

Summer 8-2014

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

Valerie Joanna Cruz  
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The University of Southern Mississippi

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

Valerie Joanne Cruz

A Thesis

Submitted to the Graduate School  
of The University of Southern Mississippi  
in Partial Fulfillment of the Requirements  
for the Degree of Master of Science

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August 2014

ABSTRACT

ASSEMBLAGE COMPARISONS OF LIVING BENTHIC FORAMINIFERA  
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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  $\geq 45$ - $\mu\text{m}$  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.

## ACKNOWLEDGMENTS

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<br>(CARTHE) Observation Site..... | <i>Obs</i>      |
| Depth of Habitation.....   | <i>DOH</i>      |
| Gulf Institute Petroleum.....  | <i>GIP</i>      |
| Gulf of Mexico .....   | <i>GOM</i>      |
| Multidimensional Scaling.....  | <i>MDS</i>      |
| Number of Species.....   | <i>S index</i>  |
| Pielou's Diversity Index .....   | <i>J index</i>  |
| Shannon-Wiener Diversity Index .....   | <i>H' index</i> |
| Simpson's Diversity Index .....  | <i>D index</i>  |
| Species Richness.....  | <i>SR index</i> |
| Total Polycyclic Aromatic Hydrocarbons.....  | <i>TPAH</i>     |

## 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  $4.9 \pm 10\%$  (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 accidentally 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 Louchouart 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<sup>3</sup>). 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.

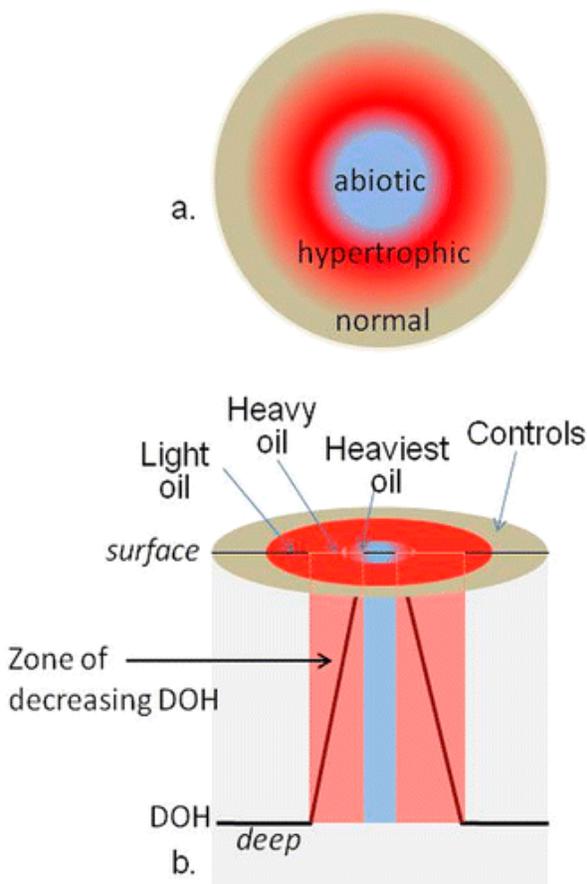
Culture studies with varying concentrations of Erika spill oil caused deformities and lower population density at higher oil concentrations. Morvan et al. (2004) noticed deformities in 45% of juveniles and a few adults in treatments with  $\geq 5.5$  mg per 100 mL of Erika spill oil. Deformities have 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- $\mu\text{m}$  size fraction resulted in a significant loss of smaller specimens in the 63-125- $\mu\text{m}$  fraction. However, they did not establish if significant numbers of Foraminifera occurred in the size fractions smaller than 63  $\mu\text{m}$ . A study done by Pawlowski (1991) found abundant foraminifers in the size class from 32 to 63  $\mu\text{m}$ , contrary to the suggestion of Schröder et al. (1987) that the >63- $\mu\text{m}$  fraction is the best suited for achieving a better species spectrum. In addition, Kurbjeweit et al. (2000) found high abundance within the 30-125  $\mu\text{m}$  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  $\mu\text{m}$ ) than paleoceanographic studies, which generally use larger classes (>63 or >150  $\mu\text{m}$ ), which are sensitive enough for the application (Schröder et al., 1987; Pawlowski, 1991; Scott et al., 2008). Therefore, using a smaller size fraction (>45  $\mu\text{m}$ , 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  $\geq 74 \mu\text{m}$  residues from various sites studied by Parker (1954) consisted of 205 species with densities ranging from 1 to 27 individuals/10 cm<sup>3</sup>, 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  $\mu\text{m}$  with an average density of 24 individuals/10 cm<sup>3</sup>, 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  $\geq 63 \mu\text{m}$  residues with densities

ranging from 4 to 45 individuals/10 cm<sup>3</sup>, 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  $\geq 63 \mu\text{m}$  residue consisted of 183 species and that the density ranged from 0.2 to 174 individuals/10 cm<sup>3</sup>. 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<sup>3</sup>, with one outlier of about 100 individuals/10 cm<sup>3</sup> 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<sup>th</sup> 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  $10\text{ cm}^{-2}$  embraced by 10<sup>th</sup>/90<sup>th</sup> percentiles of 135/640 specimens  $10\text{ cm}^{-2}$  (site 824: 133-362

specimens  $10 \text{ cm}^{-2}$ , site 827: 184-444 specimens  $10 \text{ cm}^{-2}$ , and site 838: 137-835 specimens  $10 \text{ cm}^{-2}$ ). 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  $10 \text{ cm}^{-2}$  embraced by 10<sup>th</sup>/90<sup>th</sup> percentiles of 141/611 specimens  $10 \text{ cm}^{-2}$  (site 131: 133-623 specimens  $10 \text{ cm}^{-2}$ , site 132: 304-1090 specimens  $10 \text{ cm}^{-2}$ , and site 137: 113-449 specimens  $10 \text{ cm}^{-2}$ ). 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  $50 \text{ cm}^{-2}$  embraced by 10<sup>th</sup>/90<sup>th</sup> percentiles of 256/3125 specimens  $50 \text{ cm}^{-2}$  (site 108: 3446-3687 specimens  $50 \text{ cm}^{-2}$ , site 110: 1908-2375 specimens  $50 \text{ cm}^{-2}$ , and site 112: 1656-1928 specimens  $50 \text{ cm}^{-2}$ ). 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

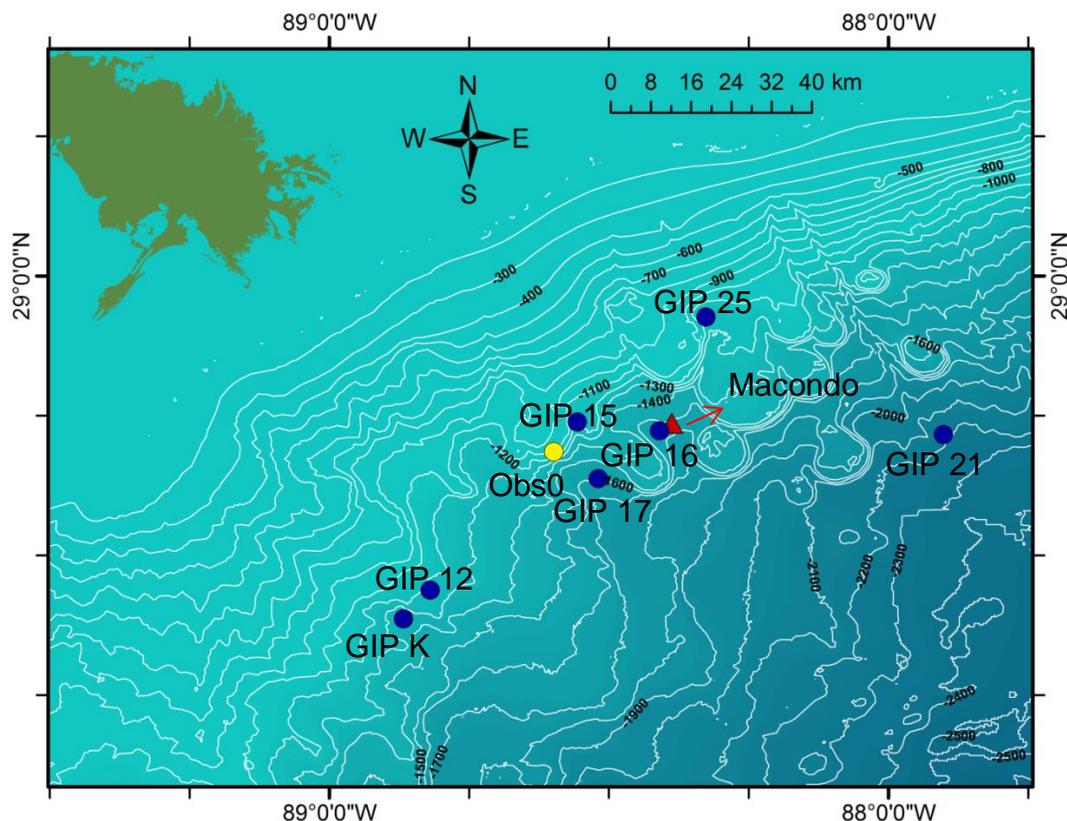
- H1. The standing stock, S index, diversity, and density (defined in the introduction) of foraminifers will be higher at the uncontaminated sites in comparison to heavily contaminated sites. Additionally, sites with moderate to heavy oil contamination will show signs of a hypertrophic zonation (e.g., 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 Louchouart. 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  $\pm 3$  mL 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  $\mu\text{m}$  openings. The  $\geq 45 \mu\text{m}$  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<sup>th</sup>, 50<sup>th</sup>, and 75<sup>th</sup>) 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

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

$T$  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<sup>3</sup>) measured

by displacement, the constant, 6, is the number of aliquots in the splitter device and 10 is the volume (cm<sup>3</sup>) 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  $-\sum p_i \ln p_i$ , 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  $\sum [n_i*(n_i-1)/(N*(N-1))]$ , 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. Louchouart 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.

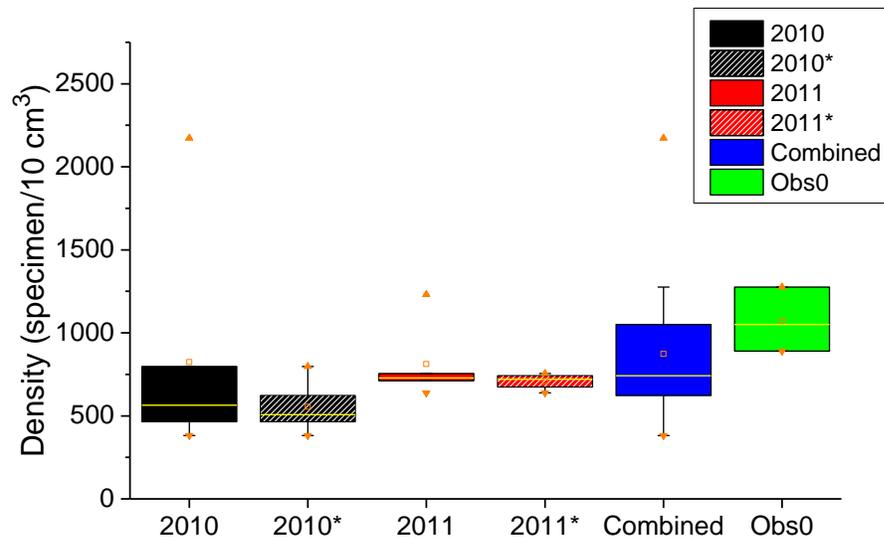
Both sites have a muddy texture with some similar features in the subsurface sediment, with a few differences between years. The 1-to-10-cm interval of each core contains sparse foraminiferal sand, except GIP 15 (2011). Several dark spots, possibly pyrite precursor minerals, are scattered throughout 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<sup>3</sup>) among the surface samples are apparently different between years with a median of 565 embraced by 25<sup>th</sup> and 75<sup>th</sup> percentiles of 465 and 798 in 2010, a median of 729 embraced by 25<sup>th</sup> and 75<sup>th</sup> percentiles of 711 and 755 from 2011, and a median of 1,050 embraced by 25<sup>th</sup> and 75<sup>th</sup> 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<sup>3</sup> (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<sup>3</sup>, 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<sup>3</sup> (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, 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 2

*Specimen Densities of All Surface Samples*

| Sample    | Density (specimens/ 10 cm <sup>3</sup> ) |
|-----------|--|
| 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 <sup>3</sup> ) |
|-----------|--|
| 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<sup>3</sup>.

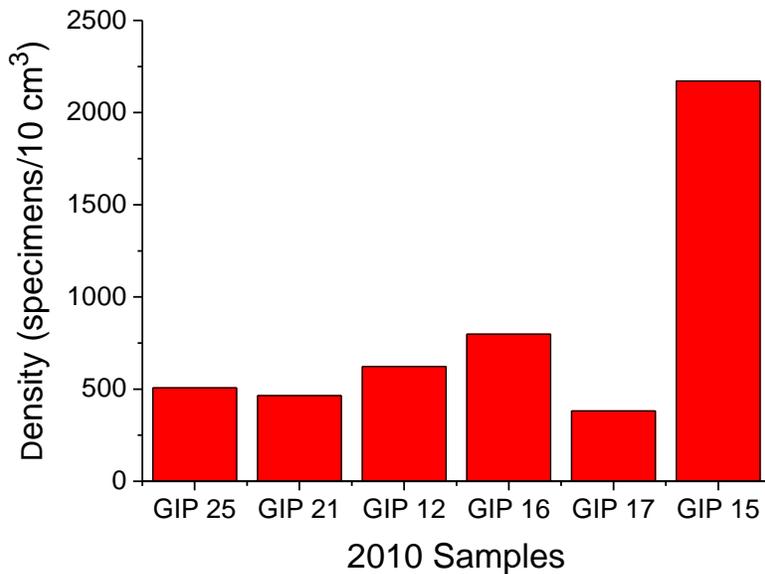


Figure 4. Specimen density of surface samples from 2010. The samples are ordered from left to right by increasing [TPAH].

