7, figs. 25, 30-31.
Notes: The juvenile stage of this species is documented in at least one sample.

Genus *Globobulimina* Cushman, 1927

Globobulimina affinis (d'Orbigny)
Bulimina affinis d'Orbigny, 1839, vol. 8, pp. 105, pl. 2, figs. 25-26.
Notes: The juvenile stage of this species is documented in at least one sample.

Globobulimina mississippiensis Parker
Globobulimina mississippiensis Parker, 1954, no. 10, pp. 511, pl. 7, figs. 3-4.
Notes: The juvenile stage of this species is documented in at least one sample.

Genus *Praeglobobulimina* Hofker, 1951

Praeglobobulimina ovata (d'Orbigny)
Bulimina ovata d'Orbigny, 1846, pp. 185, pl. 11, figs. 13-14.

Praeglobobulimina ovula (d'Orbigny)
Bulimina ovula d'Orbigny, 1839, tome 5, pp. 51, pl. 1, figs. 10-11.

Family UVIGERINIDAE Haeckel, 1894
Subfamily ANGULOGERININAE Galloway, 1933
Genus *Angulogerina* Cushman, 1927

Angulogerina jamaicensis Cushman and Todd
Angulogerina jamaicensis Cushman and Todd, 1945, no. 15, pp. 53, pl. 8, fig. 3.

Genus *Trifarina* Cushman, 1923

Trifarina bradyi Cushman
Trifarina bradyi Cushman, 1923, no. 104, pp. 99, pl. 22, figs. 3-9.

Subfamily UVIGERININAE Haeckel, 1894
Genus *Uvigerina* d'Orbigny, 1826

Uvigerina auberiana d'Orbigny
Uvigerina auberiana d'Orbigny, 1839, vol. 8, pp. 106, pl. 2, figs. 23-24.

Uvigerina bellula Bandy
Uvigerina bellula Bandy, 1956, pp. 199, pl. 31, fig. 13.

Uvigerina peregrina Cushman
Uvigerina peregrina Cushman, 1923, no. 104, pp. 166, pl. 42, figs. 7-10.
Notes: The species is found at relative frequencies of >10% in at least one sample and is shown in Figures 15a-b in Appendix F. Figures shown are from sample Obs0a (0-1 cm) from 2012. The species has a strong fit with Axis 3 of the MDS analysis (surface samples). The juvenile stage of this species is documented in at least one sample.

Superfamily CASSIDULINACEA d'Orbigny, 1839
Family CASSIDULINIDAE d'Orbigny, 1839
Subfamily CASSIDULININAE d'Orbigny, 1839
Genus *Cassidulina* d'Orbigny, 1826

Cassidulina carinata Silvestri
Cassidulina laevigata d'Orbigny var. *carinata* Silvestri, 1896, vol. 12, pp. 104, pl. 2, figs. 10a-c.
Notes: The species is found at relative frequencies of >10% in at least one sample and is shown in Figures 4a-b in Appendix F. Figures shown are from sample Obs0a (0-1 cm) from 2012. The juvenile stage of this species is documented in at least one sample.

Cassidulina laevigata d'Orbigny
Cassidulina laevigata d'Orbigny, 1826, ser. 1, vol. 7, pp. 282, pl. 15, figs. 4-5.
Cassidulina obtusa Williamson
Cassidulina obtusa Williamson, 1858, pp. 69, pl. 6, figs. 143-144.

Genus *Evolvocassidulina* Eade, 1967

Evolvocassidulina tenuis (Phleger and Parker)
Cassidulinoides tenuis Phleger and Parker, 1951, no. 46, pp. 27, pl. 14, figs. 14-17.

Genus *Globocassidulina* Voloshinova, 1960

Globocassidulina subglobosa (Brady)
Cassidulina subglobosa Brady, 1881, vol. 21, pp. 60; *figure in* Brady, 1884, vol. 9, pl. 54, fig. 17.
Notes: The juvenile stage of this species is documented in at least one sample.

Superfamily CHILOSTOMELLACEA Brady, 1881
Family CHILOSTOMELLIDAE Brady, 1881
Genus *Chilostomella* Reuss*, 1849*

Chilostomella oolina Schwager
Chilostomella oolina Schwager, 1878, vol. 9, pp. 527, pl. 1, fig. 16.

Family GAVELINELLIDAE Hofker, 1956
Subfamily GAVELINELLINAE Hofker, 1956

Genus *Gyroidina* d'Orbigny, 1826

Gyroidina bradyi (Trauth)
Truncatulina bradyi Trauth, 1918, pp. 235, pl. 95, fig. 5.

Gyroidina orbicularis d'Orbigny

Gyroidina orbicularis d'Orbigny, 1826, ser. 1, vol. 7, pp. 278, pl. 3, fig. 85.

Subfamily GYROIDINOIDINAE Saidova, 1981
Genus *Gyroidinoides* Brotzen, 1942

Gyroidinoides altiformis (Stewart and Stewart)
Gyroidina soldanii d'Orbigny var. *altiformis* Stewart and Stewart, 1930, vol. 4, no. 1, pp. 67, pl. 9, fig. 2.

Gyroidinoides polius (Phleger and Parker)
Eponides polius Phleger and Parker, 1951, no. 46, pp. 21, pl. 11, figs. 1-2.

Family HETEROLEPIDAE Gonzáles-Donoso, 1969
Genus *Anomalinoides* Brotzen, 1942

Anomalinoides globulosus (Chapman and Parr)
Anomalina globulosa Chapman and Parr, 1937, vol. 1, pp. 117, pl. 9, fig. 27.

Anomalinoides mexicana Parker
Anomalinoides mexicana Parker, 1954, no. 10, vol. 111, pp. 539, pl. 11, figs. 21-23.

Family ORIDORSALIDAE Loeblich and Tappan, 1984
Genus *Oridorsalis* Anderson, 1961

Oridorsalis tener (Brady)
Truncatulina tener Brady, 1884, vol. 9, pp. 665, pl. 95, fig. 11.

Oridorsalis umbonatus (Reuss)
Rotalina umbonata Reuss, 1851, pp. 75, pl. 5, fig. 35.

Family OSANGULARIIDAE Loeblich and Tappan, 1964
Genus *Osangularia* Brotzen, 1940

Osangularia culter (Parker and Jones)
Planorbulina farcta (Fichtel and Moll) var. *ungeriana* (d'Orbigny) subvar. *culter* Parker and Jones, 1865, vol. 155, pp. 382, 421, pl. 19, figs. 1a-b.
Notes: The juvenile stage of this species is documented in at least one sample.

Osangularia rugosa (Phleger and Parker)
Pseudoparrella rugosa Phleger and Parker, 1951, no. 46, pp. 28, pl. 15, figs. 8-9.
Notes: The species is found at relative frequencies of >10% in at least one sample and is shown in Figures 9a-b in Appendix F. Figures shown are from sample GIP 15 (5-6 cm) from 2010. The juvenile stage of this species is documented in at least one sample.

Superfamily DISCORBACEA Ehrenberg, 1838

Family BAGGINIDAE Cushman, 1927
Subfamily BAGGININAE Cushman, 1927
Genus *Neocrosbyia* McCulloch, 1977

Neocrosbyia minuta (Parker)
Valvulineria minuta Parker, 1954, no. 10, vol. 111, pp. 527, pl. 9, figs. 4-6.

Subfamily SEROVAININAE Sliter, 1968
Genus *Valvulineria* Cushman, 1926

Valvulineria glabra (Cushman)
Valvulineria vilardeboana (d'Orbigny) var. *glabra* Cushman, 1927, vol. 1, pp. 161, pl. 4, figs. 5-6.

Family DISCORBIDAE Ehrenberg, 1838
Genus *Discorbis* Lamarck, 1804

Discorbis bulbosa Parker
Discorbis bulbosa Parker, 1954, vol. 11, no. 10, pp. 523, pl. 8, figs. 10-12.

Family EPONIDIDAE Hofker, 1951
Subfamily EPONIDINAE Hofker, 1951
Genus *Eponides* de Montfort, 1808

Eponides regularis Phleger and Parker
Eponides regularis Phleger and Parker, 1951, no. 46, pp. 21, pl. 11, figs. 3-4.

Genus *Ionella* Saidova, 1975

Ionella tumidula (Brady)
Truncatulina tumidula Brady, 1884, vol. 9, pp. 666, pl. 95, fig. 8.

Family ROSALINIDAE Reiss, 1963
Genus *Gavelinopsis* Hofker, 1951

Gavelinopsis basilica (Bandy)
Rotorbinella basilica Bandy, 1956, pp. 199, pl. 31, figs. 3a-c.

Gavelinopsis translucens (Phleger and Parker)
Rotalia translucens Phleger and Parker, 1951, no. 46, pp. 24, pl. 12, figs. 11-12.
Notes: The juvenile stage of this species is documented in at least one sample.

Family SPHAEROIDINIDAE Cushman, 1927
Genus *Sphaeroidina* d'Orbigny, 1826

Sphaeroidina bulloides d'Orbigny
Sphaeroidina bulloides d'Orbigny, 1826, ser. 1, tome 7, pp. 267; *figure in* Parker, Jones, and Brady, 1865, vol. 16, ser. 3, pl. 2, fig. 58.

Superfamily DISCORBINELLACEA Sigal, 1952
Family DISCORBINELLIDAE Sigal, 1952
Subfamily DISCORBINELLINAE Sigal, 1952
Genus *Laticarinina* Galloway and Wissler, 1927

Laticarinina pauperata (Parker and Jones)
Pulvinulina repanda Fichtel and Moll var. *menardii* d'Orbigny subvar. *pauperata* Parker and Jones, 1865, vol. 155, pp. 395, pl. 16, figs. 50a-b.

Family PARRELLOIDIDAE Hofker, 1956
Genus *Cibicidoides* Thalmann, 1939

Cibicidoides pachyderma (Rzehak)
Truncatulina pachyderma Rzehak, 1886, vol. 28, pp. 8, fig. 5.
Notes: The juvenile stage of this species is documented in at least one sample.

Cibicidoides robertsonianus (Brady)
Planorbulina robertsoniana Brady, 1881, vol. 21, pp. 65; *figure in* Brady, 1884, vol. 9, pl. 99, fig. 4.

Family PSEUDOPARRELLIDAE Voloshinova, 1952
Genus *Epistominella* Husezima and Maruhasi, 1944

Epistominella decorate (Phleger and Parker)
Pseudoparrella decorate Phleger and Parker, 1951, no. 46, pp. 28, pl. 15, figs. 4-5.

Epistominella exigua (Brady)
Pulvinulina exigua Brady, 1884, vol. 9, pp. 696, pl. 103, figs. 13-14.
Notes: The species is found at relative frequencies of >10% in at least one sample and is shown in Figures 6a-b in Appendix F. Figures shown are from sample GIP 17 (0-1 cm) from 2010. The juvenile stage of this species is documented in at least one sample.

Epistominella levicula Resig
Epistominella levicula Resig, 1958, no. 3, vol. 4, pp. 304, figs. 6a-c.
Notes: The species is found at relative frequencies of >10% in at least one sample and is shown in Figures 7a-b in Appendix F. Figures shown are from sample GIP 17 (0-1 cm) from 2011. The species has a strong fit with Axis 3 of the MDS analysis (downcore samples). The juvenile stage of this species is documented in at least one sample.

Epistominella vítrea Parker

Epistominella vítrea Parker, 1953, no. 2, pp. 9, pl. 4, figs. 34-36.

Superfamily FURSENKOINACAE Loeblich and Tappan, 1961
Family FURSENKOINIDAE Loeblich and Tappan, 1961
Genus *Fursenkoina* Loeblich and Tappan, 1961

Fursenkoina obliqua Saidova
Fursenkoina obliqua Saidova, 1975, pp. 316, pl. 87, fig. 10; pl. 112, fig. 13.
Notes: The juvenile stage of this species is documented in at least one sample.

Fursenkoina tessellata (Phleger and Parker)
Virgulina tessellata Phleger and Parker, 1951, no. 46, pp. 19, pl. 9, figs. 15-16.
Notes: The species is found at relative frequencies of >10% in at least one sample and is shown in Figures 8a-b in Appendix F. Figures shown are from sample GIP 15 (5-6 cm) from 2010. The species has a strong fit with Axis 2 of the MDS analysis (downcore samples). The juvenile stage of this species is documented in at least one sample.

Genus *Rutherfordoides* McCulloch, 1981

Rutherfordoides mexicanus (Cushman)
Virgulina mexicanus Cushman, 1922, no. 104, pp. 120, pl. 23, fig. 8.
Notes: The species is found at relative frequencies of >10% in at least one sample and is shown in Figures 11a-b in Appendix F. Figures shown are from sample GIP 25 (0-1 cm) from 2011. The juvenile stage of this species is documented in at least one sample.

Superfamily LOXOSTOMATACEA Loeblich and Tappan, 1962
Family LOXOSTOMATIDAE Loeblich and Tappan, 1962
Genus *Loxostomum* Ehrenberg, 1954

Loxostomum abruptum Phleger and Parker
Loxostomum abruptum Phleger and Parker, 1952, new name, no. 46, pp. 17, pl. 7, figs. 15-19.
Notes: The species has a strong fit with Axis 1 of the MDS analysis (downcore samples). The juvenile stage of this species is documented in at least one sample.

Superfamily NONIONACEA Schultze, 1854
Family NONIONIDAE Schultze, 1854
Subfamily ASTRONONIONINAE Saidova, 1981
Genus *Laminononion* Hornibrook, 1964

Laminononion tumidum (Cushman and Edwards)
Astrononion tumidum Cushman and Edwards, 1937, vol. 13, pp. 33, pl. 3, fig. 17.

Genus *Pullenia* Parker and Jones, 1862

Pullenia bulloides (d'Orbigny)
Nonionina bulloides d'Orbigny, 1846, ser. 1, tome 7, no. 2, pp. 127, pl. 5, figs. 9-10.

Pullenia quinqueloba (Reuss)
Nonionina quinqueloba Reuss, 1851, pp. 71, pl. 5, fig. 31.

Subfamily NONIONINAE Schultze, 1854
Genus *Haynesina* Banner and Culver, 1978

Haynesina germanica Banner and Culver
Haynesina germanica Banner and Culver, 1978, vol 8, no. 3, pp. 191-195, pls. 4-9, figs. 1-6, 1-8, 1-7, 1-10, 1-11.

Genus *Nonionella* Cushman, 1926

Nonionella atlantica Cushman
Nonionella atlantica Cushman, 1947, vol. 23, pp. 90, pl. 20, figs. 4-5.

Nonionella iridea Heron-Allen and Earland
Nonionella iridea Heron-Allen and Earland, 1932, vol. 4, pp. 438, pl. 16, figs. 14-16.

Nonionella opima Cushman
Nonionella opima Cushman, 1947, vol. 23, pp. 90, pl. 20, figs. 1-3.

Genus *Nonionoides* Saidova, 1975

Nonionoides grateloupii (d'Orbigny)
Nonionina grateloupii d'Orbigny, 1839, vol. 8, pp. 46, pl. 6, figs. 6-7.