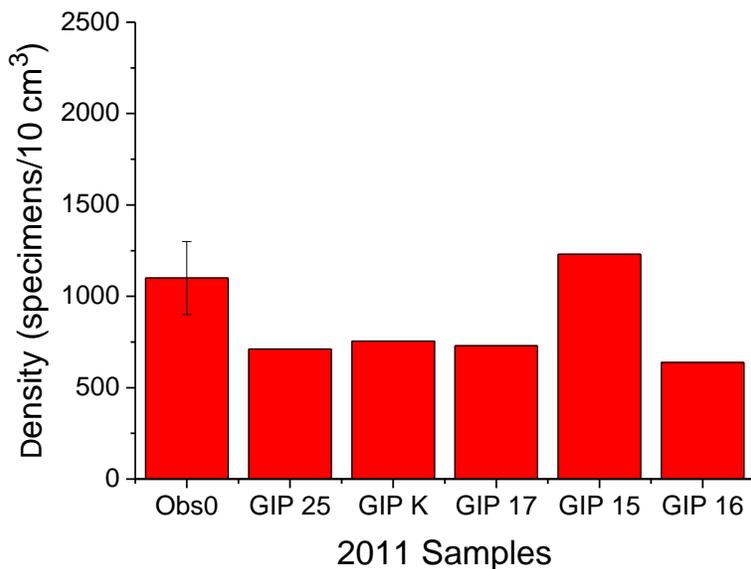
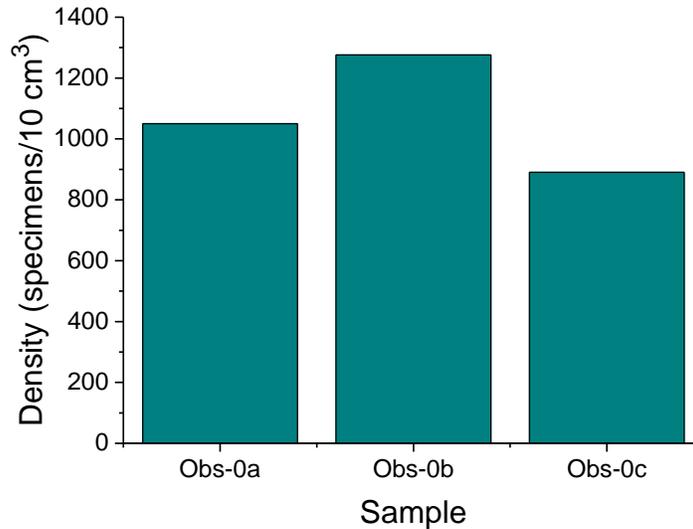


Figure 5. Specimen density of surface samples from 2011. All samples have [TPAH] <1,000 ng/g (background concentrations) and are ordered from left to right by increasing [TPAH].



*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)*

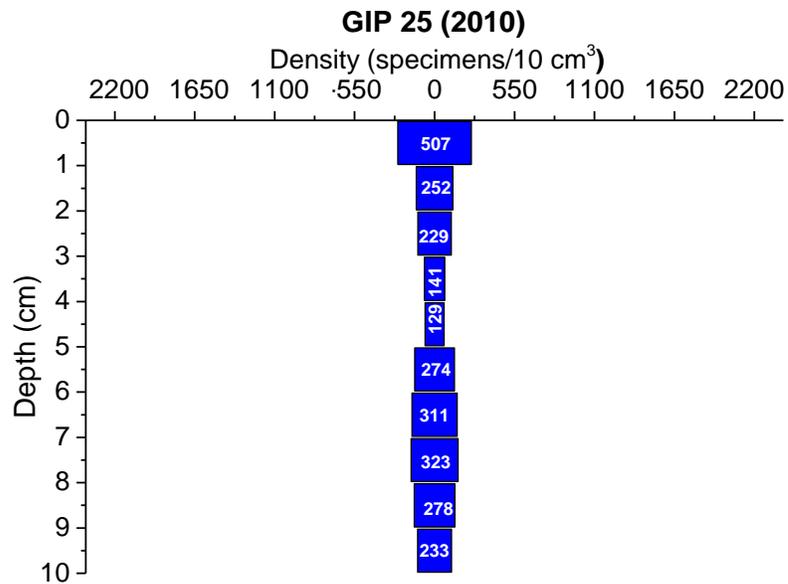
The median of specimen density (specimens/10 cm<sup>3</sup>) among the downcore samples at GIP 25 are similar between years with a median of 263 embraced by 25<sup>th</sup> and 75<sup>th</sup> percentiles of 229 and 311 in 2010 and a median of 290 embraced by 25<sup>th</sup> and 75<sup>th</sup> percentiles 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<sup>3</sup> at the surface to 129 specimens/10 cm<sup>3</sup> at 5 cm (Figure 7), then increased to 323 specimens/10 cm<sup>3</sup> at 8 cm, and decreased again to 233 specimens/10 cm<sup>3</sup> at 10 cm. Density in the 2011 core has a similar trend (Figure 8). The density decreased from 711 to 165 specimens/10 cm<sup>3</sup> from the surface to 5 cm, then increased to 627 specimens/10 cm<sup>3</sup> by 10 cm depth in core.

Table 4

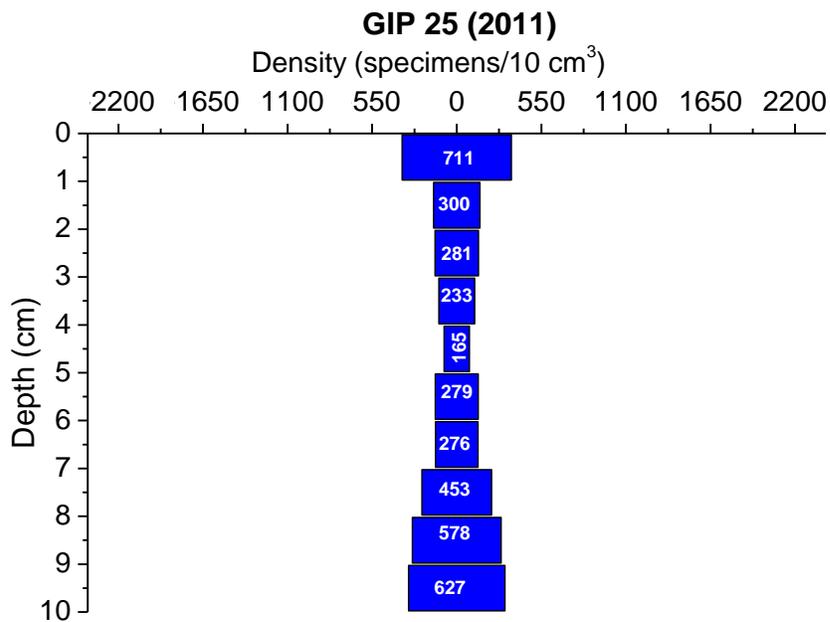
*Specimen Densities of GIP 25's Downcore Samples*

| Sample              | Density (specimens/ 10 cm <sup>3</sup> ) |
|---------------------|--|
| 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<sup>3</sup>) than that in 2011 (3,903 specimens/10 cm<sup>3</sup>).

Table 5

*Downcore DOH, Living Percentage, and Standing Stock*

| Site (Year)    | Standing Stock<br>(specimens/ 10 cm <sup>2</sup> ) | Depth of<br>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.

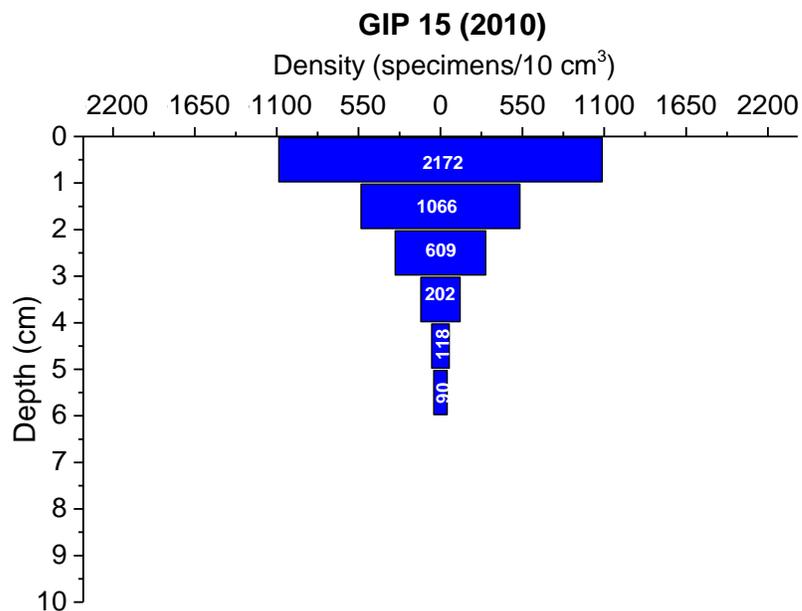
The median of specimen density (specimens/10 cm<sup>3</sup>) among the downcore samples at GIP 15 is somewhat similar between years with a median of 436 embraced by 25<sup>th</sup> and 75<sup>th</sup> percentiles of 118 and 1,066 in 2010 and a median of 500 embraced by 25<sup>th</sup> and 75<sup>th</sup> 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<sup>3</sup> at the surface to 90 specimens/10 cm<sup>3</sup> at 6 cm (Figure 9). The decline in density in the 2011 core is more gradual, decreasing from 1,230 specimens/10 cm<sup>3</sup> at the surface to 161 specimens/10 cm<sup>3</sup> 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

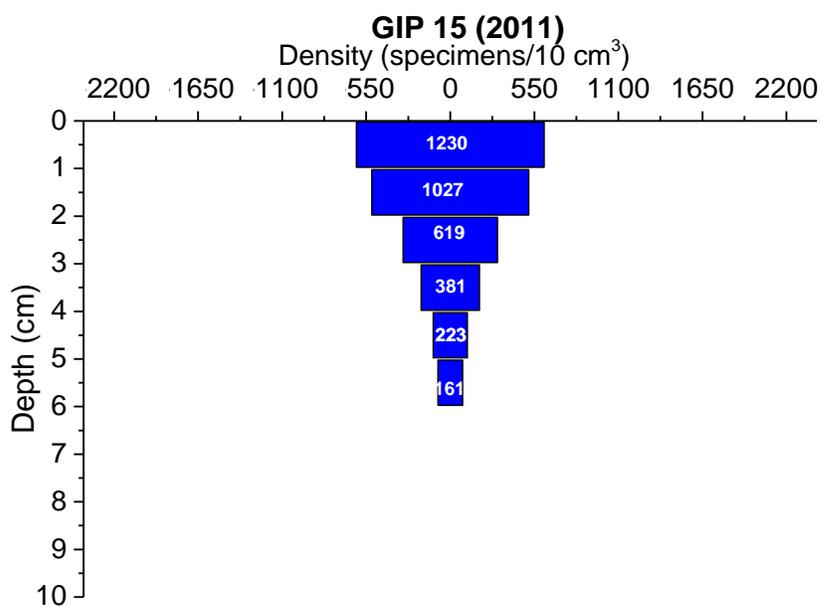
*Specimen Densities of GIP 15's Downcore Samples*

| Sample             | Density (specimens/ 10 cm <sup>3</sup> ) |
|--------------------|--|
| 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<sup>3</sup>) than in 2011 (3,642 specimens/10 cm<sup>3</sup>).

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

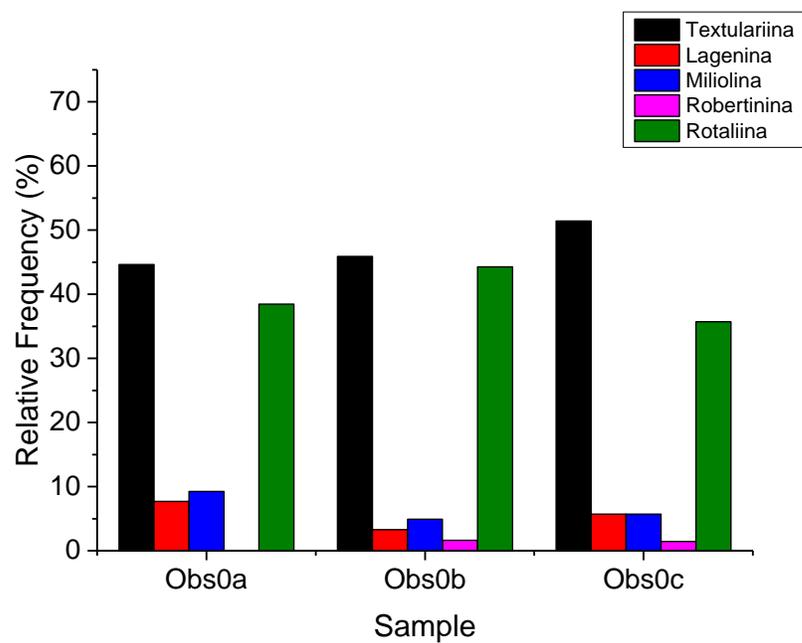
### *General Information*

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

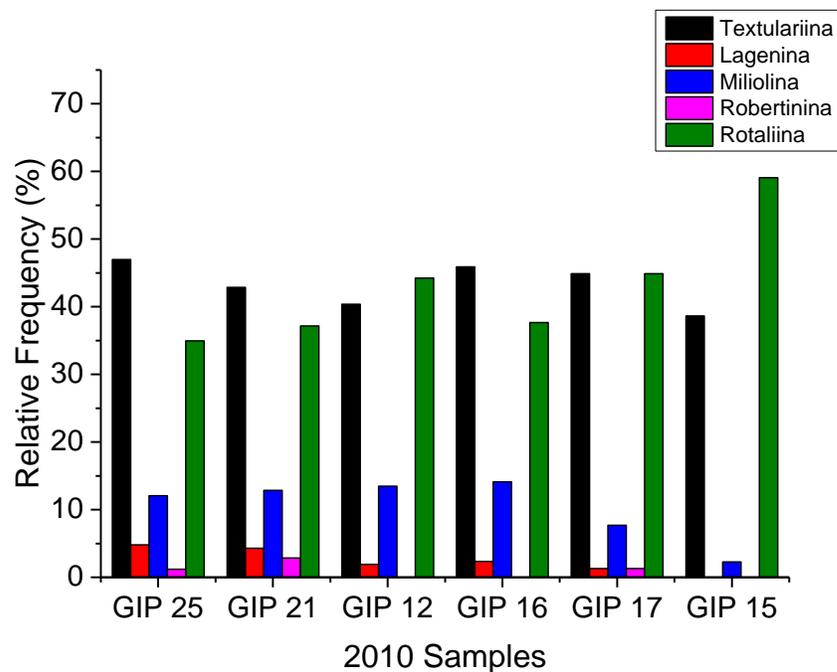
collection. Twenty-six species comprise >5% of the assemblage in at least one sample (Appendix E). Photographs were taken of the 15 species with relative frequencies of >10% in a least one sample (Appendix F).

### *Suborders*

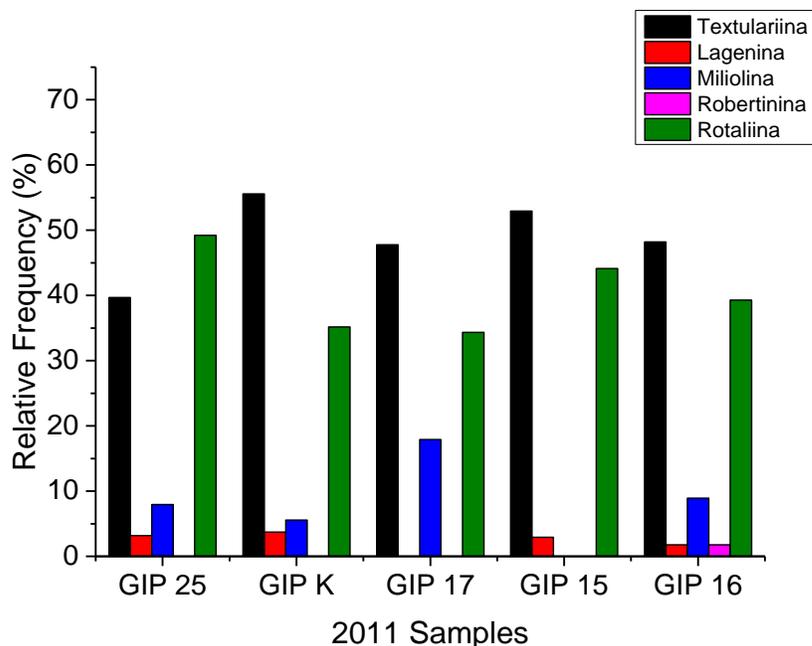
*Surface samples.* A total of five suborders were encountered in the surface samples from all collection years; however, their distributions vary by site and year. Textulariina dominated all three pseudo-replicates followed by the suborder, Rotaliina (Figure 11). One of the pseudo-replicates (Obs0a) 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.



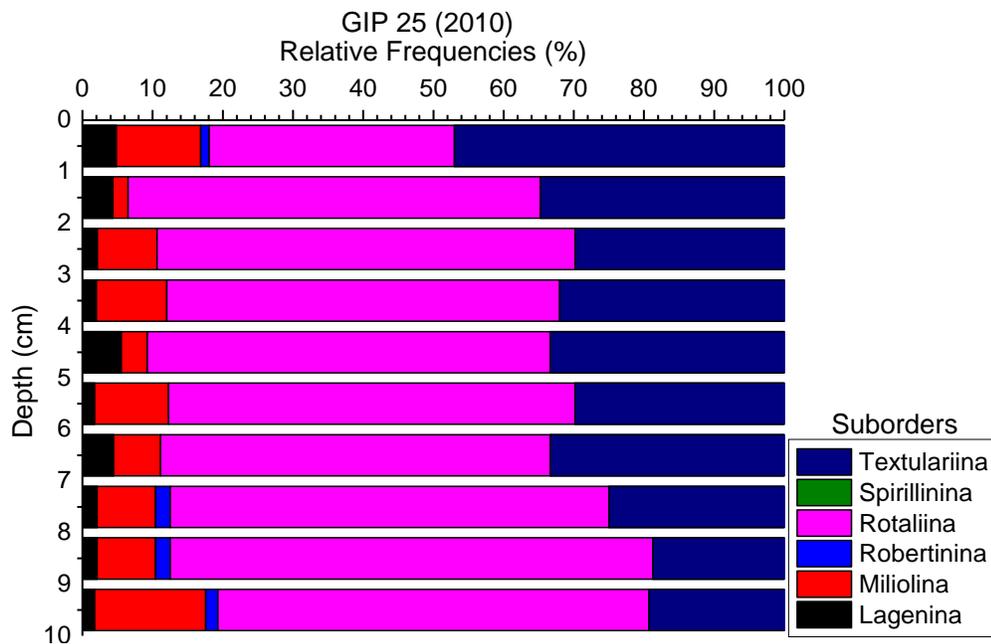
*Figure 12.* Relative frequency of suborders from 2010 surface samples. Surface samples are ordered by increasing [TPAH] from left to right. GIP 12 and 16 did not contain any species from the suborder, Robertinina. GIP 15 did not contain any species from the suborders, Lagenina or Robertinina.



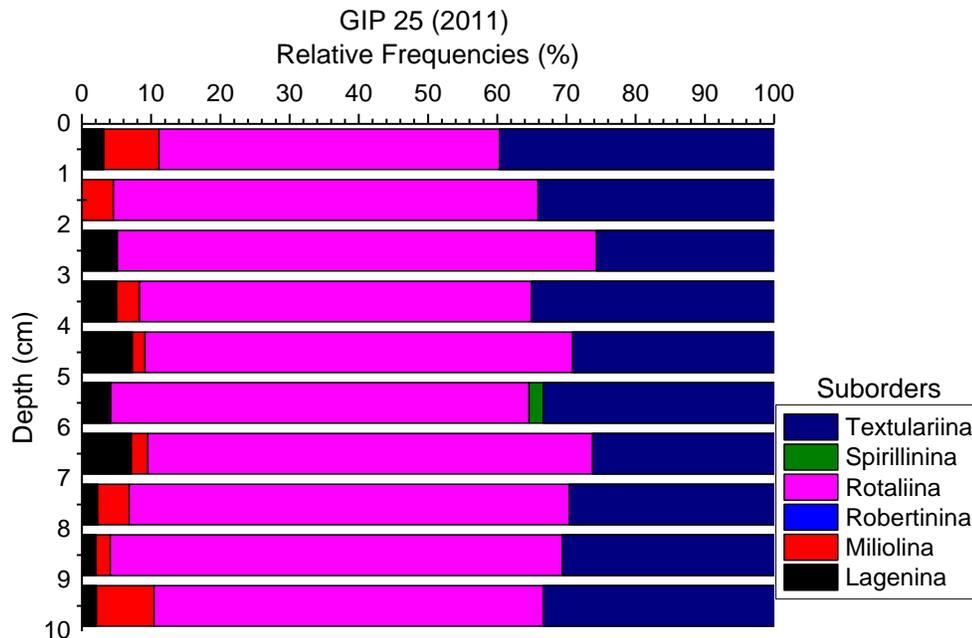
*Figure 13.* Relative frequency of suborders from 2011 surface samples. All samples have [TPAH] <1,000 ng/g (background concentrations) and are ordered by increasing [TPAH] from left to right. GIP 25, K, 17, and 15 do not contain any species from the suborder, Robertinina. GIP 17 does not contain any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

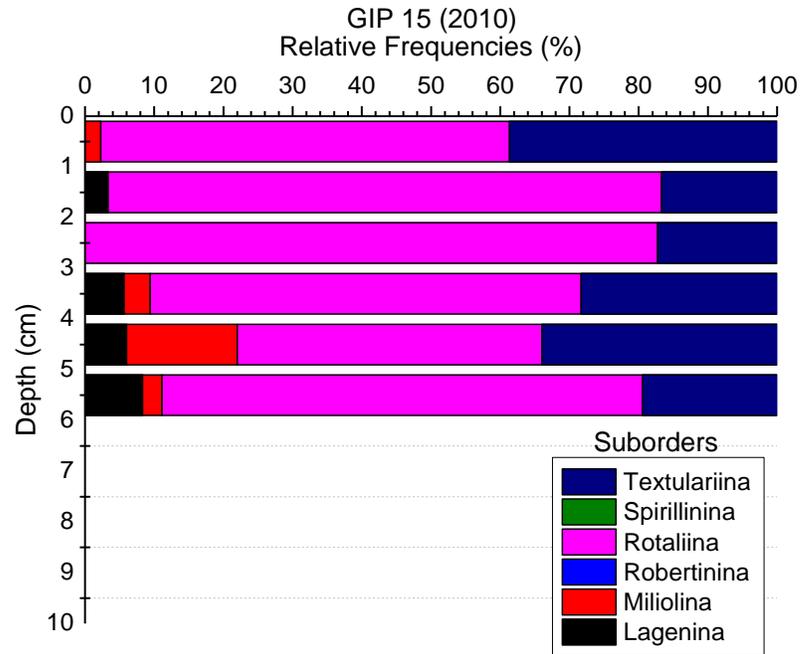


*Figure 14.* Relative frequency of suborders from GIP 25 downcore samples (2010). None of the downcore samples contain any species from the suborder, Spirillinina. The 1-to-7-cm interval does not contain any species from the suborder, Robertinina.

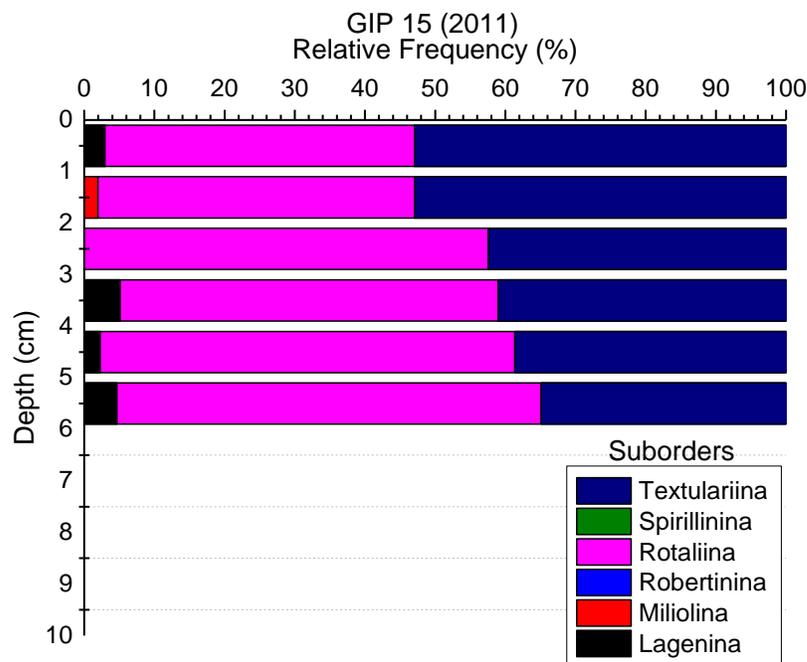


*Figure 15.* Relative frequency of suborders from GIP 25 downcore samples (2011). None of the downcore samples contain any species from the suborder, Robertinina. The 5-to-6-cm interval is the only downcore sample with the suborder, Spirillinina.

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-to-1-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.

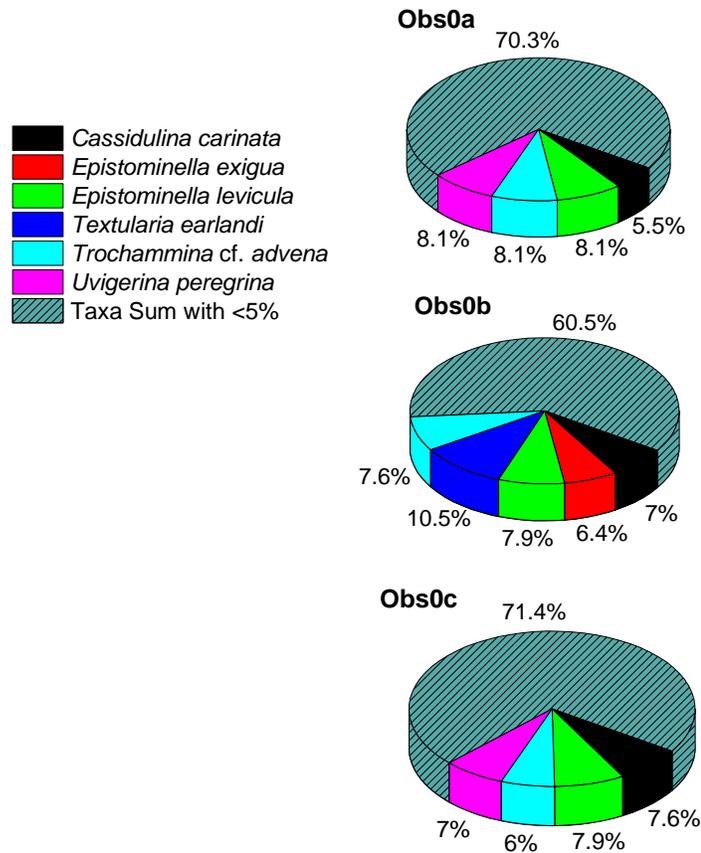


Figure 18. Species with relative frequencies >5% at Obs0. Only four, five, and four species are documented with >5% frequency in samples Obs0a, Obs0b, and Obs0c, respectively.

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*.

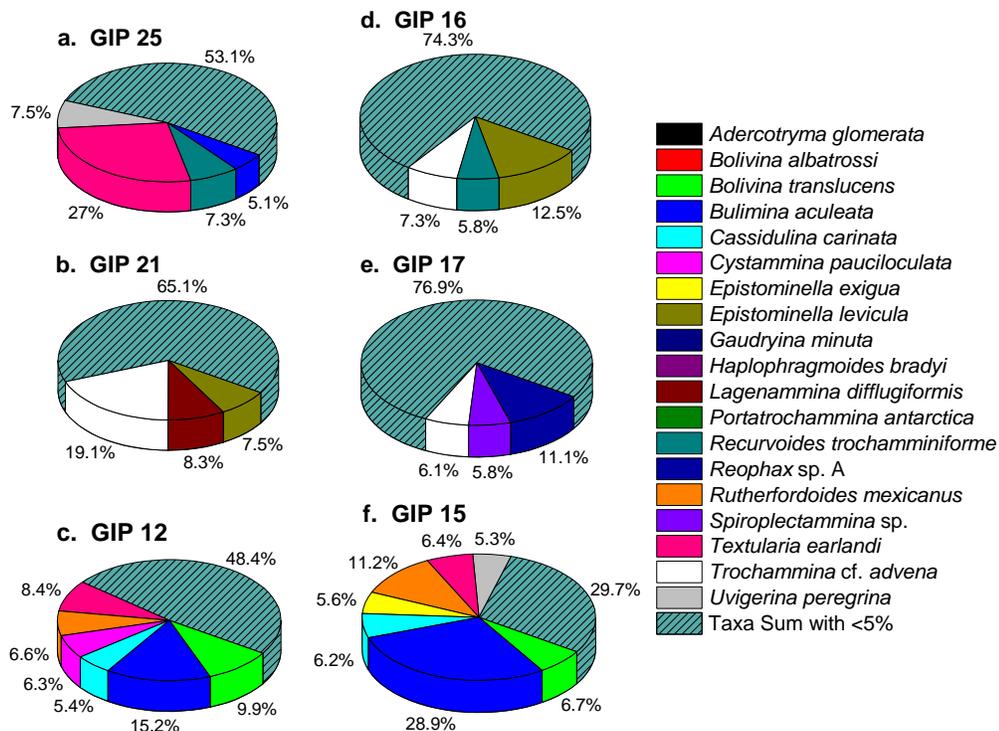
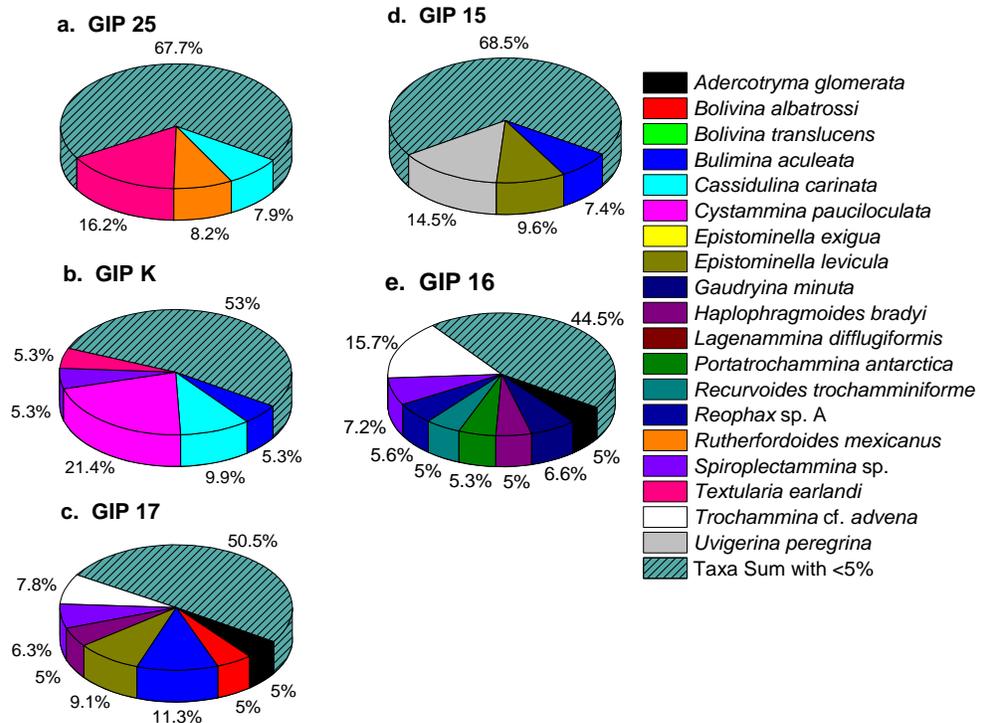


Figure 19. Species with relative frequencies >5% for surface samples (2010). Pie charts are arranged by increasing [TPAH] from a-f. Only three to seven species are documented with >5% frequency within the surface samples.