Superfamily PLANORBULINACEA Schwager, 1877
Family CIBICIDIDAE Cushman, 1927
Subfamily CIBICIDINAE Cushman, 1927
Genus *Cibicides* de Montfort, 1808

Cibicides corpulentus Phleger and Parker
Cibicides corpulentus Phleger and Parker, 1952, new name, no. 46, pp. 31, pl. 17, figs. 1-4.

Cibicides kullenbergi Parker
Cibicides kullenbergi Parker, 1953, vol. 7, pp. 49, pl. 11, figs. 7-8.
Notes: The juvenile stage of this species is documented in at least one sample.

Cibicides mollis Phleger and Parker

Cibicides mollis Phleger and Parker, 1951, no. 46, pp. 30, pl. 16, figs. 7-9.

Cibicides rugosus Phleger and Parker
Cibicides rugosa Phleger and Parker, 1951, no. 46, pp. 31, pl. 17, figs. 5-6.

Cibicides wuellerstorfi (Schwager)
Anomalina wuellerstorfi Schwager, 1866, pp. 258, pl. 7, figs. 105, 107.

Family PLANULINIDAE Bermúdez, 1952
Genus *Planulina* d'Orbigny, 826

Planulina exorna Phleger and Parker
Planulina exorna Phleger and Parker, 1951, no. 46, pp. 32, pl. 18, figs. 5-7.

Superfamily STILOSTOMELLACEA Finlay, 1947
Family STILOSTOMELLIDAE Finlay, 1947
Genus *Siphonodosaria* Silvestri, 1924

Siphonodosaria calomorpha (Reuss)
Nodosaria calomorpha Reuss, 1866, pp. 129, pl. 1, figs. 15-19.

Superfamily TURRILINACEA Cushman, 1927
Family STAINFORTHIIDAE Reiss, 1963
Genus *Stainforthia* Hofker, 1956

Stainforthia complanata (Egger)
Virgulina schreibersiana Cziczek var. *complanata* Egger, 1893, pp. 292, pl. 8, figs. 91-92.

APPENDIX B

Table of All Taxa Documented with the Number of Samples

Taxa	Number of Samples
Adercotryma glomerata	30
Agglutinated sp. A	15
Agglutinated sp. D	1
Agglutinated sp. F	1
Agglutinated sp. G	13
Agglutinated sp. H	3
Agglutinated sp. M	1
Agglutinated sp. N	1
Agglutinated sp. P	1
Agglutinated sp. Q	1
Agglutinated sp. R	1
Agglutinated sp. S	1
Agglutinated sp. T	3
Agglutinated sp. U	1
Agglutinated sp. V	1
Agglutinated sp. W	1
Agglutinated sp. X	1
Agglutinated sp. Y	7
Agglutinated sp. Z	1
Agglutinated sp. Ab	3
Agglutinated sp. Bb	2
Agglutinated sp. Cb	1
Agglutinated sp. Eb	2
Agglutinated sp. Fb	6
Agglutinated sp. Gb	1
Agglutinated sp. Hb	4
Agglutinated sp. Ib	2
Agglutinated sp. Kb	1
Agglutinated sp. Lb	1
Agglutinated sp. Mb	5
Agglutinated sp. Nb	1
Agglutinated sp. Qb	2
Agglutinated sp. Rb	1
Agglutinated sp. Sb	2
Agglutinated sp. Tb	4
Agglutinated sp. Vb	1
Agglutinated sp. Wb	1
Agglutinated sp. Xb	1
Agglutinated sp. Yb	1

Taxa	Number of Samples
Alveolophragmium subglobosum	1
Alveolophragmium sp. A	8
Ammolagena clavata	1
Ammobaculites filiformis	1
Anomalinoides globulosus	1
Anomalinoides mexicana	5
Ammodiscus sp. A	1
Ammodiscus sp. B	1
Ammodiscus tenuis	5
Angulogerina jamaicensis	1
Bagginidae sp. A	1
Biloculinella irregularis	1
Bolivina albatrossi	40
Bolivina barbata	1
Bolivina lanceolata	3
Bolivina lowmani	1
Bolivina minima	36
Bolivina c.f. ordinaria	10
Bolivina paula	31
Bolivina pusilla	1
Bolivina striatula	19
Bolivina cf. subaenariensis mexicana	4
Bolivina translucens	37
Brizalina subspinescens	3
Bulimina aculeata	41
Bulimina alazanensis	38
Bulimina marginata	4
Bulimina sp. D	1
Bulimina sp. I	1
Bulimina spicata	28
Buliminella bassendorfensis	2
Buzasina ringens	3
Cassidulina carinata	40
Cassidulina obtusa	5
Cassidulina laevigata	2
Cassidulinoides tenuis	1
Chilostomella oolina	16
Cibicides corpulentus	3
Cibicides kullenbergi	30

Taxa	Number of Samples
Cibicides mollis	1
Cibicides rugosus	1
Cibicides wuellerstorfi	5
Cibicidoides pachydermus	4
Cibicidoides robertsonianus	2
Cornuspira involvens	5
Cribrostomoides nitidum	9
Cribrostomoides scitulus	6
Cribrostomoides subglobosus	4
Cribrostomoides sp. B	1
Cruciloculina triangularis	2
Cyclammina cancellata	1
Cyclammina trullissata	1
Cystammina pauciloculata	21
Discammina compressa	2
Discorbis bulbosa	18
Dorothia scabra	7
Eggerella bradyi	3
Epistominella decorata	3
Epistominella exigua	40
Epistominella levicula	42
Epistominella vitrea	18
Eponides regularis	20
Evolvocassidulina tenuis	1
Fissurina aradasii	5
Fissurina fissa	1
Fissurina flintiana	3
Fissurina sp. A	1
Fissurina sp. B	1
Fissurina sp. F	1
Fissurina incomposita	2
Fursenkoina obliqua	9
Fursenkoina tessellata	34
Gaudryina minuta	33
Gavelinopsis basilica	2
Gavelinopsis translucens	35
Glomospira gordialis	4
Glomospira irregularis	15
Globobulimina affinis	21

Taxa	Number of Samples
Globobulimina mississippiensis	8
Globocassidulina subglobosa	32
Globotextularia sp. A	20
Gyroidina bradyi	2
Gyroidina orbicularis	19
Gyroidinoides altiformis	2
Gyroidinoides polius	3
Haplophragmoides bradyi	27
Haplophragmoides kirki	19
Haplophragmoides subinvolutum	2
Haynesina germanica	34
Hoeglundina elegans	1
Hormosinella distans	15
Hormosina globulifera	1
Hormosinella guttifera	9
Hormosinella pilulifera	16
Hyperammina friabilis	6
Hyperammina spp.	15
Ioanella tumidula	1
Karrerulina apicularis	4
Lagenaid sp. A	4
Lagenaid sp. B	2
Lagenaid sp. C	1
Lagenaid sp. D	1
Lagenaid sp. E	1
Lagena hispidula	2
Lagena sp. B	1
Lagenammina difflugiformis	23
Lagenammina tubulata	10
Laminononion tumidum	3
Laticarinina pauperata	1
Lenticulina convergens	2
Lenticulina gibba	2
Lenticulina peregrina	1
Lenticulina sp. A	1
Lituola lituolinoidea	2
Lituotuba lituiformis	2
Loxostomum abruptum	31
Miliolida sp. A	3

Taxa	Number of Samples
Miliolida sp. B	6
Miliolida sp. C	1
Miliolida sp. F	1
Miliolida sp. G	2
Miliolida sp. H	9
Miliolida sp. I	2
Miliolida sp. J	1
Miliolida sp. L	3
Miliolida sp. O	1
Miliolida sp. P	1
Miliolida sp. Q	1
Miliolida sp. R	1
Miliolida sp. S	1
Miliolida sp. T	2
Miliolida sp. U	2
Miliolida sp. V	1
Miliolida sp. W	1
Miliolida sp. X	1
Miliolinella antarctica	3
Miliolinella californica	5
Miliolinella oblonga	6
Miliolinella warreni	5
Neocrosbyia minuta	10
Neolenticulina chathamensis	5
Neolenticulina variabilis	3
Nonionella atlantica	6
Nonionella iridea	33
Nonionella opima	35
Nonionoides grateloupi	1
Oolina ovum	3
Oolina sp. A	1
Oridorsalis tenera	1
Oridorsalis umbonatus	7
Osangularia culter	37
Osangularia rugosa	34
Pandaglandulina dinapolii	1
Parafissurina kerguelenensis	1
Parafissurina lateralis	1
Planispirinoides bucculentus placentiformis	2

Taxa	Number of Samples
Planulina exorna	2
Plectina apicularis	1
Portatrochammina antarctica	21
Praeglobobulimina ovata	4
Praeglobobulimina ovula	16
Procerolagena gracilis	6
Procerolagena sp. A	1
Prolixoplecta parvula	19
Pseudosolenia wiesneri	1
Pullenia bulloides	5
Pullenia quinqueloba	15
Pyrgo elongata	1
Pyrgo lucernula	4
Pyrgo murrhina	3
Pyrgo phlegeri	2
Pyrgo sp. A	5
Pyrgo sp. B	4
Pyrgo sp. C	1
Pyrgo sp. D	1
Pyrgo sp. E	1
Pyrgo sp. F	1
Pyrgo sp. G	1
Pyrgo cf. williamsoni	4
Pyrgoella sphaera	7
Quinqueloculina bosciana	4
Quinqueloculina lamarckiana	1
Quinqueloculina seminulum	18
Recurvoides trochamminiforme	23
Reticulophragmium venezuelanum	3
Reophax agglutinatus	13
Reophax dentaliniformis	5
Reophax hispidulus	5
Reophax scorpiurus	3
Reophax scotti	11
Reophax sp. A	17
Reophax sp. B	6
Reophax sp. D	3
Reophax sp. E	5
Reophax sp. G	2

Taxa	Number of Samples
Reophax sp. H	1
Reophax sp. I	1
Reophax sp. J	1
Rhabdammina discreta	3
Rhabdammina linearis	1
Rhabdammina spp.	1
Rhizammina indivisa	15
Robertinoides bradyi	9
Rotalid sp. A	18
Rotalid sp. D	1
Rotalid sp. F	1
Rotalid sp. L	1
Rotalid sp. M	1
Rutherfordoides mexicanus	35
Seabrookia earlandi	19
Spirillina vivipara	1
Siphonodosaria calomorpha	4
Sphaeroidina bulloides	12
Spiroplectammina sp.	41
Spiroloculina sp. A	5
Stainforthia complanata	14
Subreophax monile	1
Textularia earlandi	21
Textularia wiesneri	3
Textularia sp. B	3
Textulariacea sp. A	1
Trifarina bradyi	1
Triloculina tricarinata	14
Trochammina cf. advena	40
Trochammina globigeriniformis	4
Trochammina globulosa	28
Trochammina inflata	5
Trochammina squamata	1
Trochammina japonica	14
Trochammina quadriloba	16
Trochammina subturbinata	2
Trochammina tasmanica	18
Trochammina sp. C	2
Trochammina sp. D	1

Taxa	Number of Samples
Trochammina sp. E	1
Trochamminoides coronatus	5
Usbekistania charoides	19
Uvigerina auberiana	5
Uvigerina bellula	2
Uvigerina peregrina	38
Uvigerina sp. E	1
Uvigerina sp. F	2
Valvulineria glabra	11
Veleroninoides wiesneri	12

APPENDIX C

Tables of Raw Counts for All Samples

Raw counts for surface (0-1 cm) samples of 2010.

Taxa	GIP12	GIP15	GIP16	GIP17	GIP21	GIP25
Adercotryma glomerata	5	2	10	6	5	3
Agglutinated sp. Ab	0	0	3	0	0	0
Agglutinated sp. Bb	0	1	0	0	0	0
Agglutinated sp. G	7	1	3	1	0	0
Agglutinated sp. Hb	0	0	0	0	0	1
Agglutinated sp. Kb	0	0	0	0	0	1
Agglutinated sp. Lb	0	0	0	0	0	1
Agglutinated sp. Mb	0	0	0	0	0	1
Agglutinated sp. Qb	0	0	1	1	0	0
Agglutinated sp. Rb	0	0	0	5	0	0
Agglutinated sp. Sb	0	0	0	9	2	0
Agglutinated sp. Tb	0	0	0	3	0	0
Agglutinated sp. Vb	0	0	0	2	0	0
Agglutinated sp. Wb	0	0	0	1	0	0
Agglutinated sp. Y	0	0	1	0	0	0
Alveolophragmium sp. A	0	0	1	0	1	0
Ammobaculites filiformis	0	0	0	0	6	0
Ammodiscus tenuis	0	0	0	0	1	2
Anomalinoides mexicana	0	0	0	1	0	0
Bolivina albatrossi	4	8	4	12	0	8
Bolivina c.f. *ordinaria*	0	0	1	1	0	1
Bolivina minima	4	4	2	4	0	1
Bolivina paula	3	2	4	11	4	3
Bolivina pusilla	0	0	0	0	3	0
Bolivina striatula	1	1	7	0	0	0
Bolivina translucens	33	24	1	2	0	3
Brizalina subspinescens	0	0	0	0	3	0
Bulimina aculeata	51	103	17	17	3	25
Bulimina alazanensis	6	9	2	3	2	5
Bulimina marginata	1	0	3	3	0	0
Bulimina spicata	1	4	1	0	0	19
Buzasina ringens	0	0	0	0	1	0
Cassidulina carinata	18	22	2	7	0	22
Cassidulina laevigata	0	2	0	0	0	0
Cassidulina obtusa	0	0	0	0	1	0
Chilostomella oolina	0	0	0	1	0	1
Cibicides kullenbergi	1	1	0	0	3	2
Cibicides wuellerstorfi	0	0	0	1	1	0

Samples of 2010 Continued.

Taxa	GIP12	GIP15	GIP16	GIP17	GIP21	GIP25
Cibicidoides robertsonianus	0	0	1	0	0	0
Cribrostomoides nitidum	15	0	0	0	1	3
Cribrostomoides subglobosus	2	0	1	0	0	2
Cruciloculina triangularis	0	0	0	0	0	1
Cystammina pauciloculata	21	1	9	6	0	1
Discammina compressa	0	0	0	0	0	2
Discorbis bulbosa	0	0	2	1	5	0
Dorothia scabra	0	0	7	2	1	0
Eggerella bradyi	0	0	0	0	2	0
Epistominella decorata	0	0	0	0	13	0
Epistominella exigua	10	20	14	12	1	7
Epistominella levicula	14	11	58	3	28	5
Epistominella vitrea	0	1	4	0	3	0
Eponides regularis	2	3	0	0	3	5
Evolvocassidulina tenuis	0	0	0	0	1	0
Fissurina aradasii	0	0	0	0	0	1
Fissurina flintiana	0	0	0	0	1	0
Fursenkoina tessellata	0	1	2	4	0	0
Gaudryina minuta	1	0	10	4	11	1
Gavelinopsis translucens	0	0	4	2	0	1
Globobulimina affinis	1	0	2	13	0	4
Globobulimina mississippiensis	0	3	0	1	0	0
Globocassidulina subglobosa	2	0	7	4	5	4
Globotextularia sp. A	0	0	9	0	0	0
Glomospira irregularis	0	1	0	0	0	3
Gyroidina bradyi	0	0	2	0	0	0
Gyroidina orbicularis	0	2	0	3	4	1
Gyroidinoides polius	0	0	0	0	0	1
Haplophragmoides bradyi	0	3	15	2	3	1
Haplophragmoides kirki	2	3	10	2	0	2
Haplophragmoides subinvolutum	0	0	0	0	0	1
Haynesina germanica	0	0	0	0	3	0
Hoeglundina elegans	0	0	0	0	4	0
Hormosina globulifera	0	0	0	0	0	1
Hormosinella distans	6	0	1	9	6	0
Hormosinella guttifera	0	0	1	1	0	0
Hormosinella pilulifera	2	0	7	3	0	0
Hyperammina friabilis	1	0	0	0	0	1
Hyperammina spp.	3	0	3	1	3	3
Karrerulina apicularis	0	0	0	0	0	4

Samples of 2010 Continued.

Taxa	GIP12	GIP15	GIP16	GIP17	GIP21	GIP25
Lagena hispidula	0	0	0	0	0	1
Lagenaid sp. D	0	0	0	0	1	0
Lagenammina difflugiformis	1	0	3	0	31	6
Lagenammina tubulata	0	1	5	0	0	0
Laticarinina pauperata	0	0	0	1	0	0
Lenticulina convergens	0	0	0	2	0	0
Loxostomum abruptum	1	1	1	1	0	0
Miliolida sp. A	0	0	0	0	12	2
Miliolida sp. B	0	0	20	0	0	2
Miliolida sp. H	0	0	1	0	0	1
Miliolida sp. I	0	0	0	0	0	4
Miliolida sp. J	0	0	0	0	0	1
Miliolida sp. L	1	0	0	0	0	0
Miliolida sp. T	1	0	2	0	0	0
Miliolida sp. U	0	0	2	0	1	0
Miliolida sp. V	0	0	1	0	0	0
Miliolida sp. W	0	0	0	0	1	0
Miliolida sp. X	0	0	0	0	2	0
Miliolinella antarctica	0	0	4	1	0	0
Miliolinella californica	0	0	3	0	2	0
Miliolinella oblonga	0	0	3	0	4	0
Miliolinella warreni	0	0	0	0	1	0
Neocrosbyia minuta	0	0	1	2	0	0
Neolenticulina chathamensis	4	0	1	0	0	2
Nonionella atlantica	0	0	0	0	0	7
Nonionella iridea	8	3	12	1	2	17
Nonionella opima	2	4	3	11	1	3
Nonionoides grateloupi	0	0	0	0	2	0
Oolina ovum	0	0	1	0	0	0
Oridorsalis tenera	0	0	0	0	0	3
Oridorsalis umbonatus	0	0	1	0	1	0
Osangularia culter	0	1	3	2	3	3
Osangularia rugosa	1	0	5	1	1	0
Planispirinoides bucculentus placentiformis	0	0	0	1	0	0
Plectina apicularis	0	2	0	0	0	0
Portatrochammina antarctica	1	0	6	1	0	2
Praeglobobulimina ovata	0	0	0	2	0	0
Praeglobobulimina ovula	0	0	0	5	0	0

Samples of 2010 Continued.

Taxa	GIP12	GIP15	GIP16	GIP17	GIP21	GIP25
Procerolagena gracilis	0	0	0	0	1	1
Pullenia bulloides	0	0	0	0	3	0
Pullenia quinqueloba	0	0	0	6	0	2
Pyrgo c.f. *williamsoni*	0	0	1	2	0	0
Pyrgo elongata	0	0	0	4	0	0
Pyrgo lucernula	1	0	0	0	0	0
Pyrgo murrhina	2	0	0	0	3	0
Pyrgo phlegeri	1	0	1	0	0	0
Pyrgo sp. A	0	0	1	1	0	0
Pyrgo sp. F	1	0	0	0	0	0
Pyrgo sp. G	0	0	0	1	0	0
Pyrgoella sphaera	0	0	1	0	0	0
Quinqueloculina bosciana	0	1	0	0	0	1
Quinqueloculina lamarckiana	0	0	0	0	0	1
Quinqueloculina seminulum	3	0	0	0	2	1
Recurvoides trochamminiforme	1	7	27	5	18	36
Reophax agglutinatus	0	1	1	0	2	4
Reophax dentaliniformis	0	0	1	0	8	1
Reophax hispidulus	0	0	0	0	1	1
Reophax scorpiurus	0	0	0	2	8	0
Reophax scotti	0	0	2	1	0	0
Reophax sp. A	0	1	5	38	0	6
Reophax sp. B	0	0	0	1	0	5
Reophax sp. E	0	0	1	1	5	0
Reophax sp. J	0	0	0	0	0	1
Rhabdammina discreta	0	0	0	0	3	0
Rhabdammina linearis	0	0	0	0	12	0
Rhabdammina spp.	0	0	0	0	6	0
Rhizammina indivisa	0	0	2	5	0	2
Robertinoides bradyi	0	0	0	1	2	1
Rotalid sp. A	0	1	2	2	1	0
Rutherfordoides mexicanus	22	40	1	2	0	21
Spiroplectammina sp.	5	2	18	20	5	1
Stainforthia complanata	1	0	2	1	0	4
Subreophax monile	0	0	0	1	0	0
Textularia earlandi	28	23	1	0	0	133
Triloculina tricarinata	0	0	0	0	0	2
Trochammina c.f. *advena*	15	13	34	21	71	10
Trochammina globigeriniformis	4	0	0	0	8	1
Trochammina globulosa	5	0	7	8	4	3

Samples of 2010 Continued.						
Taxa	GIP12	GIP15	GIP16	GIP17	GIP21	GIP25
Trochammina japonica	0	0	9	4	2	2
Trochammina quadriloba	2	1	2	0	0	1
Trochammina sp. E	0	0	0	0	3	0
Trochammina subturbinata	0	0	2	1	0	0
Trochammina tasmanica	0	0	7	1	0	2
Trochamminoides coronatus	0	0	1	1	0	0
Usbekistania charoides	0	0	3	1	1	1
Uvigerina peregrina	2	19	2	10	0	37
Valvulineria glabra	0	1	0	0	0	2
Veleroninoides wiesneri	1	2	14	2	0	2
Indeterminate	4	0	4	4	4	0
Suborders						
Textulariina	21	17	39	35	30	39
Lagenina	1	0	2	1	3	4
Miliolina	7	1	12	6	9	10
Robertinina	0	0	0	1	2	1
Rotaliina	23	26	32	35	26	29
Spirillinina	0	0	0	0	0	0
Total Specimens	335	357	463	342	372	493
Splits	2	2	2	2	2	2
Pans	2	1	3	6	4	5
Volume (cm^3)	97	59	70	54	72	70
Density (spec/ 10 cm^3)	622	2172	798	382	465	507
Diversity Indices						
Species Richness	52	44	85	78	70	83
H'	3.19	2.77	3.76	3.76	3.48	3.28
D	0.06	0.12	0.04	0.03	0.06	0.09
E	0.47	0.36	0.50	0.55	0.46	0.32
J	0.81	0.73	0.85	0.86	0.82	0.74

Raw counts for surface (0-1 cm) samples of 2011.

Taxa	GIPK	GIP15	GIP16	GIP17	GIP25
Adercotryma glomerata	3	0	16	16	0
Agglutinated sp. D	1	0	0	0	0
Agglutinated sp. Eb	1	0	0	0	0
Agglutinated sp. G	4	1	0	0	1
Agglutinated sp. H	0	1	1	0	0
Agglutinated sp. Hb	0	0	0	0	3
Agglutinated sp. Mb	3	0	0	0	0
Agglutinated sp. T	0	0	0	1	0
Agglutinated sp. Tb	0	0	0	2	0
Agglutinated sp. U	0	1	0	0	0
Agglutinated sp. V	0	1	0	0	0
Agglutinated sp. W	0	1	0	0	0
Agglutinated sp. X	0	1	0	0	0
Agglutinated sp. Y	0	3	0	0	0
Alveolophragmium sp. A	0	1	0	3	0
Ammodiscus tenuis	0	0	0	0	3
Anomalinoides mexicana	0	1	0	1	0
Bolivina albatrossi	4	12	12	16	9
Bolivina c.f. *ordinaria*	0	0	2	0	1
Bolivina lanceolata	0	0	0	0	1
Bolivina lowmani	0	0	1	0	0
Bolivina minima	2	1	0	0	2
Bolivina paula	0	2	2	0	3
Bolivina striatula	0	0	3	2	0
Bolivina translucens	3	11	0	0	13
Brizalina subspinescens	0	0	0	1	0
Bulimina aculeata	16	23	6	36	6
Bulimina alazanensis	3	0	1	1	5
Bulimina sp. D	1	0	0	0	0
Bulimina spicata	0	1	0	0	5
Buliminella bassendorfensis	0	0	0	0	1
Buzasina ringens	1	2	0	0	0
Cassidulina carinata	30	15	0	2	26
Chilostomella oolina	0	2	0	0	1
Cibicides kullenbergi	0	1	0	0	0
Cibicides wuellerstorfi	0	1	0	0	0
Cibicidoides pachydermus	0	2	0	0	0
Cornuspira involvens	2	0	0	0	1
Cribrostomoides nitidum	15	1	0	0	1
Cribrostomoides scitulus	1	1	0	0	0

Samples of 2011 Continued.

Taxa	GIPK	GIP15	GIP16	GIP17	GIP25
Cribrostomoides subglobosus	3	0	0	0	0
Cyclammina trullissata	0	0	1	0	0
Cystammina pauciloculata	65	3	15	8	12
Discorbis bulbosa	0	0	0	1	2
Dorothia scabra	0	0	1	1	0
Eggerella bradyi	0	0	1	0	0
Epistominella decorata	0	0	1	3	0
Epistominella exigua	3	12	3	4	9
Epistominella levicula	1	30	15	29	11
Epistominella vitrea	0	1	0	1	0
Eponides regularis	1	1	1	0	0
Fursenkoina tessellata	0	0	1	0	8
Gaudryina minuta	0	2	21	9	3
Gavelinopsis translucens	2	0	0	1	0
Globobulimina affinis	1	1	1	0	0
Globocassidulina subglobosa	1	0	4	5	4
Globotextularia sp. A	0	3	5	4	0
Glomospira gordialis	0	4	0	0	0
Glomospira irregularis	0	6	3	2	0
Gyroidina bradyi	0	0	0	1	0
Gyroidina orbicularis	0	1	3	1	1
Gyroidinoides altiformis	1	0	0	0	0
Gyroidinoides polius	0	0	0	0	1
Haplophragmoides bradyi	0	13	16	16	7
Haplophragmoides kirki	6	0	1	0	6
Haynesina germanica	0	4	1	0	1
Hormosinella distans	2	0	1	2	1
Hormosinella guttifera	1	0	0	1	3
Hormosinella pilulifera	2	2	6	1	4
Hyperammina friabilis	1	0	0	1	0
Hyperammina spp.	6	8	0	3	1
Ioanella tumidula	0	0	1	0	0
Lagena sp. B	0	0	0	0	1
Lagenaid sp. A	1	0	0	0	1
Lagenammina difflugiformis	0	1	0	0	2
Lagenammina tubulata	3	1	1	1	1
Lenticulina convergens	0	0	1	0	0
Lenticulina peregrina	0	1	0	0	0
Lituola lituolinoidea	0	4	0	0	0
Lituotuba lituiformis	2	0	1	0	0

Samples of 2011 Continued.

Taxa	GIPK	GIP15	GIP16	GIP17	GIP25
Loxostomum abruptum	1	0	0	0	0
Miliolida sp. A	0	0	0	0	1
Miliolida sp. B	0	0	0	1	0
Miliolida sp. C	0	0	0	1	0
Miliolida sp. H	0	0	1	1	0
Miliolida sp. I	0	0	0	1	0
Miliolida sp. L	0	0	0	2	0
Miliolinella oblonga	0	0	1	1	0
Miliolinella warreni	0	0	0	1	0
Neocrosbyia minuta	0	0	0	1	0
Nonionella atlantica	0	0	0	0	3
Nonionella iridea	3	3	3	3	4
Nonionella opima	0	4	6	10	8
Oolina ovum	1	0	0	0	0
Osangularia culter	0	7	0	6	3
Osangularia rugosa	0	1	0	1	0
Planispirinoides bucculentus placentiformis	0	0	0	1	0
Portatrochammina antarctica	14	0	17	3	2
Praeglobobulimina ovula	1	0	0	0	3
Prolixoplecta parvula	1	0	0	0	0
Pullenia quinqueloba	0	0	2	2	0
Pyrgo lucernula	0	0	0	1	0
Pyrgo sp. A	0	0	1	0	3
Pyrgo sp. B	0	0	0	1	0
Pyrgo sp. C	0	0	0	0	1
Pyrgoella sphaera	0	0	0	1	0
Quinqueloculina seminulum	5	0	6	0	1
Recurvoides trochamminiforme	3	0	16	4	0
Reophax agglutinatus	1	0	0	1	0
Reophax dentaliniformis	0	0	0	0	1
Reophax hispidulus	0	0	0	0	1
Reophax scorpiurus	0	0	0	2	0
Reophax scotti	8	5	3	4	0
Reophax sp. A	4	0	18	12	2
Reophax sp. B	0	0	0	0	3
Reophax sp. D	1	1	0	0	0
Reophax sp. E	0	1	0	2	0
Rhabdammina discreta	0	0	0	0	1
Rhizammina indivisa	0	1	0	1	0
Robertinoides bradyi	0	0	1	0	0

Samples of 2011 Continued.

Taxa	GIPK	GIP15	GIP16	GIP17	GIP25
Rotalid sp. A	0	3	2	0	5
Rotalid sp. D	0	1	0	0	0
Rutherfordoides mexicanus	6	2	0	0	27
Seabrookia earlandi	0	1	0	0	0
Sphaeroidina bulloides	0	2	0	0	0
Spiroplectammina sp.	16	4	23	20	2
Stainforthia complanata	0	1	0	0	1
Textularia earlandi	16	13	0	1	53
Textularia wiesneri	0	3	0	0	0
Textulariacea sp. A	0	1	0	0	0
Triloculina tricarinata	1	0	1	1	0
Trochammina c.f. *advena*	12	13	50	25	9
Trochammina globigeriniformis	2	0	0	0	0
Trochammina globulosa	9	1	1	4	0
Trochammina inflata	0	0	1	0	0
Trochammina japonica	0	2	0	0	0
Trochammina quadriloba	0	0	2	6	0
Trochammina squamata	0	1	0	0	0
Trochammina tasmanica	0	2	1	9	0
Trochamminoides coronatus	0	4	0	0	0
Usbekistania charoides	0	0	3	5	3
Uvigerina auberiana	0	1	0	2	1
Uvigerina peregrina	2	45	3	0	15
Valvulineria glabra	0	0	0	0	10
Veleroninoides wiesneri	0	0	8	6	4
Indeterminate	5	4	0	0	0
Suborders					
Textulariina	30	36	27	32	25
Lagenina	2	2	1	0	2
Miliolina	3	0	5	12	5
Robertinina	0	0	1	0	0
Rotaliina	19	30	22	23	31
Spirillinina	0	0	0	0	0

Samples of 2011 Continued.					
Taxa	GIPK	GIP15	GIP16	GIP17	GIP25
Total Specimens	304	311	319	319	328
Splits	3	3	2	3	2
Pans	10	14	2	15	2
Volume (cm^3)	87	39	90	63	83
Density (spec/ 10 cm^3)	755	1230	638	729	711
Diversity Indices					
Species Richness	54	68	56	67	63
H'	3.16	3.45	3.31	3.52	3.49
D	0.07	0.05	0.05	0.04	0.05
E	0.44	0.46	0.49	0.51	0.52
J	0.79	0.82	0.82	0.84	0.84

Raw Counts for Obs0 (0-1 cm).