**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.

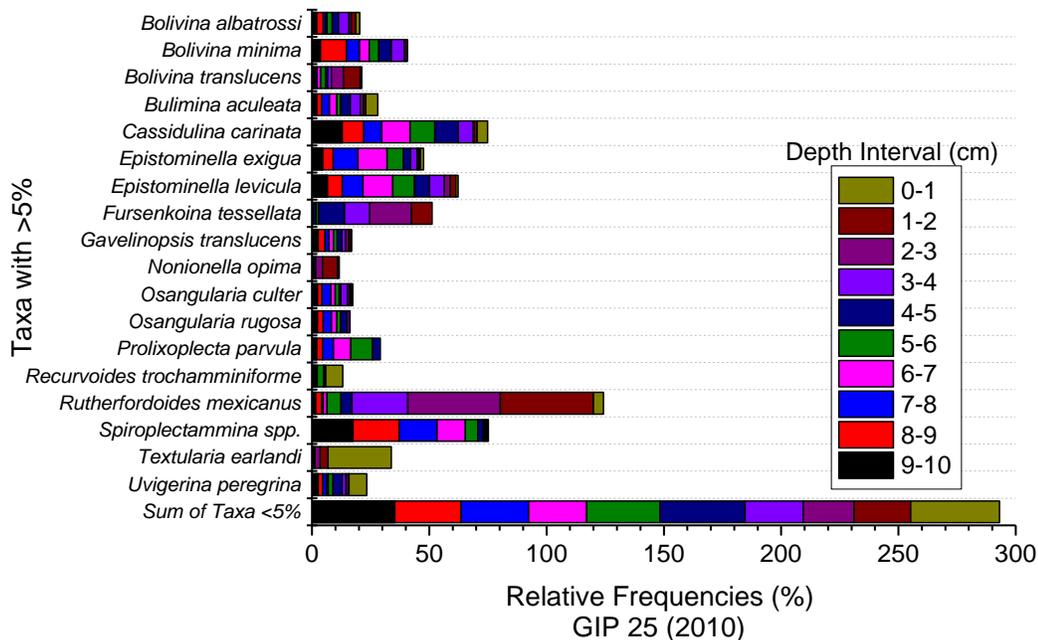


Figure 21. Species with relative frequencies >5% from GIP 25 downcore samples (2010). Eighteen species with relative frequencies >5% are documented at GIP 25. The last row of the chart contains sum of frequencies of taxa with <5% for each of the depth intervals.

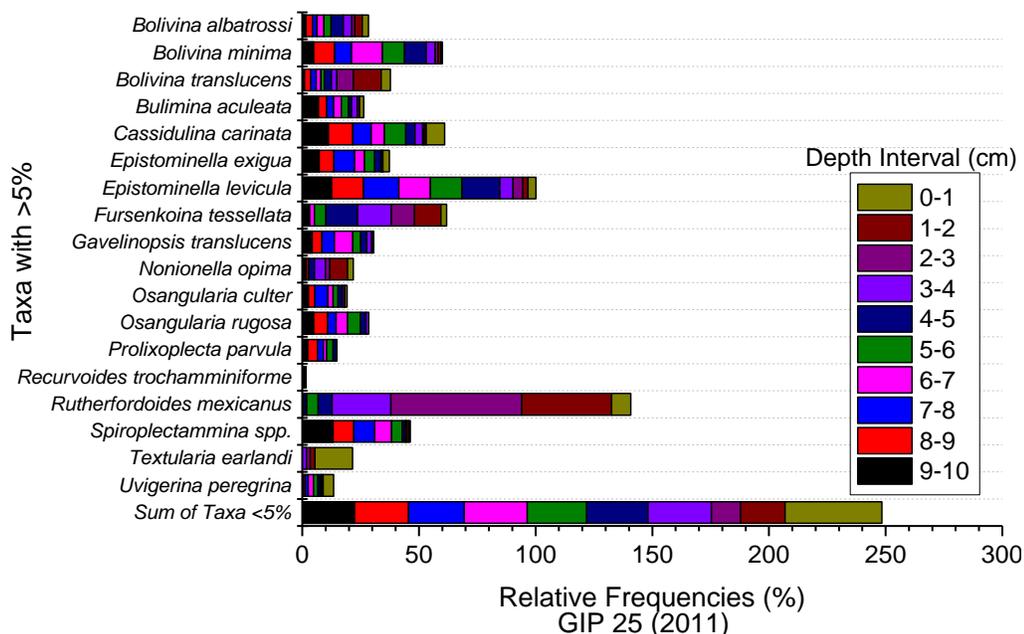


Figure 22. Species with relative frequencies >5% from GIP 25 downcore samples (2011). Eighteen species with relative frequencies >5% are documented at GIP 25. The last row of the chart contains sum of frequencies of taxa with <5% for each of the depth intervals.

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.

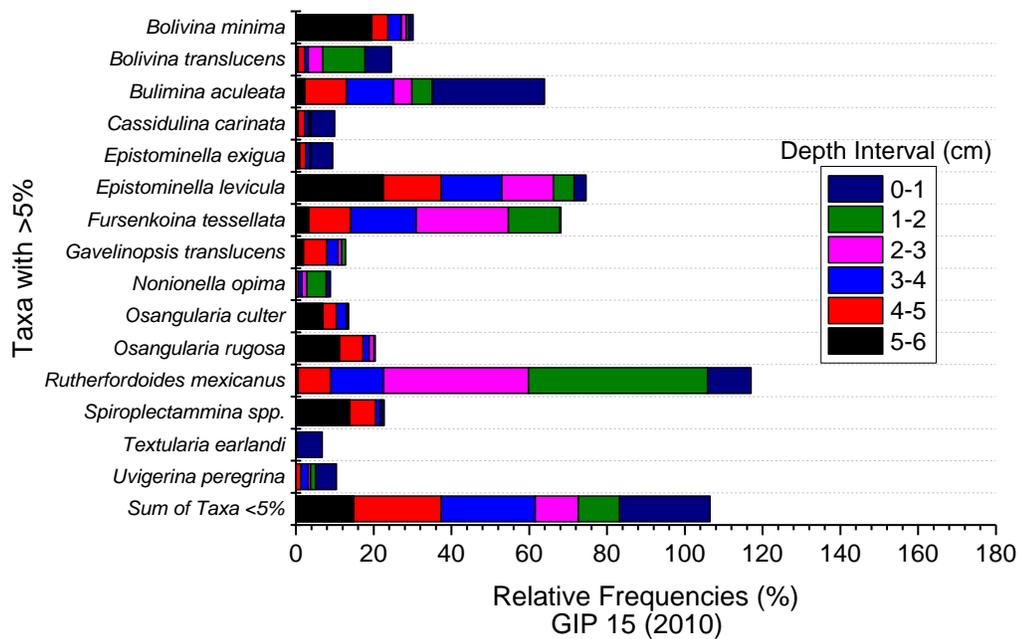
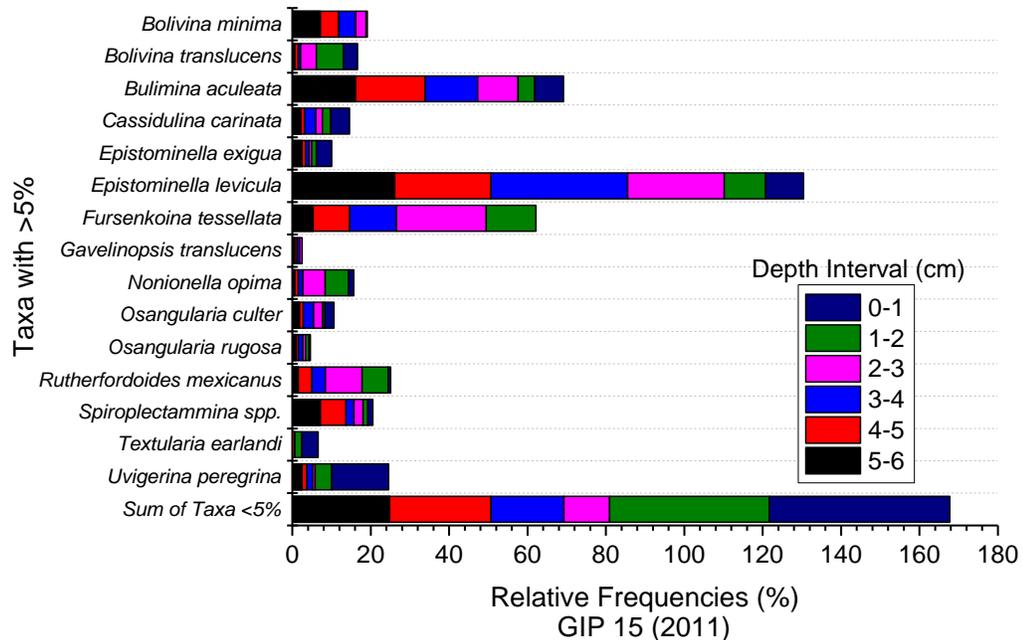


Figure 23. Species with relative frequencies >5% from GIP 15 downcore samples (2010). Fifteen species with relative frequencies >5% are documented at GIP 15. The last row of the chart contains sum of frequencies of taxa with <5% for each of the depth intervals.



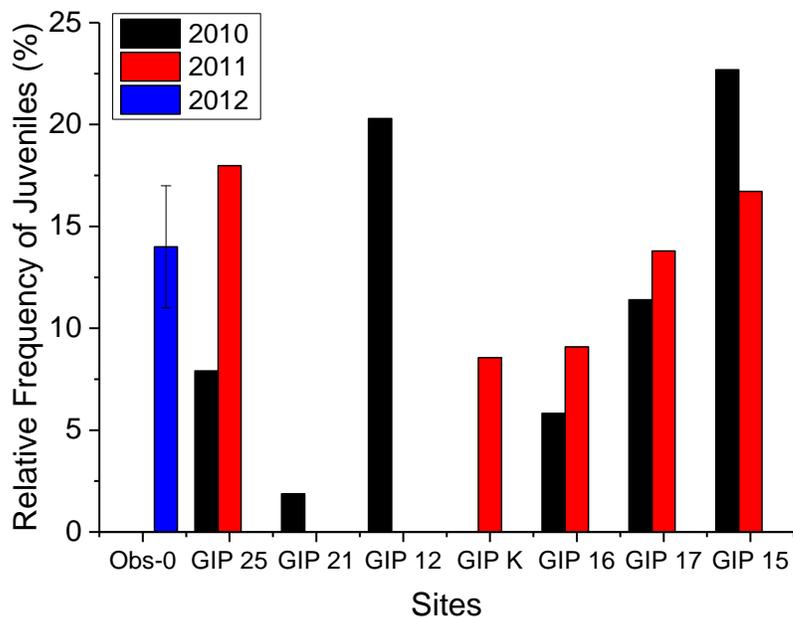
*Figure 24.* Species with relative frequencies >5% from GIP 15 downcore samples (2011). Fifteen species are documented at GIP 15. The last row of the chart contains the sum of frequencies of taxa with <5% for each of the depth intervals.

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*, *Rutherfordoides 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. albatrossi*, *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.

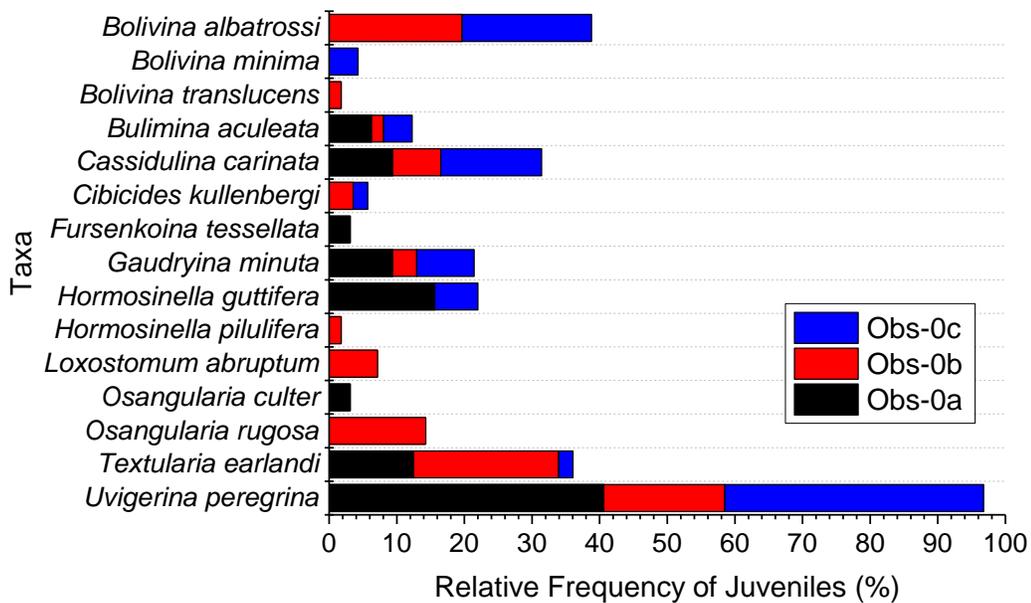


Figure 26. Relative frequency of juveniles present at Obs0. A total of 15 species are documented in the juvenile stage at Obs0. The pseudo-replicates share six juvenile species.

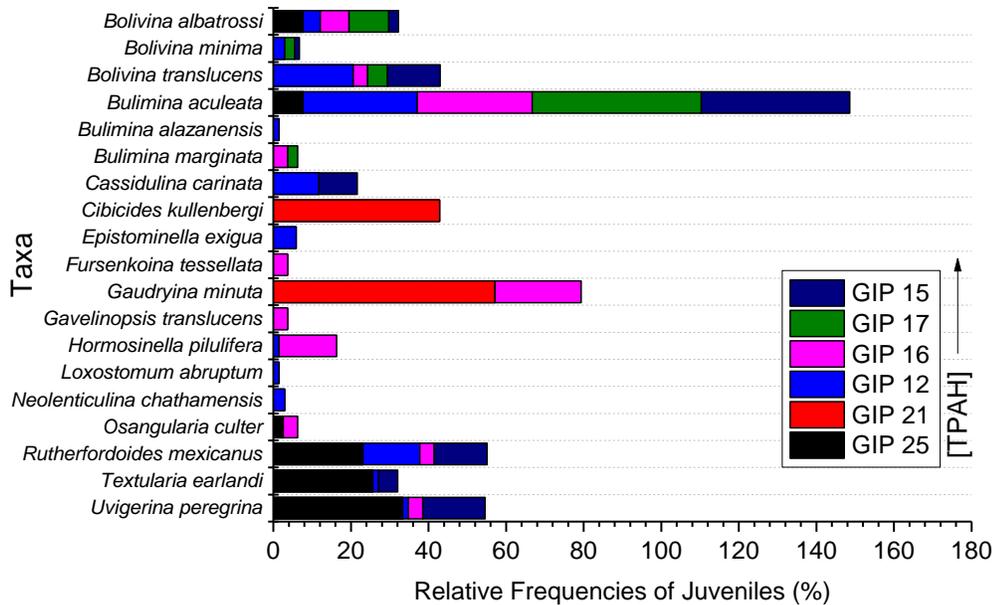


Figure 27. Relative frequency of juveniles present in all surface samples (2010). Samples in the legend are ordered from bottom to top by increasing [TPAH]. A total of 19 species are documented in the juvenile stage in the surface samples.

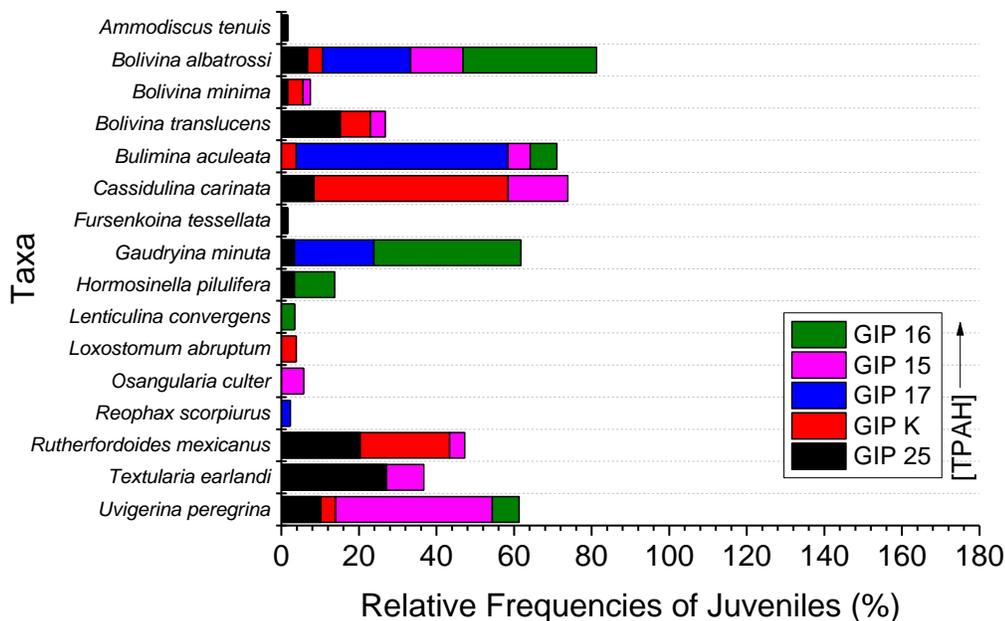
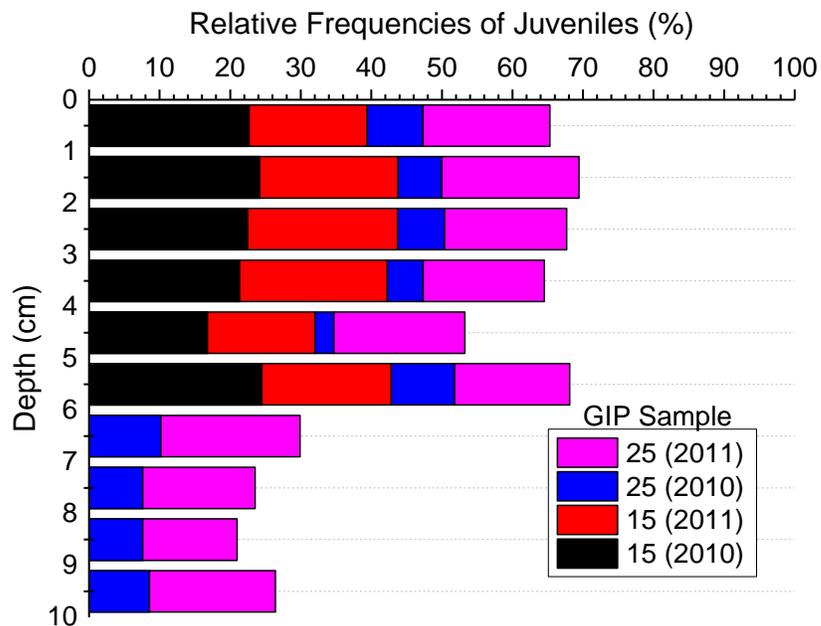


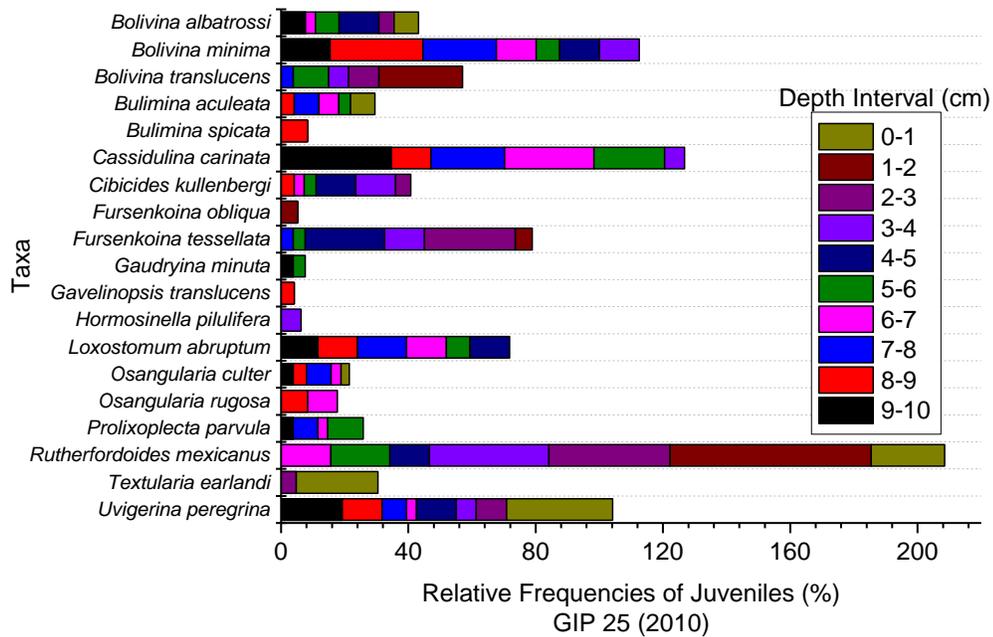
Figure 28. Relative frequency of juveniles present in all surface samples (2011). All samples have [TPAH] <1,000 ng/g (background concentrations) and are ordered by increasing [TPAH] from bottom to top in the legend. A total of 16 species are documented in the juvenile stage in the surface samples.

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.

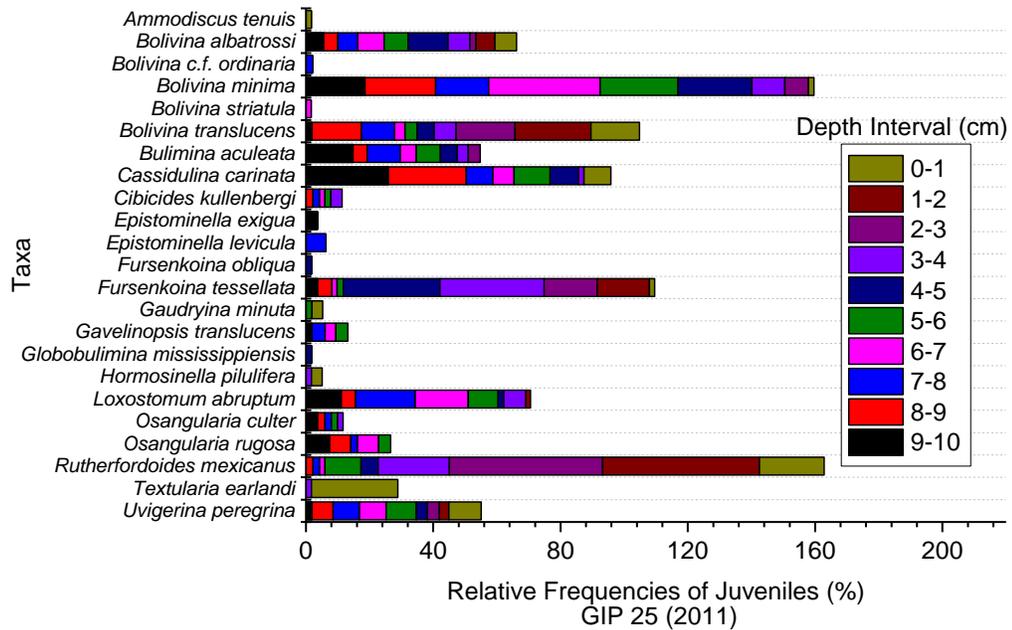


Figure 31. Relative frequency of juveniles in GIP 25 downcore samples (2011). A total of 23 species are documented in the juvenile stage within the downcore samples.

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.

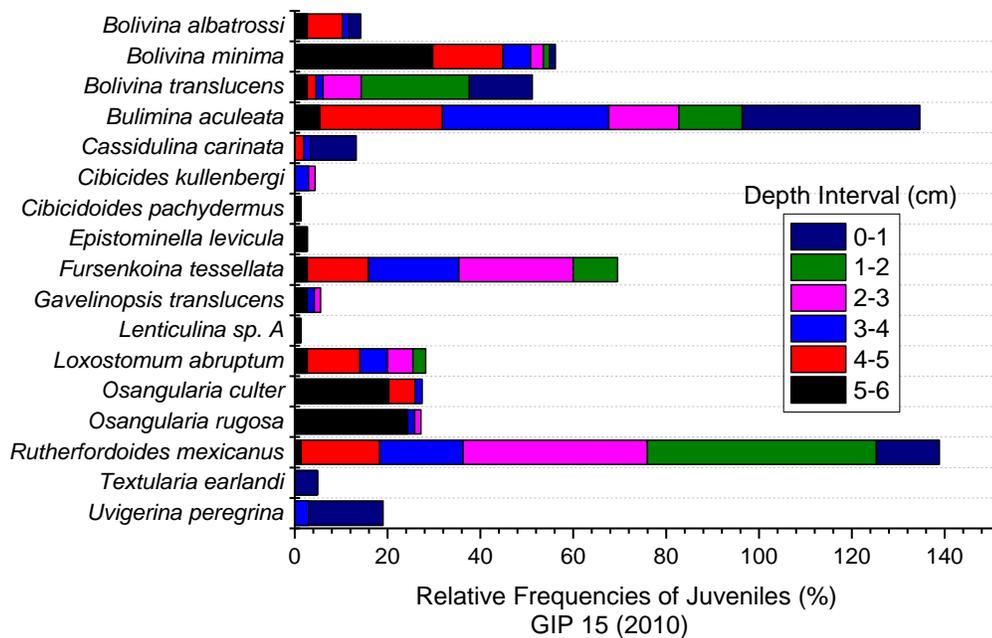


Figure 32. Relative frequency of juveniles present in GIP 15 downcore samples (2010). A total of 17 species are documented in the juvenile stage in the downcore samples.

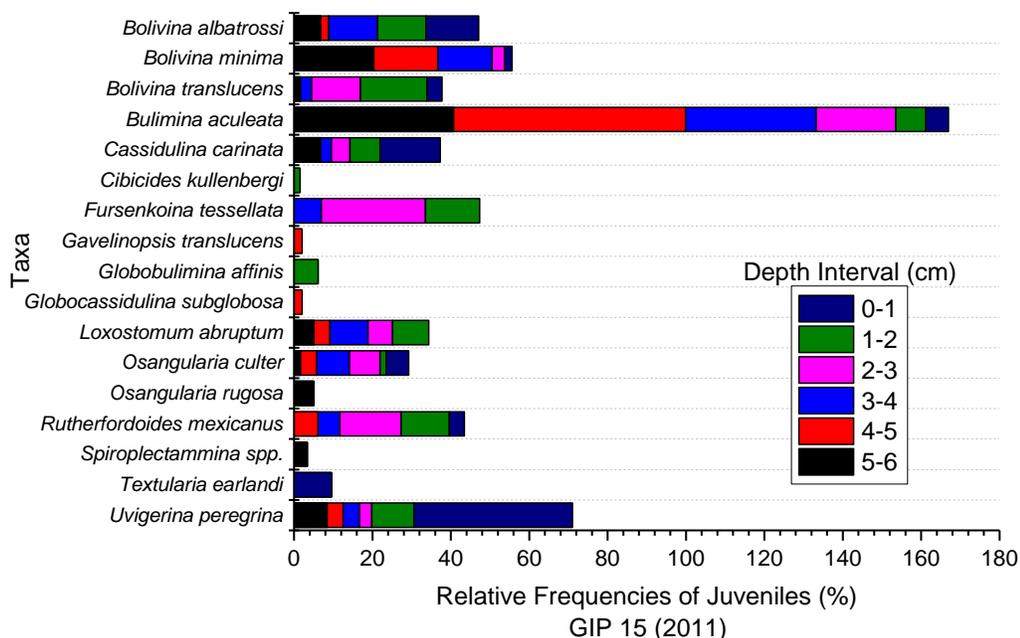


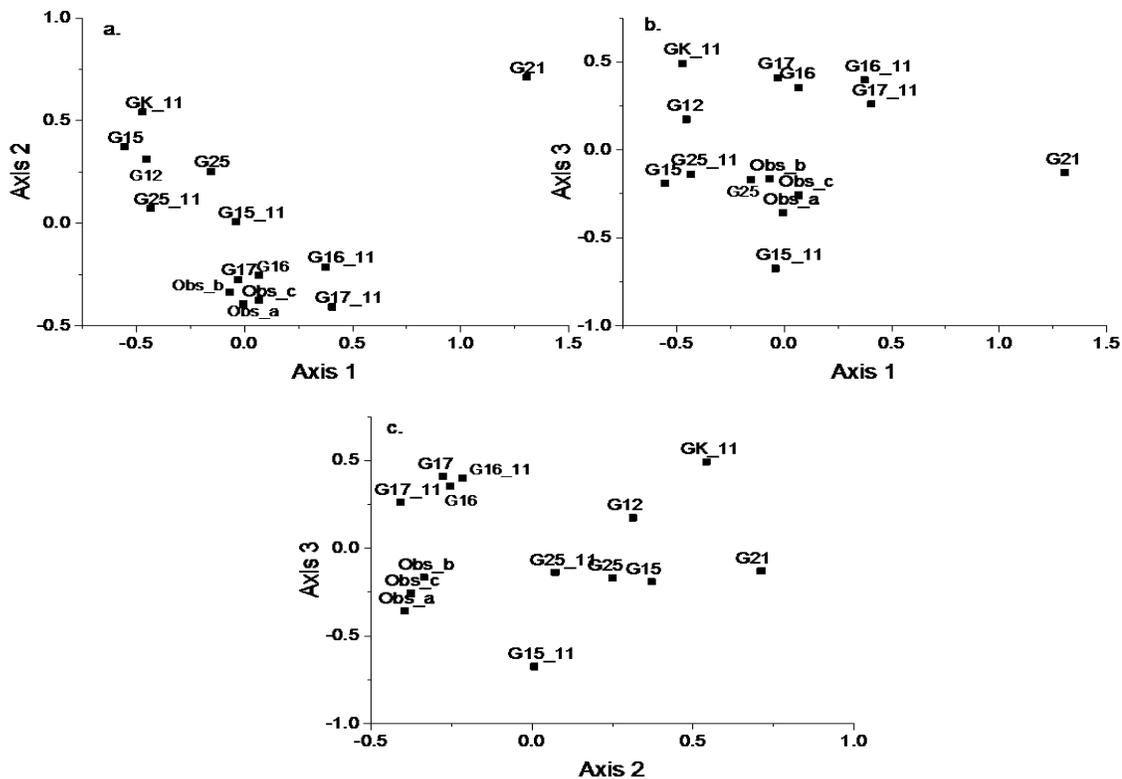
Figure 33. Relative frequency of juveniles in GIP 15 downcore samples (2011). A total of 17 species are documented in the juvenile stage in the downcore samples.