Taxa	Obs0a	Obs0c	Obs0c
Adercotryma glomerata	4	4	7
Agglutinated sp. A	0	0	1
Agglutinated sp. G	0	2	0
Agglutinated sp. Tb	2	1	0
Agglutinated sp. Xb	0	1	0
Agglutinated sp. Y	0	1	0
Agglutinated sp. Yb	0	0	1
Ammodiscus sp. A	0	0	1
Ammodiscus sp. B	0	0	2
Ammodiscus tenuis	1	0	1
Ammolagena clavata	1	0	0
Bolivina albatrossi	10	14	15
Bolivina minima	0	1	3
Bolivina paula	7	7	0
Bolivina striatula	2	0	1
Bolivina translucens	0	1	0
Bulimina aculeata	11	6	5
Bulimina alazanensis	9	6	5
Bulimina marginata	0	1	0
Bulimina spicata	1	3	6
Cassidulina carinata	17	24	24
Cassidulina obtusa	0	1	0
Cibicides kullenbergi	0	2	1
Cribrostomoides scitulus	8	0	1
Cribrostomoides sp. B	1	0	0
Cyclammina cancellata	1	0	0
Cystammina pauciloculata	3	8	2
Discammina compressa	0	0	1
Discorbis bulbosa	0	0	2
Epistominella exigua	13	22	13
Epistominella levicula	25	27	25
Epistominella vitrea	0	0	2
Eponides regularis	4	2	1
Fissurina aradasii	0	2	2
Fursenkoina tessellata	1	2	0
Gaudryina minuta	4	7	7
Gavelinopsis translucens	3	1	1
Globobulimina affinis	1	0	0
Globocassidulina subglobosa	2	2	2
Globotextularia sp. A	0	2	0

Obs0 Continued.

Taxa	Obs0a	Obs0c	Obs0c
Glomospira gordialis	5	1	1
Glomospira irregularis	2	3	10
Gyroidina orbicularis	1	0	1
Gyroidinoides altiformis	0	1	0
Haplophragmoides bradyi	0	5	3
Haynesina germanica	9	3	6
Hormosinella distans	8	6	6
Hormosinella guttifera	8	2	5
Hormosinella pilulifera	1	2	2
Hyperammina friabilis	1	0	0
Hyperammina spp.	9	5	9
Lagena hispidula	1	0	0
Lagenaid sp. B	0	0	1
Lagenaid sp. E	2	0	0
Lagenammina difflugiformis	3	1	0
Lagenammina tubulata	0	2	0
Lituola lituolinoidea	0	0	1
Loxostomum abruptum	0	4	0
Miliolida sp. H	0	1	1
Miliolinella californica	0	0	1
Miliolinella oblonga	0	1	0
Miliolinella warreni	1	0	1
Neolenticulina chathamensis	1	0	0
Neolenticulina variabilis	1	0	0
Nonionella iridea	6	10	10
Nonionella opima	3	8	12
Osangularia culter	3	4	2
Osangularia rugosa	1	11	1
Parafissurina kerguelenensis	0	0	1
Portatrochammina antarctica	2	2	2
Procerolagena gracilis	0	0	1
Pseudosolenia wiesneri	1	0	0
Pullenia quinqueloba	1	0	1
Pyrgo sp. B	1	0	1
Pyrgoella sphaera	1	0	0
Quinqueloculina seminulum	1	0	0
Recurvoides trochamminiforme	0	15	9
Reophax agglutinatus	0	0	4
Reophax hispidulus	1	0	1
Reophax scotti	0	0	2

Obs0 Continued.

Taxa	Obs0a	Obs0c	Obs0c
Reophax sp. B	4	3	1
Reophax sp. G	2	0	0
Reticulophragmium venezuelanum	3	0	2
Rhizammina indivisa	4	1	3
Robertinoides bradyi	0	1	1
Rotalid sp. A	0	0	1
Seabrookia earlandi	0	1	0
Sphaeroidina bulloides	2	1	0
Spiroloculina sp. A	1	0	0
Spiroplectammina sp.	9	15	14
Stainforthia complanata	1	0	0
Textularia earlandi	15	36	10
Textularia wiesneri	0	0	2
Triloculina tricarinata	1	1	0
Trochammina c.f. *advena*	25	26	19
Trochammina globulosa	0	1	1
Trochammina inflata	0	0	3
Trochammina japonica	2	1	1
Trochammina tasmanica	1	3	1
Usbekistania charoides	7	2	1
Uvigerina auberiana	0	1	0
Uvigerina peregrina	25	10	22
Valvulineria glabra	1	0	1
Veleroninoides wiesneri	0	0	2
Indeterminate	2	2	3
Suborders			
Textulariina	29	28	36
Lagenina	5	2	4
Miliolina	6	3	4
Robertinina	0	1	1
Rotaliina	25	27	25
Spirillinina	0	0	0
Total Specimens	310	342	315
Splits	3	2	2
Pans	8	5	2
Volume (cm^3)	82	19	64
Density (spec/ 10 cm^3)	1050	1276	890

Obs0 Continued.			
Taxa	Obs0a	Obs0c	Obs0c
Diversity Indices			
Species Richness	65	61	70
H'	3.61	3.47	3.63
D	0.04	0.04	0.03
E	0.57	0.53	0.54
J	0.86	0.84	0.86

Raw counts for GIP 15 of 2010.

Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm
Adercotryma glomerata	0	0	2	1	0
Agglutinated sp. A	0	0	0	1	2
Agglutinated sp. Z	0	0	0	1	0
Agglutinated sp. Ab	1	0	0	1	0
Agglutinated sp. Fb	0	0	1	0	0
Alveolophragmium sp. A	0	0	2	0	0
Anomalinoides mexicana	0	0	1	0	0
Biloculinella irregularis	0	0	0	1	0
Bolivina albatrossi	1	2	7	13	3
Bolivina minima	2	4	11	13	59
Bolivina paula	0	3	1	0	0
Bolivina striatula	0	0	2	0	1
Bolivina translucens	33	12	3	5	2
Bulimina aculeata	16	15	38	34	7
Bulimina alazanensis	1	0	2	1	1
Buliminella bassendorfensis	1	0	0	0	0
Bulimina spicata	1	0	1	0	0
Cassidulina carinata	1	1	3	5	2
Cassidulina laevigata	0	0	1	0	0
Cassidulina obtusa	0	0	1	0	0
Chilostomella oolina	5	4	0	1	0
Cibicides kullenbergi	0	1	3	2	0
Cibicides rugosus	0	0	0	0	2
Cibicidoides pachydermus	0	0	0	0	1
Cornuspira involvens	0	0	0	1	0
Cribrostomoides scitulus	0	0	0	1	0
Epistominella exigua	0	1	3	5	3
Epistominella levicula	16	43	49	47	68
Epistominella vitrea	0	0	2	0	3
Fissurina aradasii	0	0	0	1	1
Fissurina flintiana	0	0	1	0	0
Fursenkoina tessellata	40	77	53	34	10
Gaudryina minuta	0	0	1	1	0
Gavelinopsis basilica	0	0	1	0	1
Gavelinopsis translucens	3	3	9	19	6
Globobulimina affinis	3	0	1	3	0
Glomospira irregularis	0	0	2	1	0
Globobulimina mississippiensis	3	4	0	0	0
Globocassidulina subglobosa	0	0	6	4	1
Globotextularia sp. A	0	0	0	2	9

GIP 15 of 2010 Continued

Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm
Gyroidina orbicularis	0	0	0	1	0
Haplophragmoides bradyi	0	0	2	0	1
Haplophragmoides kirki	0	1	0	0	0
Haynesina germanica	1	2	3	3	2
Lagenammina difflugiformis	1	0	2	1	0
Lagenammina tubulata	0	0	1	0	0
Lamininonion tumidum	0	0	1	0	0
Lenticulina sp. A	0	0	0	0	1
Loxostomum abruptum	2	4	6	7	2
Miliolinella warreni	0	0	0	1	0
Nonionella atlantica	1	1	0	0	0
Nonionella iridea	0	0	0	0	1
Nonionella opima	15	4	3	2	0
Oolina ovum	0	0	0	0	1
Oolina sp. A	0	0	0	2	0
Osangularia culter	0	1	8	11	21
Osangularia rugosa	1	4	5	19	34
Portatrochammina antarctica	0	0	0	1	1
Praeglobobulimina ovata	1	0	0	0	0
Praeglobobulimina ovula	1	1	1	0	0
Prolixoplecta parvula	0	0	2	2	0
Procerolagena sp. A	0	0	1	0	0
Pullenia quinqueloba	0	0	0	0	4
Pyrgo sp. B	0	0	1	0	0
Pyrgo c.f. *williamsoni*	0	0	0	1	0
Pyrgoella sphaera	0	0	0	1	0
Quinqueloculina seminulum	0	0	0	2	0
Recurvoides trochamminiforme	0	0	1	0	0
Reophax agglutinatus	1	0	0	0	0
Reophax sp. A	1	1	0	0	0
Reophax sp. G	0	0	0	1	0
Rhizammina indivisa	0	1	1	1	0
Rotalid sp. A	0	1	0	0	0
Rotalid sp. F	0	0	0	0	3
Rutherfordoides mexicanus	139	121	43	26	2
Seabrookia earlandi	2	0	1	2	0
Siphonodosaria calomorpha	0	1	1	0	0
Sphaeroidina bulloides	1	0	2	0	0
Spiroplectammina sp.	0	1	4	21	42
Spiroloculina sp. A	0	0	0	1	0

GIP 15 of 2010 Continued					
Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm
Stainforthia complanata	0	0	1	0	0
Textularia earlandi	0	0	0	0	1
Triloculina tricarinata	0	0	1	2	1
Trochammina c.f. *advena*	3	2	2	1	1
Trochammina globulosa	0	0	1	1	0
Trochammina quadriloba	0	0	1	1	0
Uvigerina peregrina	4	2	6	4	0
Uvigerina sp. E	0	0	0	0	1
Indeterminate	1	7	6	3	1
Suborders					
Textulariina	5	5	15	17	7
Lagenina	1	0	3	3	3
Miliolina	0	0	2	8	1
Robertinina	0	0	0	0	0
Rotaliina	24	24	33	22	25
Spirillinina	0	0	0	0	0
Total Specimens	302	325	314	316	302
Splits	2	2	4	4	1
Pans	2	3	310	656	3
Volume (cm^3)	51	64	65	53	67
Density (spec/ 10 cm^3)	1066	609	202	118	90
Diversity Indices					
Species Richness	30	29	53	50	36
H'	2.02	1.99	2.91	3.04	2.50
D	0.25	0.22	0.09	0.07	0.13
E	0.25	0.25	0.34	0.42	0.34
J	0.59	0.59	0.73	0.78	0.70

Raw counts for GIP 15 of 2011.

Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm
Adercotryma glomerata	3	1	4	13	3
Agglutinated sp. A	0	2	0	0	0
Agglutinated sp. F	0	1	0	0	0
Agglutinated sp. G	7	2	0	0	0
Agglutinated sp. H	0	1	0	0	0
Agglutinated sp. M	0	0	0	1	0
Agglutinated sp. N	0	0	0	1	0
Agglutinated sp. P	0	0	0	1	0
Agglutinated sp. Q	0	0	1	0	0
Agglutinated sp. R	0	0	1	0	0
Agglutinated sp. S	0	0	1	0	0
Agglutinated sp. T	1	0	0	0	0
Alveolophragmium sp. A	1	0	0	0	0
Anomalinoides globulosus	0	0	0	1	0
Anomalinoides mexicana	2	0	0	0	0
Bagginidae sp. A	0	0	0	0	1
Bolivina albatrossi	13	0	11	3	6
Bolivina minima	0	8	15	15	23
Bolivina paula	0	3	0	1	2
Bolivina striatula	0	0	2	2	0
Bolivina translucens	23	12	2	3	2
Brizalina subspinescens	0	0	0	0	1
Bulimina aculeata	14	31	46	57	52
Bulimina alazanensis	0	1	0	2	4
Bulimina spicata	0	0	1	0	0
Cassidulina carinata	7	5	10	3	7
Cibicides kullenbergi	4	1	0	1	1
Cornuspira involvens	1	0	0	0	0
Cribrostomoides nitidum	0	0	1	0	0
Cribrostomoides scitulus	1	0	0	0	0
Cystammina pauciloculata	2	0	0	0	1
Epistominella exigua	4	2	3	3	8
Epistominella levicula	35	74	120	79	84
Epistominella vitrea	1	1	3	10	14
Fissurina incomposita	0	0	0	1	0
Fissurina sp. A	0	0	0	0	1
Fissurina sp. B	0	0	1	0	0
Fursenkoina obliqua	1	0	0	0	0
Fursenkoina tessellata	42	69	41	30	17
Gaudryina minuta	1	3	1	10	7

GIP 15 of 2011 Continued					
Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm
Gavelinopsis translucens	0	2	2	2	2
Globobulimina affinis	12	5	3	2	1
Globobulimina mississippiensis	3	0	0	0	0
Globocassidulina subglobosa	0	0	0	1	0
Globotextularia sp. A	2	2	4	4	4
Glomospira irregularis	0	0	0	1	0
Haplophragmoides bradyi	6	1	0	0	5
Haplophragmoides kirki	4	2	4	0	0
Haplophragmoides subinvolutum	2	0	0	0	0
Haynesina germanica	5	0	5	5	1
Hormosinella distans	0	0	0	0	1
Hormosinella pilulifera	1	0	0	0	0
Hyperammina spp.	2	0	0	0	0
Karrerulina apicularis	0	0	0	1	1
Lagenammina difflugiformis	0	1	0	0	0
Loxostomum abruptum	6	4	7	2	3
Nonionella iridea	2	0	0	4	0
Nonionella opima	20	17	4	3	2
Osangularia culter	2	7	9	3	6
Osangularia rugosa	3	2	4	2	3
Portatrochammina antarctica	1	0	0	2	0
Praeglobobulimina ovula	1	0	0	0	0
Prolixoplecta parvula	0	0	5	3	7
Pullenia quinqueloba	0	0	0	0	1
Recurvoides trochamminiforme	0	0	0	2	0
Reophax agglutinatus	1	0	0	0	0
Reophax scotti	11	0	0	0	2
Reophax sp. D	1	0	0	0	0
Rotalid sp. A	8	0	1	1	1
Rutherfordoides mexicanus	22	28	12	11	5
Seabrookia earlandi	0	0	1	0	2
Spiroplectammina sp.	4	7	7	21	23
Stainforthia complanata	0	0	0	0	1
Textularia earlandi	6	0	0	2	0
Textularia wiesneri	1	0	0	0	0
Trochammina c.f. *advena*	12	2	1	3	5
Trochammina globulosa	1	1	1	0	0
Trochammina japonica	1	0	1	0	0
Trochammina quadriloba	2	0	2	1	0
Trochammina sp. C	0	0	0	2	1

GIP 15 of 2011 Continued					
Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm
Trochammina sp. D	0	0	0	1	0
Trochammina tasmanica	1	0	0	0	1
Trochamminoides coronatus	2	0	1	0	0
Usbekistania charoides	0	1	1	0	1
Uvigerina peregrina	14	2	5	4	8
Veleroninoides wiesneri	8	0	0	0	1
Indeterminate	1	0	0	1	0
Suborders					
Textulariina	27	14	16	17	15
Lagenina	0	0	2	1	2
Miliolina	1	0	0	0	0
Robertinina	0	0	0	0	0
Rotaliina	23	19	21	26	26
Spirillinina	0	0	0	0	0
Total Specimens	331	301	344	321	322
Splits	3	3	2	2	2
Pans	8	15	5	7	10
Volume (cm^3)	87	74	65	74	72
Density (spec/ 10 cm^3)	1027	619	381	223	161
Diversity Indices					
Species Richness	51	33	39	44	43
H'	3.31	2.47	2.54	2.78	2.81
D	0.05	0.14	0.16	0.11	0.11
E	0.54	0.36	0.32	0.37	0.38
J	0.84	0.71	0.69	0.74	0.75

Raw Counts for GIP 25 of 2010.

Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm	6-7 cm	7-8 cm	8-9 cm	9-10 cm
Adercotryma glomerata	2	1	0	4	4	4	1	4	9
Agglutinated sp. A	0	0	1	1	0	2	0	0	0
Agglutinated sp. Fb	0	0	0	0	0	0	2	0	1
Agglutinated sp. G	0	0	0	0	0	0	2	0	0
Agglutinated sp. Hb	1	0	0	0	0	0	0	0	0
Agglutinated sp. Mb	0	1	1	0	0	1	0	0	0
Agglutinated sp. Nb	0	1	0	0	0	0	0	0	0
Agglutinated sp. Y	1	0	0	0	1	0	0	0	0
Alveolophragmium sp. A	0	0	0	1	1	0	0	0	0
Bolivina albatrossi	6	3	14	8	7	2	3	9	6
Bolivina barbata	0	0	0	0	0	0	2	0	0
Bolivina c.f. *ordinaria*	0	0	0	0	1	1	0	0	1
Bolivina c.f. *subaenariensis mexicana*	0	0	1	0	1	0	0	0	0
Bolivina minima	0	3	18	16	12	13	19	35	11
Bolivina paula	1	4	5	3	2	0	3	1	1
Bolivina striatula	0	0	0	0	2	0	0	1	1
Bolivina translucens	22	16	5	3	6	5	3	2	2
Bulimina aculeata	3	4	14	12	5	10	11	7	6
Bulimina alazanensis	3	2	3	5	7	5	14	12	13
Bulimina sp. I	0	0	0	0	0	0	0	0	1
Bulimina spicata	3	2	3	5	5	2	6	5	4
Cassidulina carinata	4	1	20	30	32	38	26	29	39
Cassidulina obtusa	0	0	0	0	0	0	0	1	2
Chilostomella oolina	3	2	2	1	0	0	0	0	0
Cibicides kullenbergi	0	2	12	6	4	3	3	5	5

GIP 25 of 2010 Continued.

Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm	6-7 cm	7-8 cm	8-9 cm	9-10 cm
Cibicides wuellerstorfi	0	0	0	1	0	0	0	0	1
Cibicidoides pachydermus	0	0	0	0	0	0	0	0	1
Cornuspira involvens	0	0	0	0	0	1	0	0	0
Cribrostomoides nitidum	0	0	0	0	0	0	1	0	0
Cystammina pauciloculata	0	0	1	0	1	1	0	1	0
Discorbis bulbosa	0	1	0	1	3	0	6	5	2
Dorothia scabra	0	0	0	0	0	0	0	0	1
Epistominella exigua	2	2	9	9	21	39	36	14	14
Epistominella levicula	7	8	20	19	28	40	30	20	20
Epistominella vitrea	0	6	0	0	0	0	0	1	4
Eponides regularis	0	0	0	1	1	0	2	2	0
Fissurina flintiana	0	0	0	4	0	0	0	0	0
Fissurina sp. F	1	0	0	0	0	0	0	0	0
Fursenkoina obliqua	9	3	2	0	0	0	0	0	0
Fursenkoina tessellata	27	56	34	33	3	1	3	2	0
Gaudryina minuta	0	0	2	1	2	0	1	3	1
Gavelinopsis translucens	3	4	5	6	5	6	6	9	8
Globobulimina affinis	1	0	0	2	1	0	0	0	0
Globobulimina mississippiensis	0	2	0	0	0	0	0	0	0
Globocassidulina subglobosa	4	3	5	4	5	8	3	2	8
Globotextularia sp. A	0	0	0	1	0	1	0	0	1
Glomospira irregularis	0	0	0	1	1	1	0	0	0
Gyroidina orbicularis	0	0	0	2	4	4	0	1	2
Gyroidinoides polius	0	0	0	0	0	0	2	0	0
Haplophragmoides bradyi	2	0	0	1	2	4	0	0	1

GIP 25 of 2010 Continued.

Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm	6-7 cm	7-8 cm	8-9 cm	9-10 cm
Haplophragmoides kirki	3	0	0	0	1	0	2	0	0
Haynesina germanica	1	3	1	11	2	4	3	1	3
Hormosinella distans	1	0	1	1	0	0	0	0	0
Hormosinella pilulifera	0	0	2	0	0	1	0	0	0
Hyperammina spp.	1	2	0	0	0	0	0	0	0
Karrerulina apicularis	1	0	0	0	0	0	0	0	0
Lagenaid sp. C	0	0	0	0	1	0	0	0	0
Lagenammina difflugiformis	2	2	3	4	2	0	2	0	0
Laminononion tumidum	0	0	0	0	0	0	1	0	1
Loxostomum abruptum	0	0	4	4	5	9	9	8	8
Miliolida sp. B	1	3	1	0	0	0	0	0	0
Miliolida sp. H	0	1	0	0	1	1	0	0	0
Miliolida sp. L	0	1	0	0	0	0	0	0	0
Miliolida sp. O	0	0	0	0	0	0	0	1	0
Miliolida sp. P	0	0	0	0	0	0	0	1	0
Miliolida sp. Q	0	0	0	0	0	0	0	0	1
Miliolida sp. R	0	0	0	0	0	0	0	0	1
Miliolida sp. S	0	0	0	0	0	0	0	0	1
Miliolinella antarctica	0	0	1	0	0	0	0	0	0
Miliolinella californica	0	0	0	0	1	1	0	0	0
Miliolinella oblonga	0	0	0	0	1	0	0	0	0
Neocrosbyia minuta	0	0	1	0	1	0	2	1	1
Neolenticulina chathamensis	0	0	0	0	0	1	0	0	0
Neolenticulina variabilis	0	0	0	1	0	0	0	0	0
Nonionella atlantica	3	0	0	0	0	0	0	0	0

GIP 25 of 2010 Continued.

Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm	6-7 cm	7-8 cm	8-9 cm	9-10 cm
Nonionella iridea	6	2	0	11	9	7	7	9	4
Nonionella opima	20	9	1	0	2	0	1	0	1
Oridorsalis umbonatus	0	0	0	0	0	0	0	2	2
Osangularia culter	2	3	9	2	5	6	13	6	7
Osangularia rugosa	0	1	3	8	5	7	12	8	7
Planulina exorna	0	0	0	1	0	1	0	0	0
Portatrochammina antarctica	0	4	0	0	1	1	0	0	0
Praeglobobulimina ovula	3	0	0	2	0	0	0	1	0
Procerolagena gracilis	0	0	0	0	0	1	0	0	0
Prolixoplecta parvula	0	0	0	10	28	23	16	8	6
Pullenia bulloides	0	0	0	1	1	0	0	0	2
Pullenia quinqueloba	4	0	1	0	1	1	0	0	0
Pyrgo c.f. *williamsoni*	0	0	0	0	1	0	0	0	0
Pyrgo murrhina	0	0	0	0	0	0	0	0	1
Pyrgo sp. D	0	0	0	0	0	0	0	0	1
Pyrgo sp. E	0	0	0	0	0	0	0	0	1
Pyrgoella sphaera	0	0	1	2	0	0	0	0	0
Quinqueloculina bosciana	0	0	0	0	0	0	1	0	0
Quinqueloculina seminulum	0	0	3	1	1	0	1	3	7
Recurvoides trochamminiforme	2	1	0	0	8	2	1	1	3
Reophax agglutinatus	0	0	0	2	0	0	0	0	0
Reophax dentaliniformis	0	0	1	0	0	0	0	0	0
Reophax sp. A	0	2	3	2	0	0	0	0	0
Rhabdammina discreta	1	0	0	0	0	0	0	0	0
Robertinoides bradyi	0	0	0	0	0	0	1	1	1

GIP 25 of 2010 Continued.

Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm	6-7 cm	7-8 cm	8-9 cm	9-10 cm
Rotalid sp. L	0	0	0	0	0	0	1	0	0
Rotalid sp. M	0	0	0	0	0	0	0	1	0
Rutherfordoides mexicanus	122	124	75	14	18	5	2	8	5
Seabrookia earlandi	1	1	2	2	0	0	1	1	1
Sphaeroidina bulloides	0	0	0	2	0	0	0	1	2
Spiroloculina sp. A	0	0	0	0	0	0	2	1	1
Spiroplectammina sp.	2	2	2	7	16	38	55	62	53
Stainforthia complanata	1	2	1	0	0	0	0	0	0
Textularia earlandi	10	7	2	2	0	0	0	0	0
Textularia sp. B	1	3	1	0	0	0	0	0	0
Triloculina tricarinata	0	1	3	0	2	0	2	0	1
Trochammina c.f. *advena*	1	3	3	2	3	3	7	4	4
Trochammina globulosa	1	3	3	4	0	2	4	3	1
Trochammina inflata	0	0	0	0	1	1	0	0	0
Trochammina japonica	0	0	1	0	1	0	0	0	0
Trochammina quadriloba	0	0	0	0	1	0	0	0	0
Trochammina tasmanica	0	0	0	1	0	0	0	0	0
Usbekistania charoides	0	3	1	1	0	0	0	1	0
Uvigerina auberiana	0	1	0	0	0	0	0	0	0
Uvigerina bellula	2	0	0	0	0	1	0	0	0
Uvigerina peregrina	1	3	5	12	6	2	6	6	8
Uvigerina sp. F	0	0	0	0	0	0	2	1	0
Valvulineria glabra	3	0	1	0	1	0	0	0	0
Indeterminate	6	1	1	9	8	5	2	4	2

GIP 25 of 2010 Continued.									
Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm	6-7 cm	7-8 cm	8-9 cm	9-10 cm
Suborders									
Textulariina	16	14	16	18	17	15	12	9	11
Lagenina	2	1	1	3	1	2	1	1	1
Miliolina	1	4	5	2	6	3	4	4	9
Robertinina	0	0	0	0	0	0	1	1	1
Rotaliina	27	28	28	31	33	25	30	33	35
Spirillinina	0	0	0	0	0	0	0	0	0
Total Specimens	307	315	314	300	301	315	341	315	303
Splits	2	2	2	2	2	2	2	2	2
Pans	9	8	12	12	6	5	5	6	7
Volume (cm^3)	51	62	67	70	66	73	76	68	67
Density (spec/ 10 cm^3)	252	229	141	129	274	311	323	278	233
Diversity Indices									
Species Richness	46	47	50	54	57	45	48	48	57
H'	2.56	2.54	3.04	3.37	3.34	2.99	3.16	3.08	3.29
D	0.18	0.19	0.09	0.04	0.05	0.07	0.06	0.07	0.06
E	0.28	0.27	0.42	0.54	0.50	0.44	0.49	0.45	0.47
J	0.67	0.66	0.78	0.84	0.83	0.79	0.82	0.80	0.81

Raw Counts for GIP 25 of 2011.

Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm	6-7 cm	7-8 cm	8-9 cm	9-10 cm
Adercotryma glomerata	0	0	0	0	0	3	1	1	0
Agglutinated sp. A	0	1	2	1	2	1	4	1	3
Agglutinated sp. Bb	1	0	0	0	0	0	0	0	0
Agglutinated sp. Cb	0	0	0	0	0	0	0	0	1
Agglutinated sp. Eb	0	0	0	0	0	0	0	0	2
Agglutinated sp. Fb	1	0	0	1	0	0	0	0	1
Agglutinated sp. G	0	0	0	1	0	0	1	0	0
Agglutinated sp. Gb	0	0	0	0	0	1	0	0	0
Agglutinated sp. Hb	0	0	1	0	0	0	0	0	0
Agglutinated sp. Ib	1	0	1	0	0	0	0	0	0
Agglutinated sp. T	0	0	0	0	0	0	0	1	0
Agglutinated sp. Y	0	1	0	0	0	0	0	1	0
Alveolophragmium subglobosum	0	0	0	0	0	0	0	1	0
Angulogerina jamaicensis	0	0	0	0	0	0	0	1	0
Bolivina albatrossi	11	4	12	16	10	9	6	9	5
Bolivina c.f. *ordinaria*	0	0	3	0	0	0	1	0	0
Bolivina c.f. *subaenariensis mexicana*	0	0	0	0	1	0	1	0	0
Bolivina lanceolata	0	1	1	0	0	0	0	0	0
Bolivina minima	4	4	13	28	31	40	22	30	15
Bolivina paula	3	1	0	2	3	0	2	1	3
Bolivina striatula	0	0	2	2	1	6	0	0	1
Bolivina translucens	41	22	8	9	5	6	7	9	3
Bulimina aculeata	0	3	8	4	10	10	9	12	21
Bulimina alazanensis	2	1	2	2	4	12	12	13	7
Bulimina spicata	0	0	1	2	5	2	5	4	1

GIP 25 of 2011 Continued.

Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm	6-7 cm	7-8 cm	8-9 cm	9-10 cm
Cassidulina carinata	3	2	11	12	30	17	24	35	34
Cassidulinoides tenuis	0	0	0	0	0	0	0	1	0
Chilostomella oolina	11	1	4	4	0	1	0	0	0
Cibicides corpulentus	1	1	1	0	0	0	0	0	0
Cibicides kullenbergi	1	0	4	1	1	1	1	1	1
Cibicides mollis	0	0	0	0	0	0	1	0	0
Cibicidoides pachydermus	0	0	0	1	0	0	0	0	0
Cibicidoides robertsonianus	1	0	0	0	0	0	0	0	0
Cribrostomoides nitidum	1	0	0	0	0	0	0	0	0
Cruciloculina triangularis	1	0	0	0	0	0	0	0	0
Cystammina pauciloculata	3	2	0	0	0	0	0	0	0
Discorbis bulbosa	0	0	0	1	2	2	1	1	1
Dorothia scabra	0	0	0	0	0	0	0	0	2
Eggerella bradyi	0	0	0	0	0	0	0	0	1
Epistominella exigua	0	1	2	8	14	13	27	21	22
Epistominella levicula	8	13	19	49	44	41	46	46	38
Epistominella vitrea	2	0	0	0	2	0	0	0	0
Eponides regularis	0	1	0	1	2	2	0	1	1
Fissurina fissa	0	0	0	0	0	1	0	0	0
Fissurina incomposita	0	0	0	0	0	1	0	0	0
Fursenkoina obliqua	3	5	7	5	0	1	0	0	0
Fursenkoina tessellata	39	31	49	41	16	6	2	2	6
Gaudryina minuta	1	2	4	1	4	0	1	3	3
Gavelinopsis translucens	2	1	7	8	11	24	16	14	13
Globobulimina affinis	1	0	2	0	0	0	0	0	0

GIP 25 of 2011 Continued.

Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm	6-7 cm	7-8 cm	8-9 cm	9-10 cm
Globobulimina mississippiensis	0	2	0	5	0	0	0	0	0
Globocassidulina subglobosa	0	2	0	5	2	5	5	1	2
Globotextularia sp. A	0	0	2	1	1	2	3	0	0
Glomospira irregularis	0	0	1	0	0	0	0	0	0
Gyroidina orbicularis	1	0	0	0	2	0	0	3	0
Haplophragmoides bradyi	2	3	3	2	3	0	0	0	1
Haplophragmoides kirki	2	0	2	1	0	0	0	1	0
Haynesina germanica	1	4	4	11	10	9	4	5	4
Hormosinella guttifera	1	0	0	0	0	0	0	0	0
Hormosinella pilulifera	0	0	1	0	0	0	0	1	0
Hyperammina friabilis	0	0	0	0	1	0	0	0	0
Lagenaid sp. A	0	0	1	2	0	0	0	0	0
Lagenaid sp. B	0	0	0	1	0	0	0	0	0
Lagenammina difflugiformis	0	0	3	1	4	1	1	0	0
Lagenammina tubulata	0	0	0	0	1	0	0	0	0
Lenticulina gibba	0	0	1	2	0	0	0	0	0
Loxostomum abruptum	1	0	5	3	5	12	14	5	8
Miliolida sp. F	0	0	0	0	0	0	0	0	1
Miliolida sp. G	0	0	0	0	0	0	1	0	1
Neocrosbyia minuta	0	0	0	1	0	0	0	1	0
Neolenticulina variabilis	0	0	0	0	0	0	0	0	1
Nonionella atlantica	1	0	0	0	0	0	0	0	0
Nonionella iridea	0	1	2	3	3	1	1	5	2
Nonionella opima	26	6	16	7	0	0	1	3	5
Oridorsalis umbonatus	0	0	0	0	1	0	0	1	1

GIP 25 of 2011 Continued.

Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm	6-7 cm	7-8 cm	8-9 cm	9-10 cm
Osangularia culter	0	1	3	5	7	7	17	9	8
Osangularia rugosa	0	0	4	7	18	15	11	20	15
Pandaglandulina dinapolii	0	0	0	0	1	0	0	0	0
Parafissurina lateralis	0	1	0	0	0	0	0	0	0
Portatrochammina antarctica	2	0	0	0	5	0	0	0	1
Praeglobobulimina ovata	1	0	1	0	0	0	0	0	0
Praeglobobulimina ovula	6	1	2	0	2	1	1	0	0
Procerolagena gracilis	0	0	1	0	0	0	1	0	0
Prolixoplecta parvula	0	0	1	4	9	4	8	14	7
Pullenia bulloides	0	0	0	0	0	0	0	0	1
Pullenia quinqueloba	0	1	3	2	0	0	0	0	0
Pyrgo lucernula	0	0	0	1	0	1	0	0	0
Pyrgo sp. A	0	0	1	0	0	0	0	0	0
Pyrgoella sphaera	1	0	0	0	0	0	0	0	0
Quinqueloculina bosciana	0	0	0	0	0	0	0	0	1
Quinqueloculina seminulum	0	0	1	0	0	0	1	1	1
Recurvoides trochamminiforme	0	2	0	1	0	0	0	0	2
Reophax agglutinatus	0	0	1	1	0	0	1	0	0
Reophax scotti	0	0	1	0	1	0	0	0	0
Reophax sp. A	0	0	3	3	0	0	0	3	1
Reophax sp. H	0	0	0	0	1	0	0	0	0
Reophax sp. I	0	0	0	1	0	0	0	0	0
Reticulophragmium venezuelanum	0	0	1	0	0	0	0	0	0
Rhizammina indivisa	0	0	0	0	1	1	1	2	0
Rotalid sp. A	3	0	1	2	0	1	0	1	0

GIP 25 of 2011 Continued.

Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm	6-7 cm	7-8 cm	8-9 cm	9-10 cm
Rutherfordoides mexicanus	133	175	85	18	16	1	3	2	0
Seabrookia earlandi	0	2	0	1	1	1	0	2	0
Siphonodosaria calomorpha	0	0	2	0	0	0	1	0	0
Sphaeroidina bulloides	0	0	1	1	0	0	0	2	1
Spirillina vivipara	0	0	0	0	1	0	0	0	0
Spiroplectammina sp.	3	1	2	3	15	22	27	30	40
Stainforthia complanata	0	0	1	0	0	0	0	1	0
Textularia earlandi	7	5	6	0	0	0	0	0	0
Trifarina bradyi	0	0	1	0	0	0	0	0	0
Trochammina c.f. *advena*	1	0	3	1	2	2	0	5	3
Trochammina globulosa	1	0	3	0	0	0	1	0	1
Trochammina japonica	0	0	2	0	1	0	0	0	0
Trochammina quadriloba	0	1	2	0	0	1	0	1	0
Trochammina tasmanica	1	0	0	0	4	5	3	2	1
Usbekistania charoides	0	3	0	1	0	0	0	0	0
Uvigerina peregrina	2	2	0	3	6	7	4	3	1
Valvulineria glabra	3	1	0	1	0	0	0	0	0
Veleroninoides wiesneri	0	0	0	0	0	0	1	0	0
Indeterminate	4	0	1	1	3	5	1	4	8

GIP 25 of 2011 Continued.

Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm	6-7 cm	7-8 cm	8-9 cm	9-10 cm
Suborders									
Textulariina	15	10	21	16	16	11	13	15	16
Lagenina	0	2	3	4	2	3	1	1	1
Miliolina	2	0	2	1	0	1	2	1	4
Robertinina	0	0	0	0	0	0	0	0	0
Rotaliina	27	27	34	34	29	27	28	32	27
Spirillinina	0	0	0	0	1	0	0	0	0
Total Specimens	345	312	338	302	325	304	302	337	307
Splits	2	2	2	2	2	2	2	2	2
Pans	6	6	9	9	7	6	4	3	3
Volume (cm^3)	69	67	58	73	60	66	60	70	58
Density (spec/ 10 cm^3)	300	281	233	165	279	276	453	578	627
Diversity Indices									
Species Richness	44	39	60	55	48	42	44	49	48
H'	2.41	1.97	3.11	3.22	3.24	3.06	3.07	3.12	3.03
D	0.19	0.33	0.10	0.07	0.05	0.06	0.06	0.06	0.07
E	0.25	0.18	0.38	0.45	0.53	0.51	0.49	0.46	0.43
J	0.64	0.54	0.76	0.80	0.84	0.82	0.81	0.80	0.78

APPENDIX D

Tables of Juveniles Counts for All Samples

Number of juvenile specimens counted in all surface (0-1 cm) samples.

Taxa	GIP12	GIP15	GIP16	GIP17	GIP21	GIP25	GIPK*	GIP15*	GIP16*	GIP17*	GIP25*	Obs0a	Obs0b	Obs0c
Ammodiscus tenuis	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Bolivina albatrossi	3	2	2	4	0	3	1	7	10	10	4	0	11	9
Bolivina minima	2	1	0	1	0	0	1	1	0	0	1	0	0	2
Bolivina translucens	14	11	1	2	0	0	2	2	0	0	9	0	1	0
Bulimina aculeata	20	31	8	17	0	3	1	3	2	24	0	2	1	2
Bulimina alazanensis	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Bulimina marginata	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Cassidulina carinata	8	8	0	2	0	0	13	8	0	0	5	3	4	7
Cibicides kullenbergi	0	0	0	0	3	0	0	0	0	0	0	0	2	1
Epistominella exigua	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Fursenkoina tessellata	0	0	1	2	0	0	0	0	0	0	1	1	0	0
Gaudryina minuta	0	0	6	1	4	0	0	0	11	9	2	3	2	4
Gavelinopsis translucens	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Hormosinella guttifera	0	0	0	0	0	0	0	0	0	0	0	5	0	3
Hormosinella pilulifera	1	0	4	0	0	0	0	0	3	0	2	0	1	0
Lenticulina convergens	0	0	0	2	0	0	0	0	1	0	0	0	0	0
Loxostomum abruptum	1	0	0	0	0	0	1	0	0	0	0	0	4	0
Neolenticulina chathamensis	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Osangularia culter	0	0	1	0	0	1	0	3	0	0	0	1	0	0
Osangularia rugosa	0	0	0	0	0	0	0	0	0	0	0	0	8	0

Surface Counts Continued

Taxa	GIP12	GIP15	GIP16	GIP17	GIP21	GIP25	GIPK*	GIP15*	GIP16*	GIP17*	GIP25*	Obs0a	Obs0b	Obs0c
Reophax scorpiurus	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Rutherfordoides mexicanus	10	11	1	1	0	9	6	2	0	0	12	0	0	0
Textularia earlandi	1	4	0	0	0	10	0	5	0	0	16	4	12	1
Uvigerina peregrina	1	13	1	6	0	13	1	21	2	0	6	13	10	18
Total	68	81	27	39	7	39	26	52	29	44	59	32	56	47

The (*) Indicates samples from 2011.

Number of juvenile specimens counted in core GIP 15 (2010).

Taxa	0-1 cm	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm
Bolivina albatrossi	2	0	0	1	4	2
Bolivina minima	1	1	2	4	8	22
Bolivina translucens	11	17	6	1	1	2
Bulimina aculeata	31	10	11	24	14	4
Cassidulina carinata	8	0	0	1	1	0
Cibicides kullenbergi	0	0	1	2	0	0
Cibicidoides pachydermus	0	0	0	0	0	1
Epistominella levicula	0	0	0	0	0	2
Fursenkoina tessellata	0	7	18	13	7	2
Gavelinopsis translucens	0	0	1	1	0	2
Lenticulina sp. A	0	0	0	0	0	1
Loxostomum abruptum	0	2	4	4	6	2
Osangularia culter	0	0	0	1	3	15
Osangularia rugosa	0	0	1	1	0	18
Rutherfordoides mexicanus	11	36	29	12	9	1
Textularia earlandi	4	0	0	0	0	0
Uvigerina peregrina	13	0	0	2	0	0
Total	81	73	73	67	53	74

Number of juvenile specimens counted in core GIP 15 (2011).

Taxa	0-1 cm	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm
Bolivina albatrossi	7	8	0	9	1	4
Bolivina minima	1	0	2	10	8	12
Bolivina translucens	2	11	8	2	0	1
Bulimina aculeata	3	5	13	24	29	24
Cassidulina carinata	8	5	3	2	0	4
Cibicides kullenbergi	0	1	0	0	0	0
Fursenkoina tessellata	0	9	17	5	0	0
Gavelinopsis translucens	0	0	0	0	1	0
Globobulimina affinis	0	4	0	0	0	0
Globocassidulina subglobosa	0	0	0	0	1	0
Loxostomum abruptum	0	6	4	7	2	3
Osangularia culter	3	1	5	6	2	1
Osangularia rugosa	0	0	0	0	0	3
Rutherfordoides mexicanus	2	8	10	4	3	0
Spiroplectammina spp.	0	0	0	0	0	2
Textularia earlandi	5	0	0	0	0	0
Uvigerina peregrina	21	7	2	3	2	5
Total	52	65	64	72	49	59

Number of juvenile specimens counted in core GIP 25 (2010).

Taxa	0-1 cm	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm	6-7 cm	7-8 cm	8-9 cm	9-10 cm
Bolivina albatrossi	3	0	1	0	1	2	1	0	0	2
Bolivina minima	0	0	0	2	1	2	4	6	7	4
Bolivina translucens	0	5	2	1	0	3	0	1	0	0
Bulimina aculeata	3	0	0	0	0	1	2	2	1	0
Bulimina spicata	0	0	0	0	0	0	0	0	2	0
Cassidulina carinata	0	0	0	1	0	6	9	6	3	9
Cibicides kullenbergi	0	0	1	2	1	1	1	0	1	0
Fursenkoina obliqua	0	1	0	0	0	0	0	0	0	0
Fursenkoina tessellata	0	1	6	2	2	1	0	1	0	0
Gaudryina minuta	0	0	0	0	0	1	0	0	0	1
Gavelinopsis translucens	0	0	0	0	0	0	0	0	1	0
Hormosinella pilulifera	0	0	0	1	0	0	0	0	0	0
Loxostomum abruptum	0	0	0	0	1	2	4	4	3	3
Osangularia culter	1	0	0	0	0	0	1	2	1	1
Osangularia rugosa	0	0	0	0	0	0	3	0	2	0
Prolixoplecta parvula	0	0	0	0	0	3	1	2	0	1
Rutherfordoides mexicanus	9	12	8	6	1	5	5	0	0	0
Textularia earlandi	10	0	1	0	0	0	0	0	0	0
Uvigerina peregrina	13	0	2	1	1	0	1	2	3	5
Total	39	19	21	16	8	27	32	26	24	26

Number of juvenile specimens counted in core GIP 25 (2011).

Taxa	0-1 cm	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm	6-7 cm	7-8 cm	8-9 cm	9-10 cm
Ammodiscus tenuis	1	0	0	0	0	0	0	0	0	0
Bolivina albatrossi	4	4	1	4	7	4	5	3	2	3
Bolivina c.f. ordinaria	0	0	0	0	0	0	0	1	0	0
Bolivina minima	1	0	4	6	13	13	21	8	10	10
Bolivina striatula	0	0	0	0	0	0	1	0	0	0
Bolivina translucens	9	16	10	4	3	2	2	5	7	1
Bulimina aculeata	0	0	2	2	3	4	3	5	2	8
Cassidulina carinata	5	0	0	1	5	6	4	4	11	14
Cibicides kullenbergi	0	0	0	2	0	1	1	1	1	0
Epistominella exigua	0	0	0	0	0	0	0	0	0	2
Epistominella levicula	0	0	0	0	0	0	0	3	0	0
Fursenkoina obliqua	0	0	0	0	1	0	0	0	0	0
Fursenkoina tessellata	1	11	9	19	17	1	1	0	2	2
Gaudryina minuta	2	0	0	0	0	1	0	0	0	0
Gavelinopsis translucens	0	0	0	0	0	2	2	2	0	1
Globobulimina mississippiensis	0	0	0	0	1	0	0	0	0	0
Hormosinella pilulifera	2	0	0	1	0	0	0	0	0	0
Loxostomum abruptum	0	1	0	4	1	5	10	9	2	6
Osangularia culter	0	0	0	1	0	1	0	1	1	2
Osangularia rugosa	0	0	0	0	0	2	4	1	3	4

GIP 25 (2011) Counts Continued

Taxa	0-1 cm	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm	6-7 cm	7-8 cm	8-9 cm	9-10 cm
Rutherfordoides mexicanus	12	33	26	13	3	6	1	1	1	0
Textularia earlandi	16	0	0	1	0	0	0	0	0	0
Uvigerina peregrina	6	2	2	0	2	5	5	4	3	1
Total	59	67	54	58	56	53	60	48	45	54

APPENDIX E

Tables of Taxa with Relative Frequencies > 5% for All Samples

Taxa with relative frequencies of > 5% for all surface (0-1 cm) samples.