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.

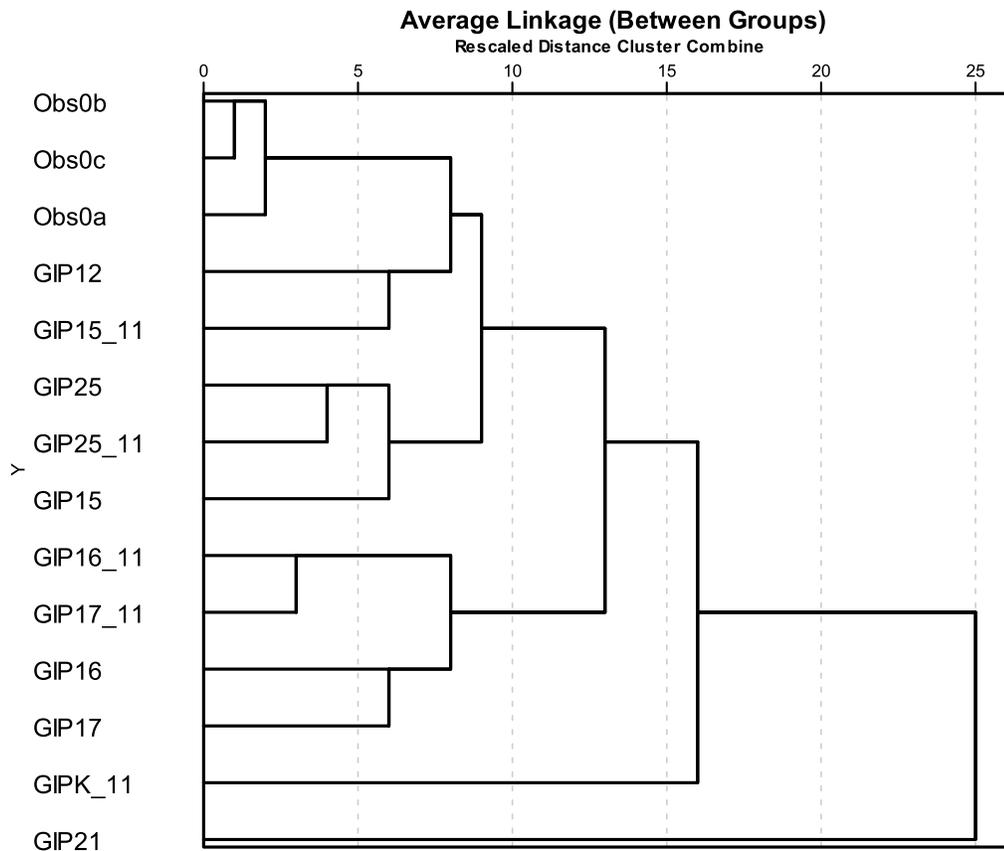
#### MDS and Q-Mode Cluster Analyses

*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.



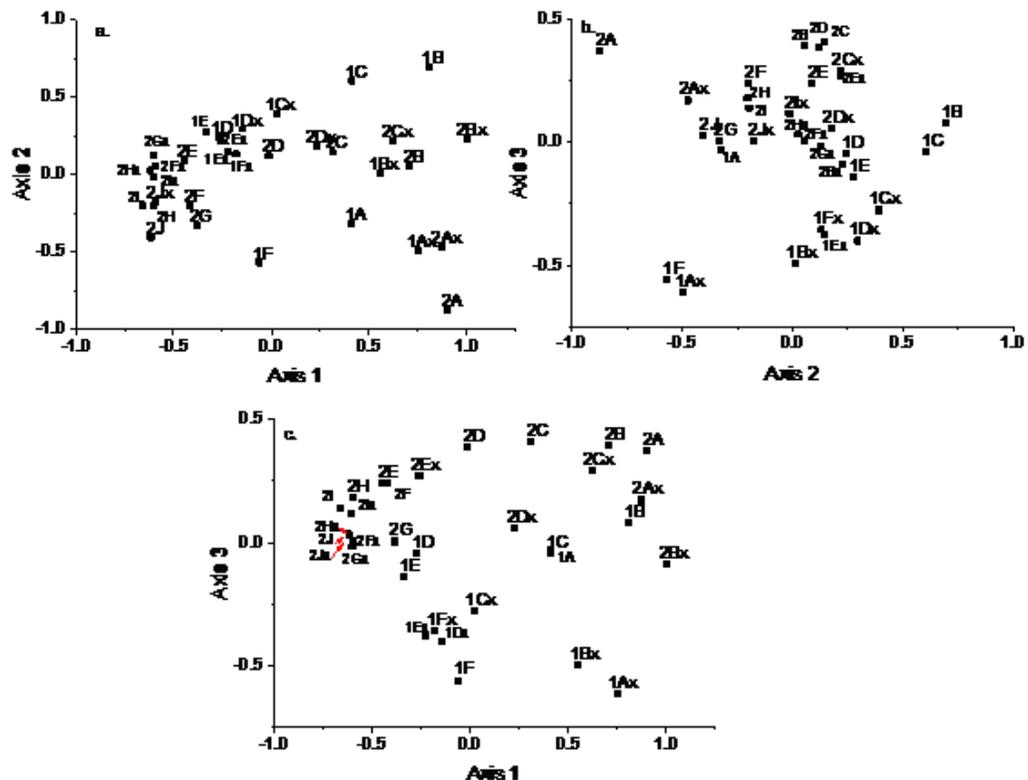
*Figure 34.* MDS of all surface samples. The MDS was performed using the Bray-Curtis similarity index of the specimen counts for all surface samples. Specimen counts were double square-root transformed prior to analysis. The “G” indicates GIP sites. The “\_10” and “\_11” indicates the collection year.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



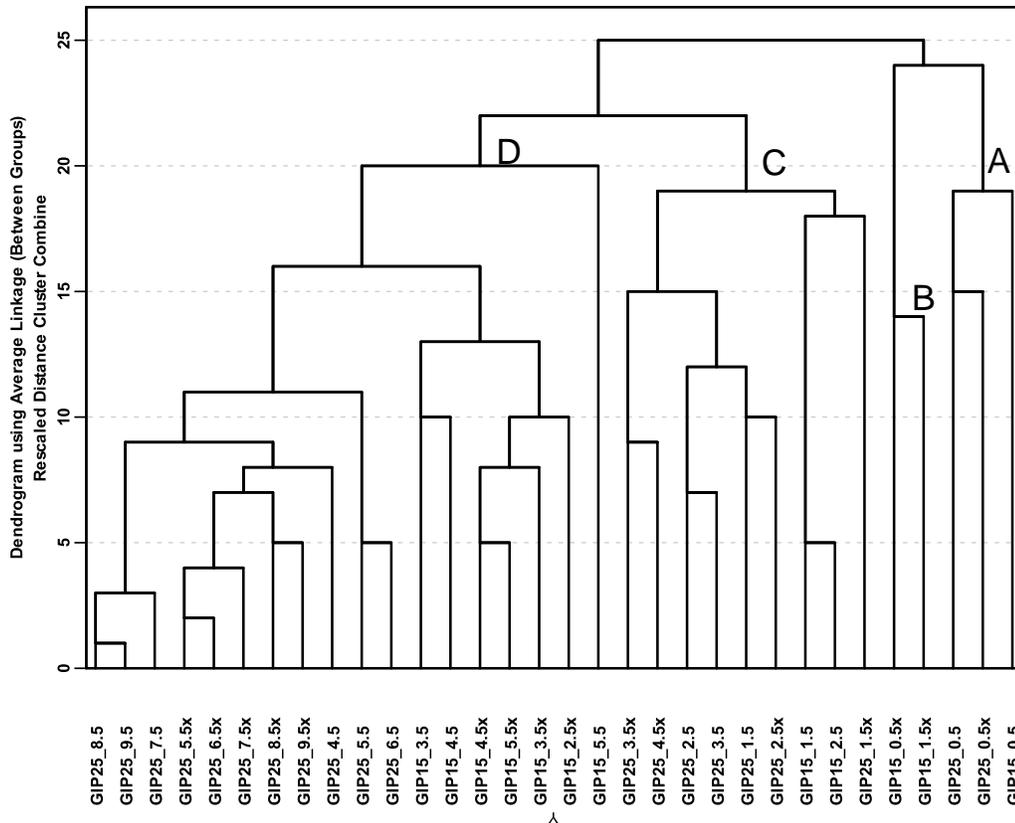
*Figure 35.* Dendrogram of the Q-mode cluster analysis for all surface samples. The cluster analysis was performed using the Bray-Curtis similarity index of the specimen counts for all surface samples. Specimen counts were double square-root transformed prior to analysis. The “\_11” indicates samples 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).

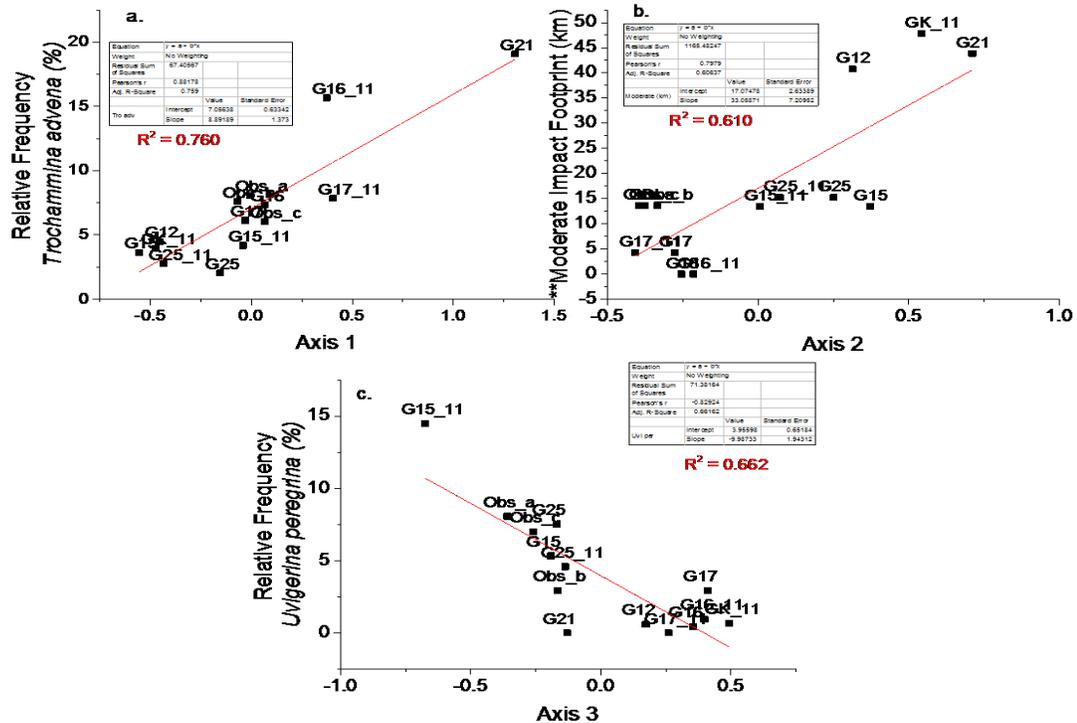


Figure 38. MDS interpretation of the surface samples. Each MDS axis is plotted with the variable that best correlates with it. The linear model is in red with terms and statistics in the associated table. The  $R^2$  is shown in red. The “G” indicates GIP sites. The “\_10” and “\_11” indicate the collection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

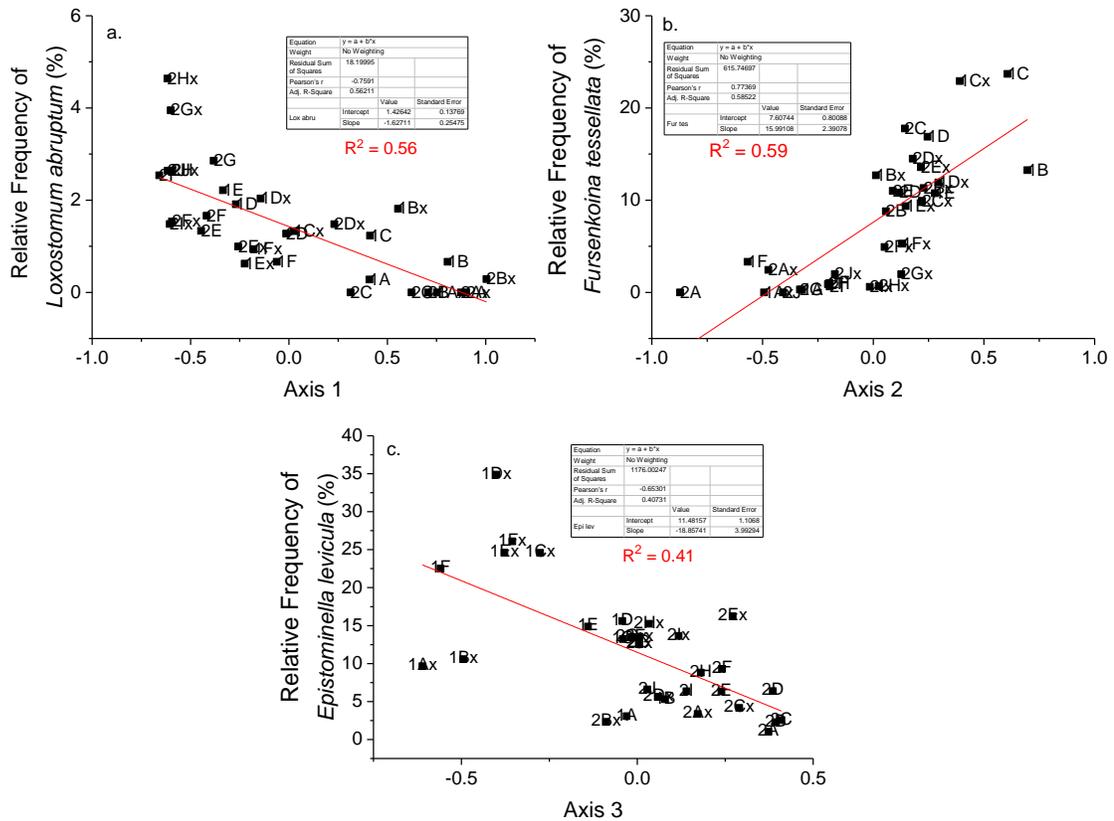


Figure 39. MDS interpretation of the downcore samples at GIP 25 and 15. Each MDS axis is plotted with the variable that best correlates with it. The linear model is in red, with terms and statistics in the associated table. The  $R^2$  is shown in red. The “1” and “2” indicate GIP 15 and 25 samples,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

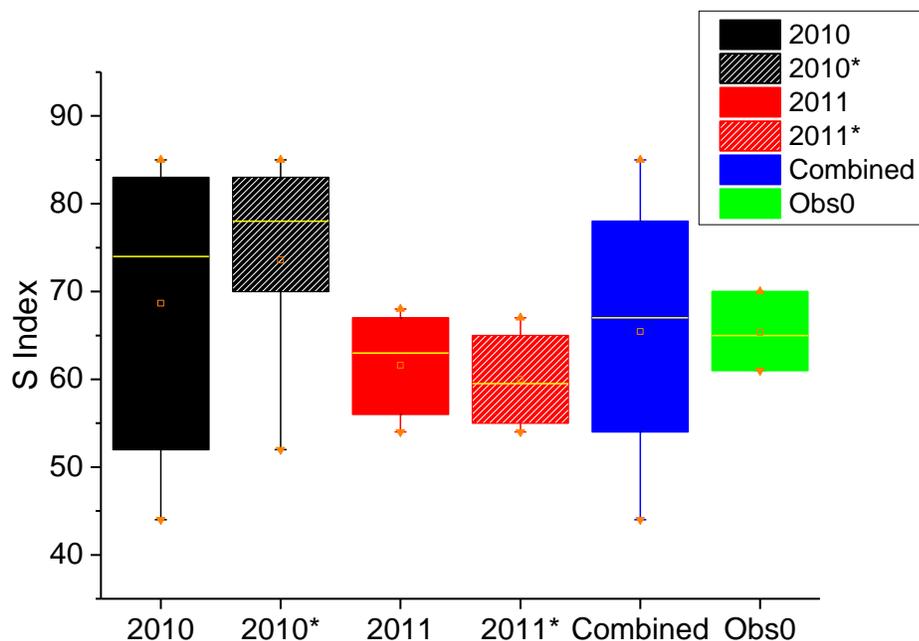
range from 0.3 to 0.8%, 0.2 to 0.6%, and 0.2 to 1.5%, respectively. The taxa from group D are documented within one to 14 samples from all other surface samples with varying relative frequencies.



## 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 25<sup>th</sup> and 75<sup>th</sup> percentiles of 52 and 83 species in 2010, a median of 63 species embraced by 25<sup>th</sup> and 75<sup>th</sup> percentiles of 56 and 57 species in 2011, and a median of 65 species embraced by 25<sup>th</sup> and 75<sup>th</sup> 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 25<sup>th</sup> and 75<sup>th</sup> percentiles. The yellow line, open orange box, and filled orange triangle indicate median, mean, and 1<sup>st</sup>/99<sup>th</sup> 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 indicated by "\_10," "\_11," and "\_12," respectively.

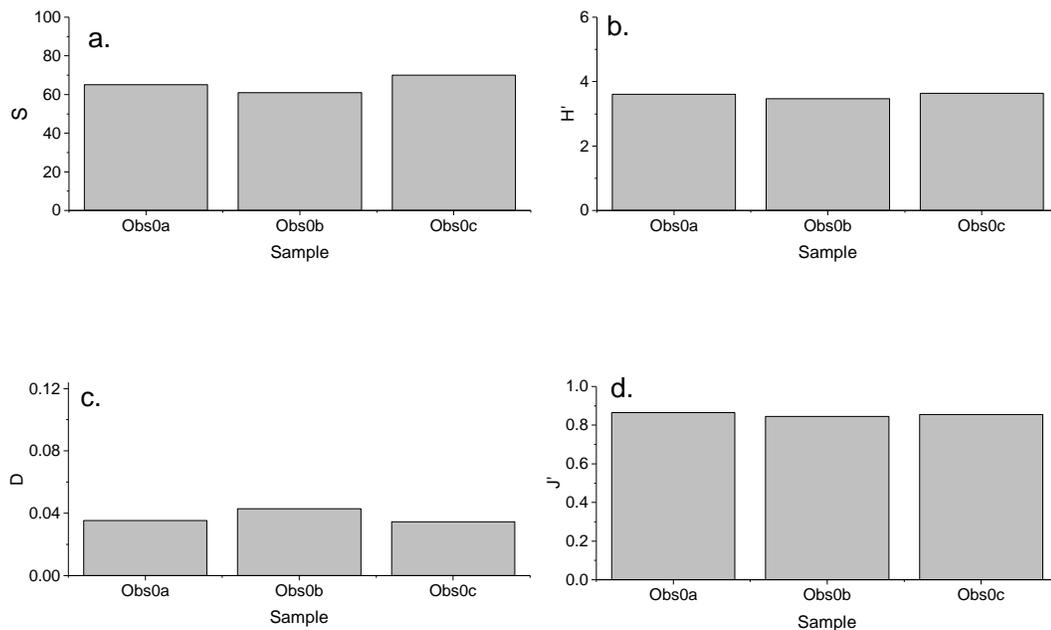
Table 8

*Measures of Central Tendency for S Index*

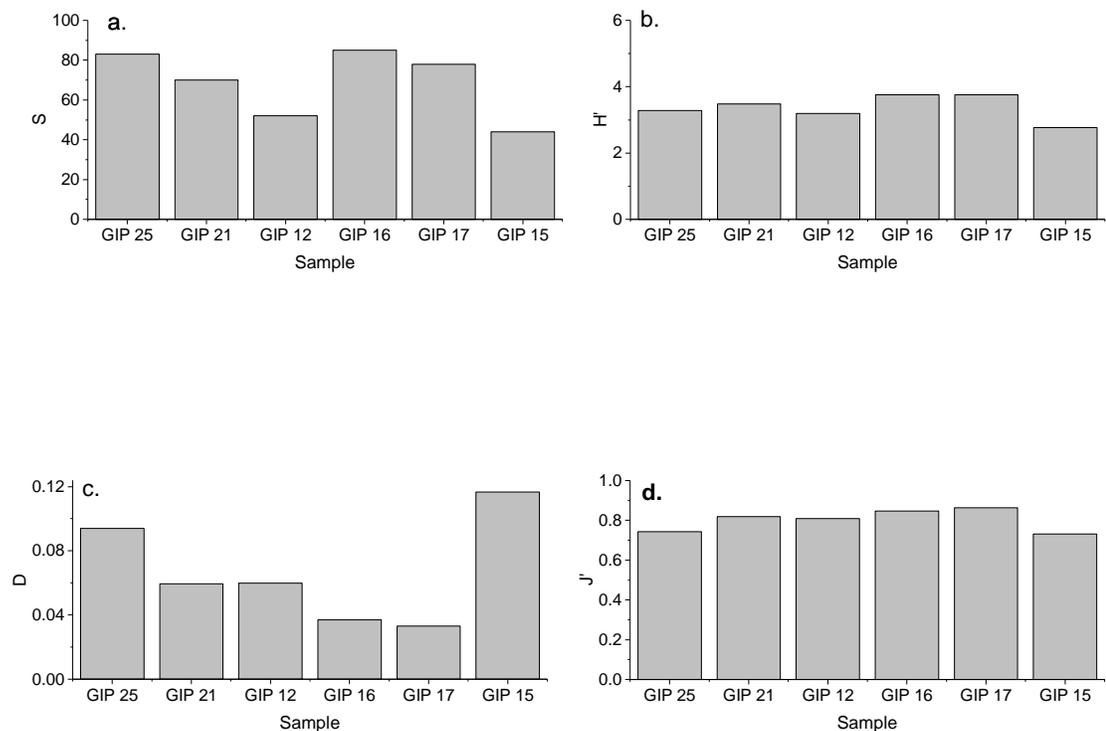
| Group                    | Median | 25% | 75% |
|--------------------------|--------|-----|-----|
| Surface Samples (2010)   | 74     | 52  | 83  |
| Surface Samples (2011)   | 63     | 56  | 57  |
| Pseudo-Replicates (Obs0) | 65     | 61  | 70  |
| GIP 25's Downcore (2010) | 49     | 47  | 57  |
| 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.

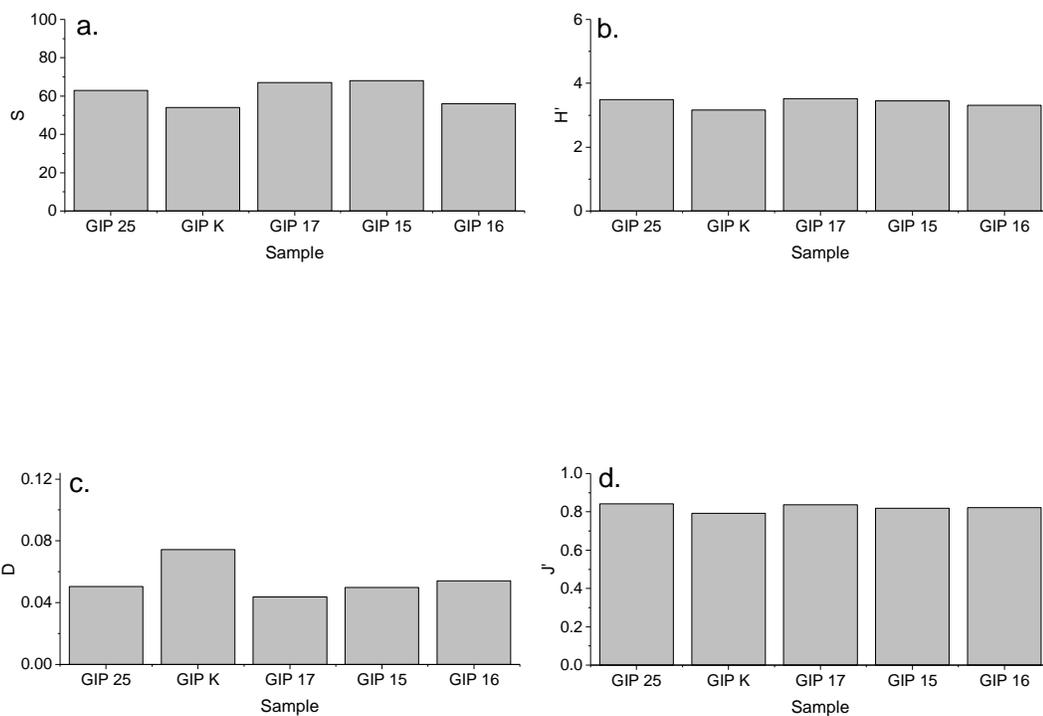
The Obs0b sample has fewer species (61) than the other two pseudo-replicates (Figure 42a). The S index ranges from 44 to 85 species in the surface samples from 2010, the lowest being from GIP 15 (Figure 43a). GIP K and 16 have the lowest S index in 2011 with 54 and 56 species, respectively (Figure 44a). 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.

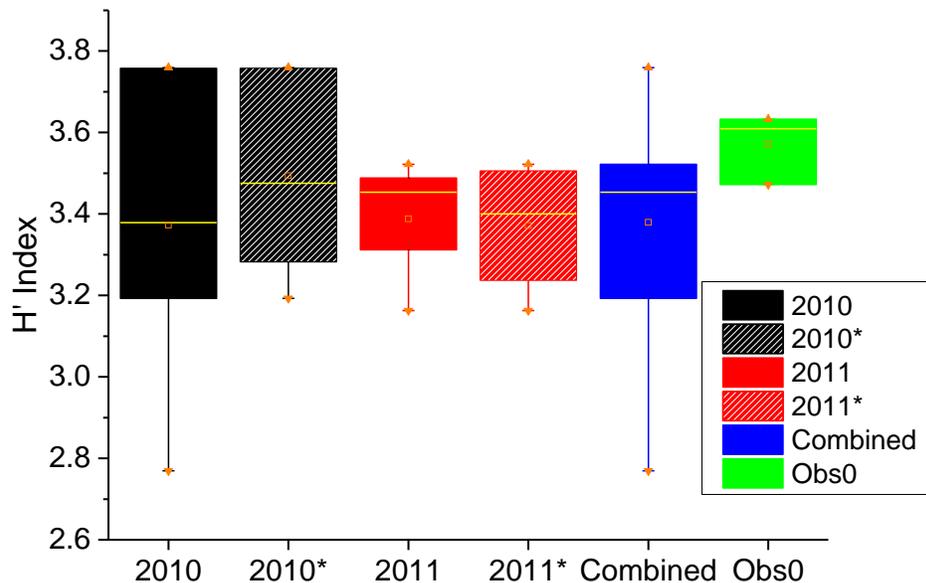


*Figure 43.* Diversity indices for all surface samples (2010). Samples are ordered from left to right by increasing [TPAH]. Higher diversities are indicated by higher values of  $S$  (a) and  $H'$  (b) and lower values of  $D$  (c). High values of the  $J'$  (d) index indicate greater equitability.

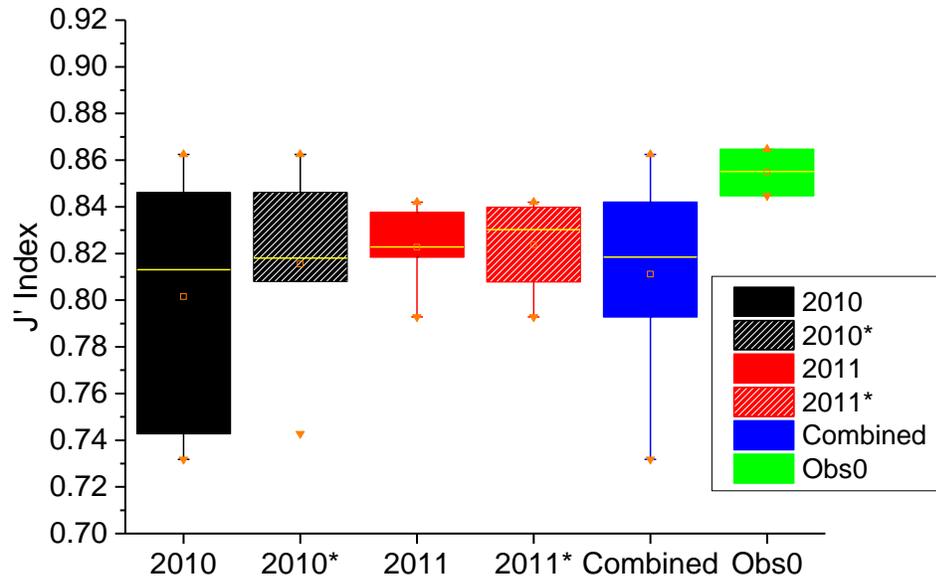


*Figure 44.* Diversity indices for all surface samples (2011). All samples have [TPAH] <1,000 ng/g (background concentrations) and are ordered from left to right by increasing [TPAH]. Higher diversities are indicated by higher values of S (a) and H' (b) and lower values of D (c). High values of the J' (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 25<sup>th</sup> and 75<sup>th</sup> percentiles. The yellow line, open orange box, and filled orange triangle indicate median, mean, and 1<sup>st</sup>/99<sup>th</sup> 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 25<sup>th</sup> and 75<sup>th</sup> percentiles. The yellow line, open orange box, and filled orange triangle indicate median, mean, and 1<sup>st</sup>/99<sup>th</sup> 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 25<sup>th</sup> and 75<sup>th</sup> percentiles of 47 and 57 species in 2010 and a median of 48 species embraced by 25<sup>th</sup> and 75<sup>th</sup> 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.