Taxa	GIP12	GIP15	GIP16	GIP17	GIP21	GIP25	GIPK*	GIP15*	GIP16*	GIP17*	GIP25*	Obs0a	Obs0b	Obs0c
Adercotryma glomerata	1.5	0.6	2.2	1.8	1.3	0.6	1.0	0.0	5.0	5.0	0.0	1.3	1.2	2.2
Bolivina albatrossi	1.2	2.2	0.9	3.5	0.0	1.6	1.3	3.9	3.8	5.0	2.7	3.2	4.1	4.8
Bolivina translucens	9.9	6.7	0.2	0.6	0.0	0.6	1.0	3.5	0.0	0.0	4.0	0.0	0.3	0.0
Bulimina aculeata	15.2	28.9	3.7	5.0	0.8	5.1	5.3	7.4	1.9	11.3	1.8	3.5	1.8	1.6
Cassidulina carinata	5.4	6.2	0.4	2.0	0.0	4.5	9.9	4.8	0.0	0.6	7.9	5.5	7.0	7.6
Cystammina pauciloculata	6.3	0.3	1.9	1.8	0.0	0.2	21.4	1.0	4.7	2.5	3.7	1.0	2.3	0.6
Epistominella exigua	3.0	5.6	3.0	3.5	0.3	1.4	1.0	3.9	0.9	1.3	2.7	4.2	6.4	4.1
Epistominella levicula	4.2	3.1	12.5	0.9	7.5	1.0	0.3	9.6	4.7	9.1	3.4	8.1	7.9	7.9
Gaudryina minuta	0.3	0.0	2.2	1.2	3.0	0.2	0.0	0.6	6.6	2.8	0.9	1.3	2.0	2.2
Haplophragmoides bradyi	0.0	0.8	3.2	0.6	0.8	0.2	0.0	4.2	5.0	5.0	2.1	0.0	1.5	1.0
Lagenammina difflugiformis	0.3	0.0	0.6	0.0	8.3	1.2	0.0	0.3	0.0	0.0	0.6	1.0	0.3	0.0
Portatrochammina antarctica	0.3	0.0	1.3	0.3	0.0	0.4	4.6	0.0	5.3	0.9	0.6	0.6	0.6	0.6
Recurvoides trochamminiforme	0.3	2.0	5.8	1.5	4.8	7.3	1.0	0.0	5.0	1.3	0.0	0.0	4.4	2.9
Reophax sp. A	0.0	0.3	1.1	11.1	0.0	1.2	1.3	0.0	5.6	3.8	0.6	0.0	0.0	0.0
Rutherfordoides mexicanus	6.6	11.2	0.2	0.6	0.0	4.3	2.0	0.6	0.0	0.0	8.2	0.0	0.0	0.0
Spiroplectammina sp.	1.5	0.6	3.9	5.8	1.3	0.2	5.3	1.3	7.2	6.3	0.6	2.9	4.4	4.4
Textularia earlandi	8.4	6.4	0.2	0.0	0.0	27.0	5.3	4.2	0.0	0.3	16.2	4.8	10.5	3.2
Trochammina cf. *advena*	4.5	3.6	7.3	6.1	19.1	2.0	3.9	4.2	15.7	7.8	2.7	8.1	7.6	6.0
Uvigerina peregrina	0.6	5.3	0.4	2.9	0.0	7.5	0.7	14.5	0.9	0.0	4.6	8.1	2.9	7.0

The (*) indicates samples collected from 2011.

Taxa with relative frequencies > 5% for GIP 15 (2010).

Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm
Bolivina minima	0.7	1.2	3.5	4.1	19.5
Bolivina translucens	10.9	3.7	1.0	1.6	0.7
Bulimina aculeata	5.3	4.6	12.1	10.8	2.3
Epistominella levicula	5.3	13.2	15.6	14.9	22.5
Fursenkoina tessellata	13.2	23.7	16.9	10.8	3.3
Gavelinopsis translucens	1.0	0.9	2.9	6.0	2.0
Osangularia culter	0.0	0.3	2.5	3.5	7.0
Osangularia rugosa	0.3	1.2	1.6	6.0	11.3
Rutherfordoides mexicanus	46.0	37.2	13.7	8.2	0.7
Spiroplectammina sp.	0.0	0.3	1.3	6.6	13.9

Taxa with relative frequencies > 5% for GIP 15 (2011).

Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm
Bolivina minima	0.0	2.7	4.4	4.7	7.1
Bolivina translucens	6.9	4.0	0.6	0.9	0.6
Bulimina aculeata	4.2	10.3	13.4	17.8	16.1
Epistominella levicula	10.6	24.6	34.9	24.6	26.1
Fursenkoina tessellata	12.7	22.9	11.9	9.3	5.3
Nonionella opima	6.0	5.6	1.2	0.9	0.6
Rutherfordoides mexicanus	6.6	9.3	3.5	3.4	1.6
Spiroplectammina sp.	1.2	2.3	2.0	6.5	7.1

Taxa with relative frequencies > 5% for GIP 25 (2010).

Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm	6-7 cm	7-8 cm	8-9 cm	9-10 cm
Bolivina minima	0.0	1.0	5.7	5.3	4.0	4.1	5.6	11.1	3.6
Bolivina translucens	7.2	5.1	1.6	1.0	2.0	1.6	0.9	0.6	0.7
Cassidulina carinata	1.3	0.3	6.4	10.0	10.6	12.1	7.6	9.2	12.9
Epistominella exigua	0.7	0.6	2.9	3.0	7.0	12.4	10.6	4.4	4.6
Epistominella levicula	2.3	2.5	6.4	6.3	9.3	12.7	8.8	6.3	6.6
Fursenkoina tessellata	8.8	17.8	10.8	11.0	1.0	0.3	0.9	0.6	0.0
Nonionella opima	6.5	2.9	0.3	0.0	0.7	0.0	0.3	0.0	0.3
Prolixoplecta parvula	0.0	0.0	0.0	3.3	9.3	7.3	4.7	2.5	2.0
Rutherfordoides mexicanus	39.7	39.4	23.9	4.7	6.0	1.6	0.6	2.5	1.7
Spiroplectammina sp.	0.7	0.6	0.6	2.3	5.3	12.1	16.1	19.7	17.5

Taxa with relative frequencies > 5% for GIP 25 (2011).

Taxa	1-2 cm	2-3 cm	3-4 cm	4-5 cm	5-6 cm	6-7 cm	7-8 cm	8-9 cm	9-10 cm
Bolivina albatrossi	3.2	1.3	3.6	5.3	3.1	3.0	2.0	2.7	1.7
Bolivina minima	1.2	1.3	3.8	9.3	9.5	13.2	7.3	8.9	5.0
Bolivina translucens	11.9	7.1	2.4	3.0	1.5	2.0	2.3	2.7	1.0
Bulimina aculeata	0.0	1.0	2.4	1.3	3.1	3.3	3.0	3.6	6.9
Cassidulina carinata	0.9	0.6	3.3	4.0	9.2	5.6	7.9	10.4	11.2
Epistominella exigua	0.0	0.3	0.6	2.6	4.3	4.3	8.9	6.2	7.3
Epistominella levicula	2.3	4.2	5.6	16.2	13.5	13.5	15.2	13.6	12.5
Fursenkoina tessellata	11.3	9.9	14.5	13.6	4.9	2.0	0.7	0.6	2.0
Gavelinopsis translucens	0.6	0.3	2.1	2.6	3.4	7.9	5.3	4.2	4.3
Nonionella opima	7.5	1.9	4.7	2.3	0.0	0.0	0.3	0.9	1.7
Osangularia culter	0.0	0.3	0.9	1.7	2.2	2.3	5.6	2.7	2.6
Osangularia rugosa	0.0	0.0	1.2	2.3	5.5	4.9	3.6	5.9	5.0
Rutherfordoides mexicanus	38.6	56.1	25.1	6.0	4.9	0.3	1.0	0.6	0.0
Spiroplectammina sp.	0.9	0.3	0.6	1.0	4.6	7.2	8.9	8.9	13.2

APPENDIX F

FORAMINIFERAL PLATES

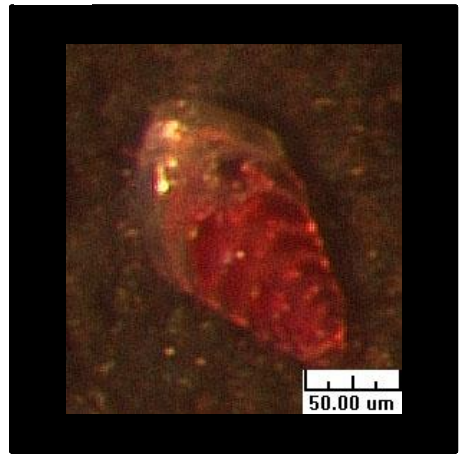
Plate 1

Figures a, b	*Bolivina minima* Phleger and Parker, 1951: a. side view; b. side view.
Figures c, d	*Bolivina translucens* Phleger and Parker, 1951: c. side view; d. side view.
Figures e, f	*Bulimina aculeata* d'Orbigny, 1826: e. aperture view; f. side view.

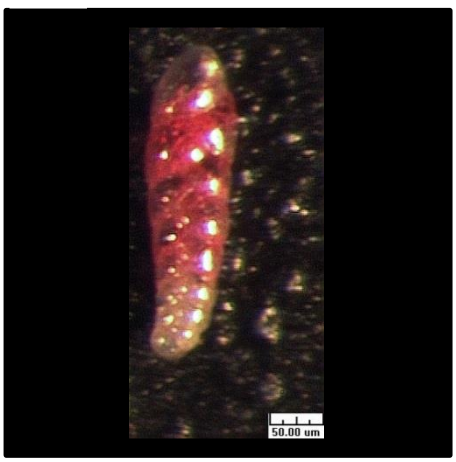
Plate 1

a.

b.



c.



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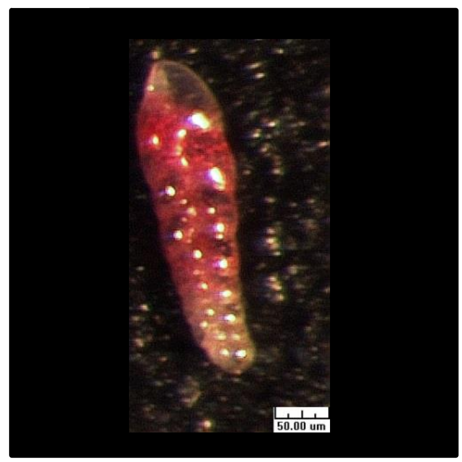

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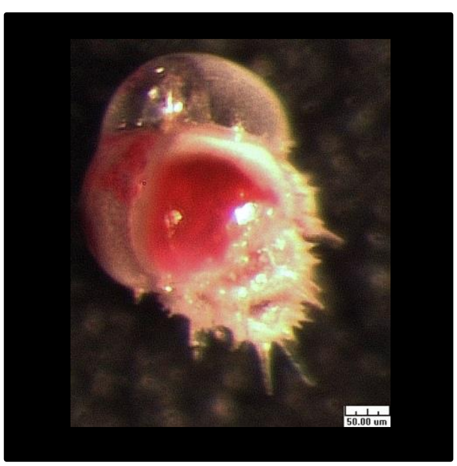


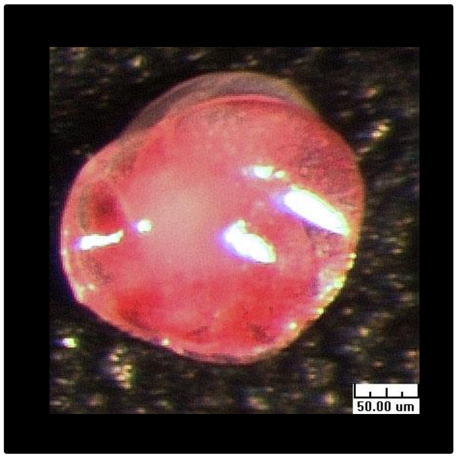
f.

Plate 2

Figures a, b	*Cassidulina carinata* Silvestri, 1896: a. side view; b. aperture view.
Figures c, d	*Cystammina pauciloculata* (Brady), 1879: c. side view; d. side view.
Figures e, f	*Epistominella exigua* (Brady), 1884: e. spiral view; f. umbilical view.

Plate 2

a.



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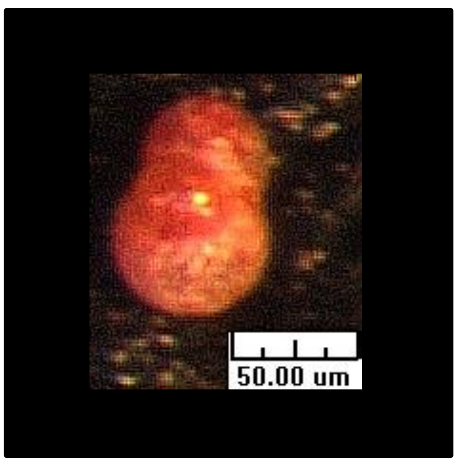
c.



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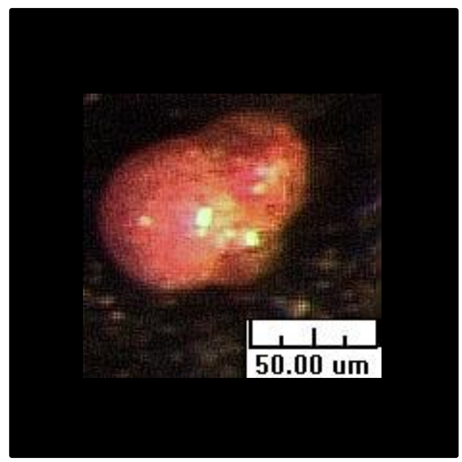

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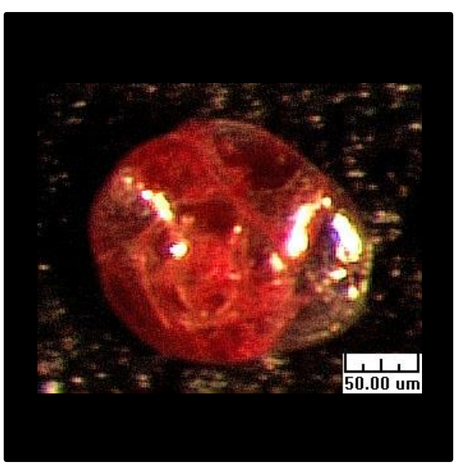

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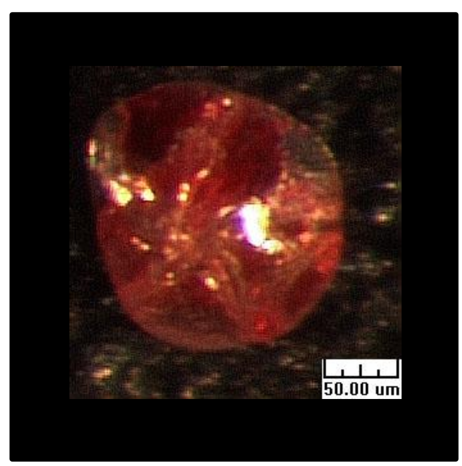
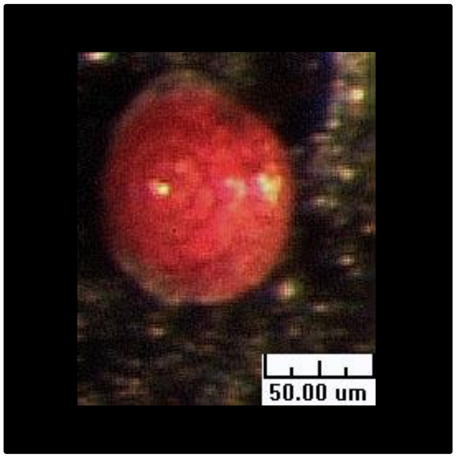


Plate 3

Figures a, b	*Epistominella levicula* Resig, 1958: a. spiral view; b. umbilical view.
Figures c, d	*Fursenkoina tessellata* (Phleger and Parker), 1951: c. side view; d. side view.
Figures e, f	*Osangularia rugosa* (Phleger and Parker), 1951: e. spiral view; f. umbilical view.

Plate 3

a.



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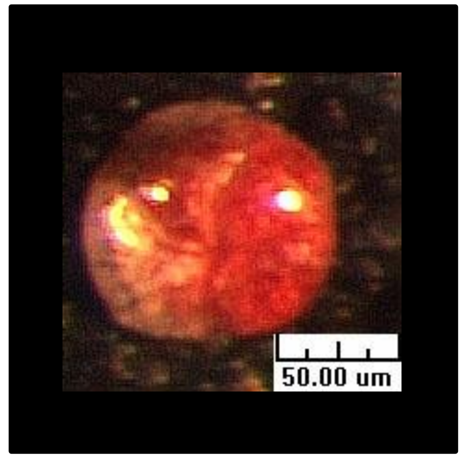
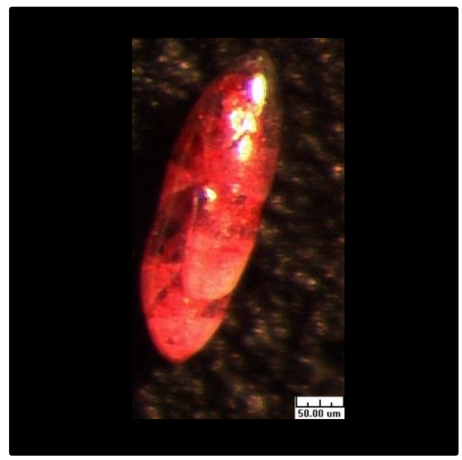


c.

d.



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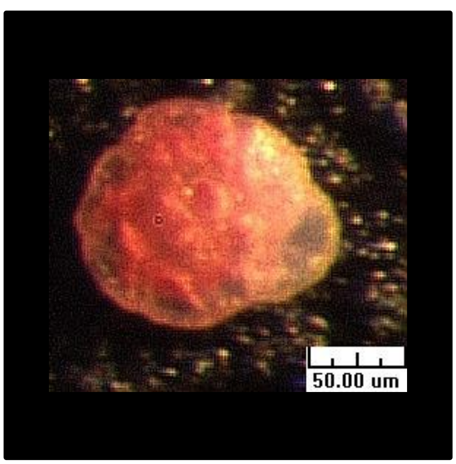

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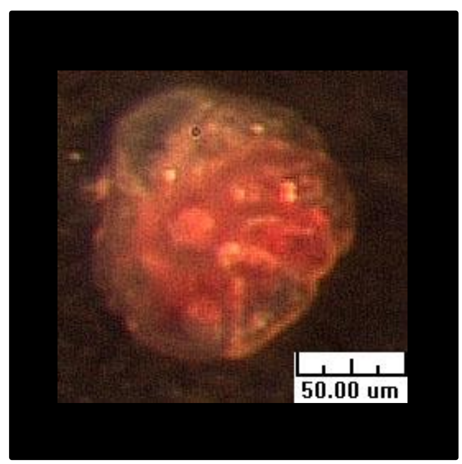
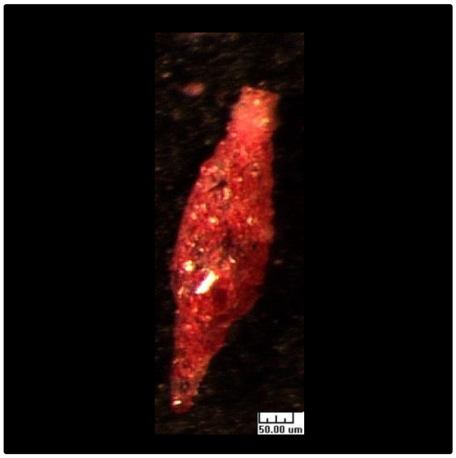


Plate 4

Figures a, b	*Reophax* sp. A: a. side view; b. side view.
Figures c, d	*Rutherfordoides mexicanus* (Cushman), 1922: c. side view; d. side view.
Figures e, f	*Spiroplectammina* sp. Cushman, 1927: e. side view; f. side view.

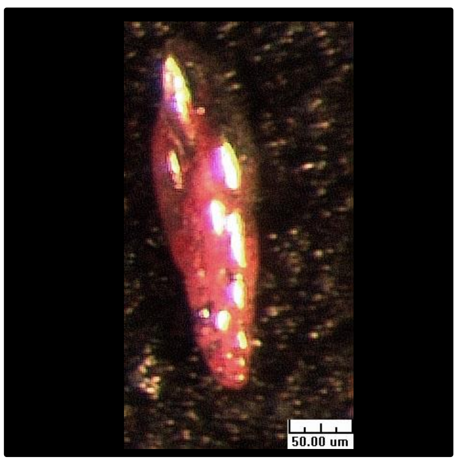
Plate 4

a.



b.

c.



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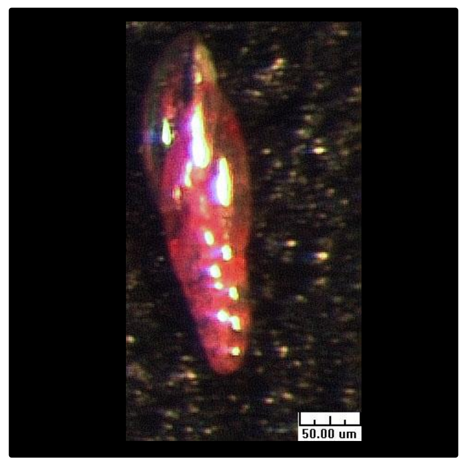

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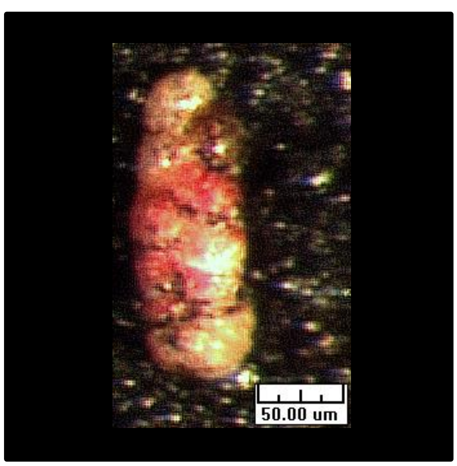

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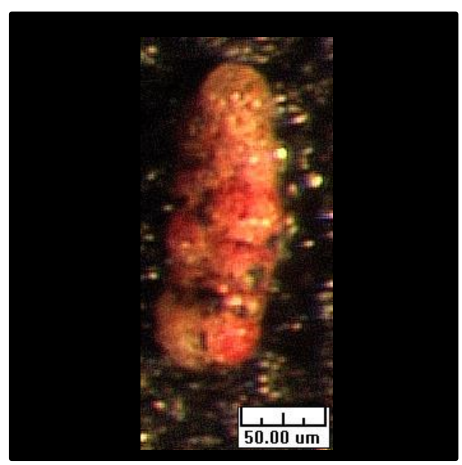
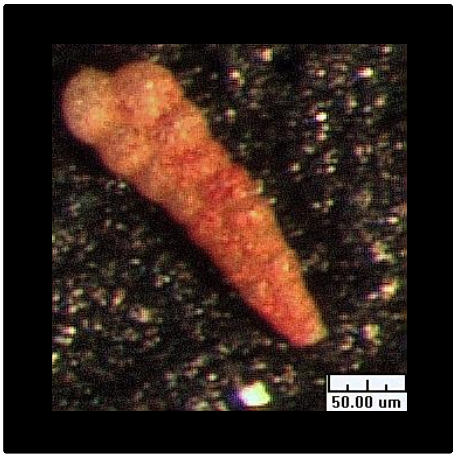


Plate 5

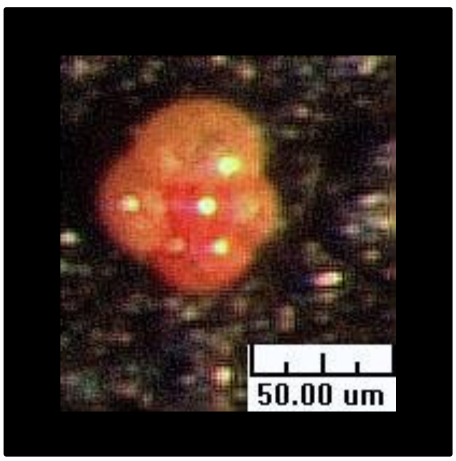
Figure a	*Textularia earlandi* Parker, 1952: a. side view.
Figures b, c	*Trochammina advena* Cushman, 1922: b. spiral view; c. umbilical view.
Figures d, e	*Uvigerina peregrina* Cushman, 1923: d. side view; e. side view.

Plate 5

a.



b.



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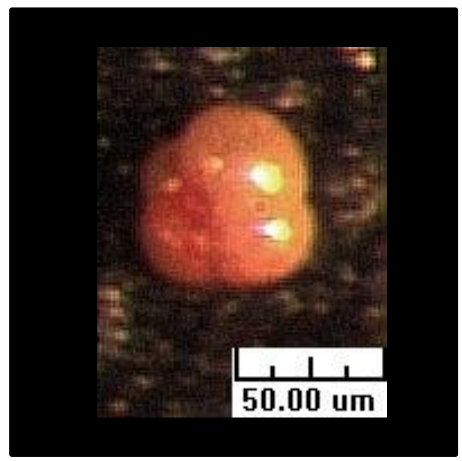
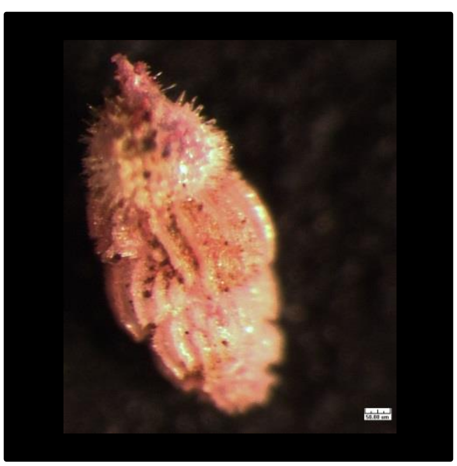
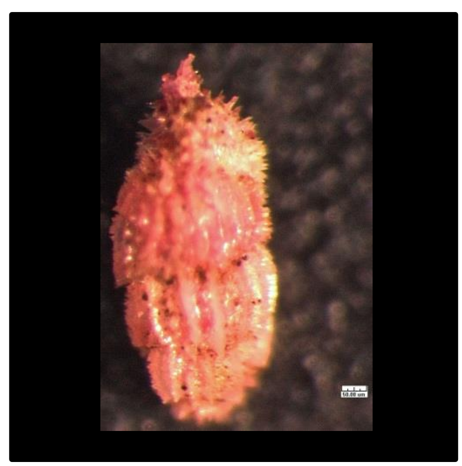


d.



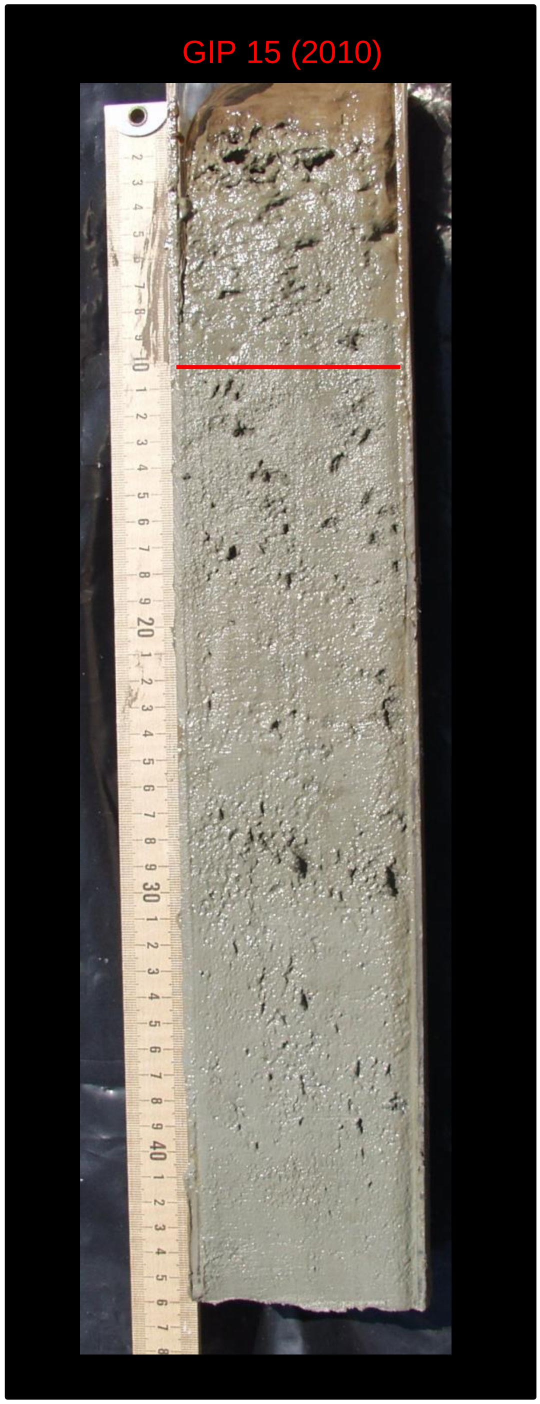
e.



APPENDIX G

SEDIMENT CORE PHOTOGRAPHS

The ruler on the left is depth in centimeters from the sediment/water interface. The number in parentheses is the year the core was sampled. The red line marks the depth to which the core was sliced for foraminifera.



GIP 25 (2010)

GIP 15 (2011)

APPENDIX H

PERMISSION FOR FIGURE 1

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Publication:	Environmental Science & Technology
Publisher:	American Chemical Society
Date:	Aug 1, 2013

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