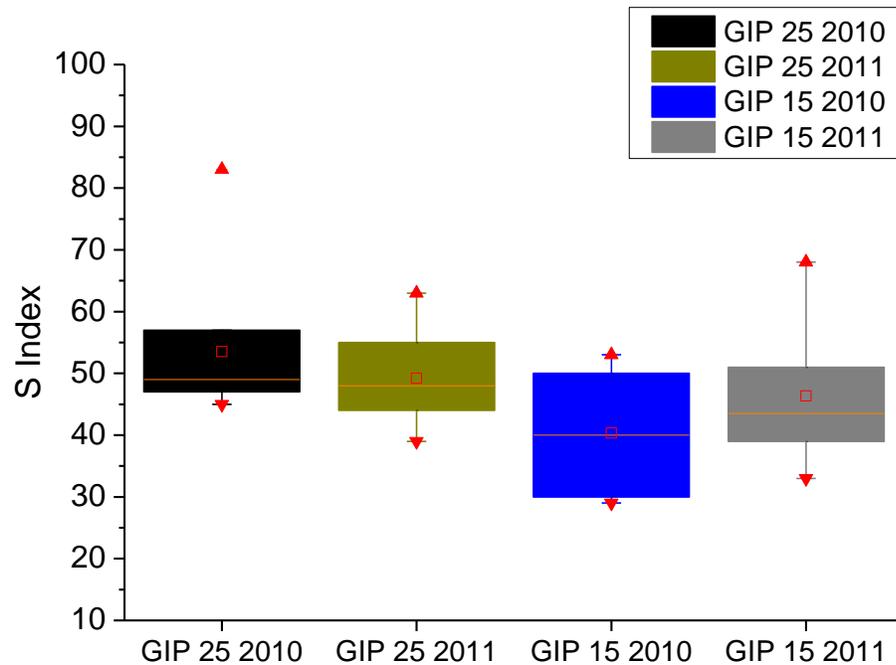


Figure 47. Whisker plot of the S index in composited downcore samples at GIP 25 and 15. The base and top of the colored boxes mark the 25<sup>th</sup> and 75<sup>th</sup> percentiles. Orange line, open red box, and filled red triangle indicate median, mean, and 1<sup>st</sup>/99<sup>th</sup> percentiles, 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

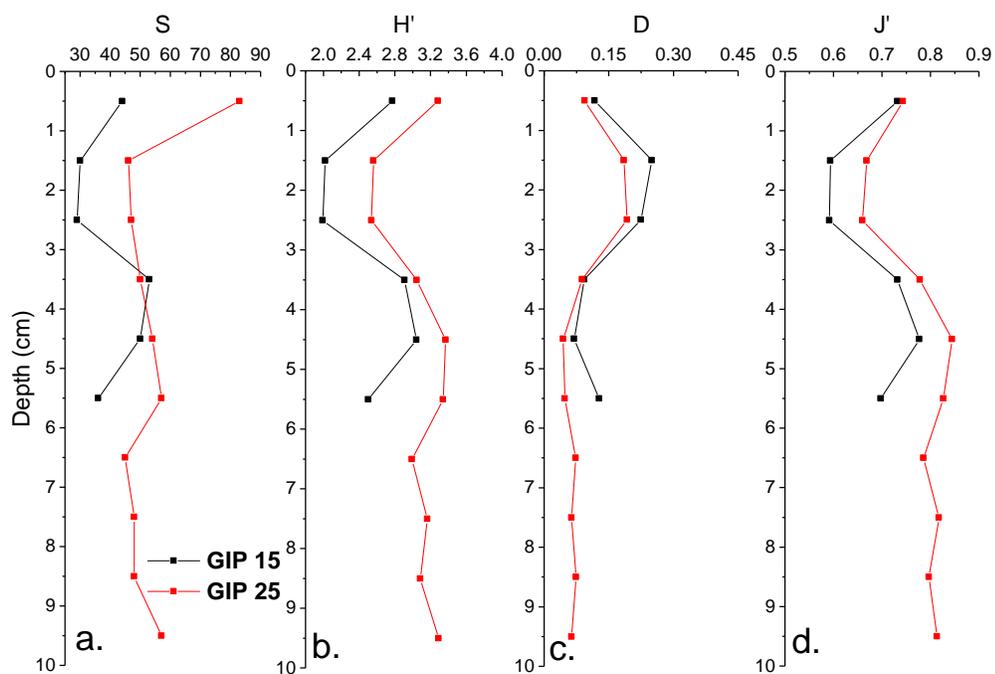
*Diversity Indices for GIP 25's Downcore Samples*

| 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 |

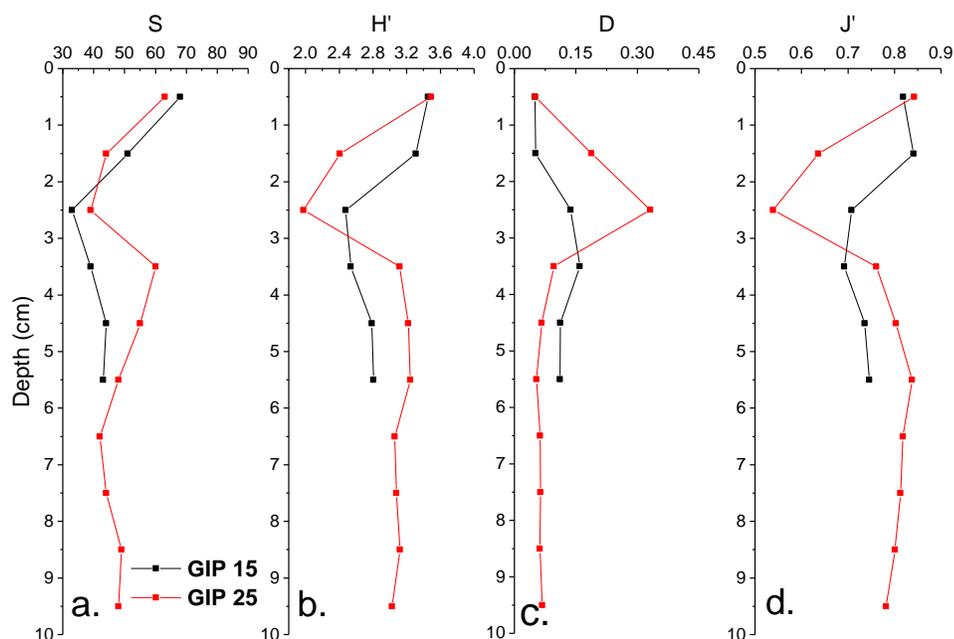
Table 12 (continued).

| 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 25<sup>th</sup>/75<sup>th</sup> percentiles of 30/50 species in 2010 and a median of 44 species and 25<sup>th</sup>/75<sup>th</sup> 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*

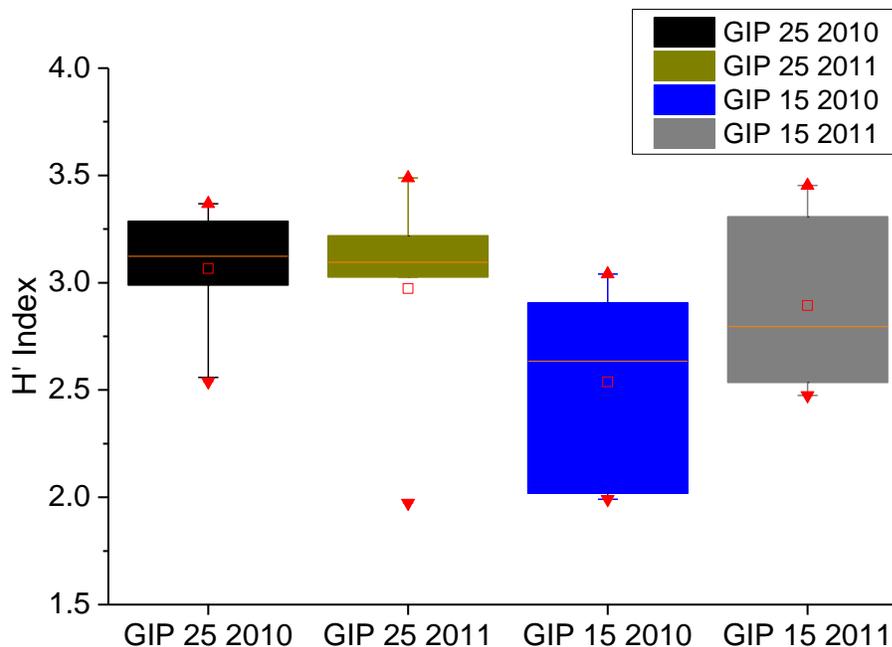
| Sample             | Species Richness | H'   | D    | E    | J    |
|--------------------|------------------|------|------|------|------|
| GIP 15_10 (0-1 cm) | 44               | 2.77 | 0.12 | 0.36 | 0.73 |
| GIP 15_10 (1-2 cm) | 30               | 2.02 | 0.25 | 0.25 | 0.59 |
| GIP 15_10 (2-3 cm) | 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 richness 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 25<sup>th</sup> and 75<sup>th</sup> percentiles. Orange line, open red box, and filled red triangle indicate median, mean, and 1<sup>st</sup>/99<sup>th</sup> 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.

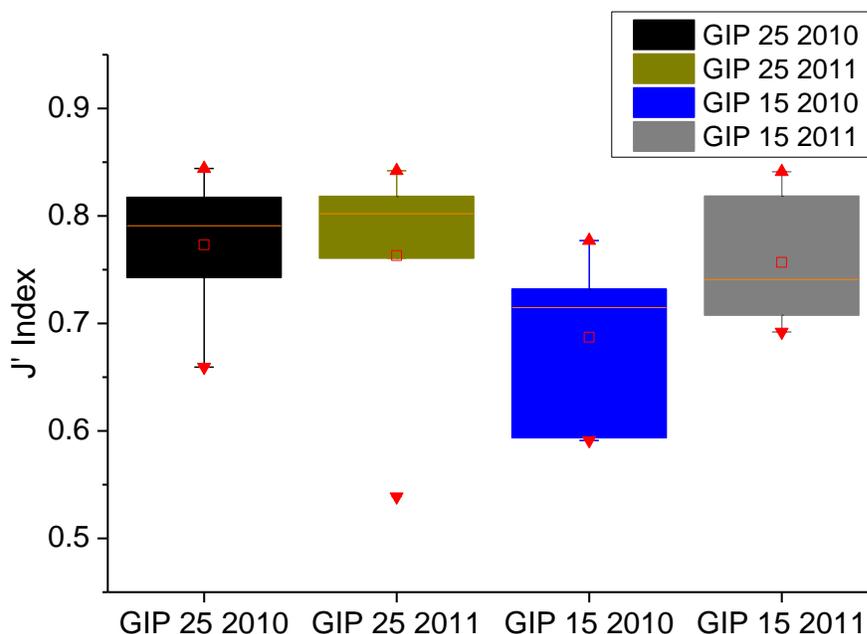


Figure 51. Whisker plot of J' index in composited downcore samples at GIP 25 and 15. The base and top of the colored boxes mark the 25<sup>th</sup> and 75<sup>th</sup> percentiles. Orange line, open red box, and filled red triangle indicate median, mean, and 1<sup>st</sup>/99<sup>th</sup> percentiles, 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 95<sup>th</sup> 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 not 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<sup>3</sup>. 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<sup>3</sup> (median: 10.4 specimens/10 cm<sup>3</sup>) 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. *Bulimina 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  $>63\ \mu\text{m}$  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 ( $> 30\ \mu\text{m}$ ) 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/ $10\ \text{cm}^2$  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/ $10\ \text{cm}^2$ ; 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 ( $> 32\ \mu\text{m}$ ) 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<sup>2</sup>), whereas the other replicates noticeably fell below the current study's density range (133-207 specimens/10 cm<sup>2</sup>). 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<sup>3</sup>, 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.

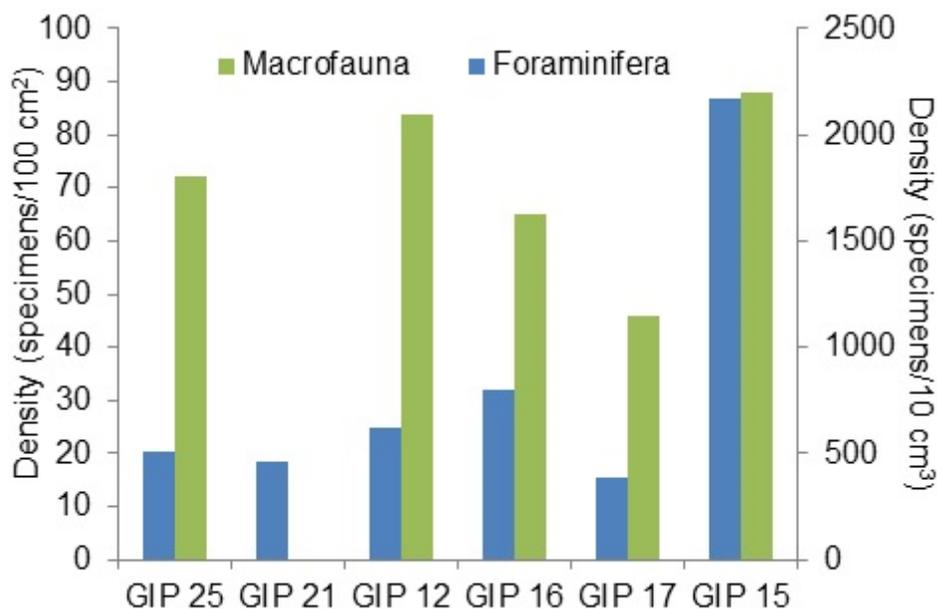
*Assemblage comparisons.* The GIP sites were compared with Poag's (1981) biofacies study in order to determine whether all GIP and Obs0 sites are within the same biofacies. Poag's (1981) biofacies study was chosen because it integrated results from Dignes (1978), Parker (1954), and several other studies 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 caveat—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.

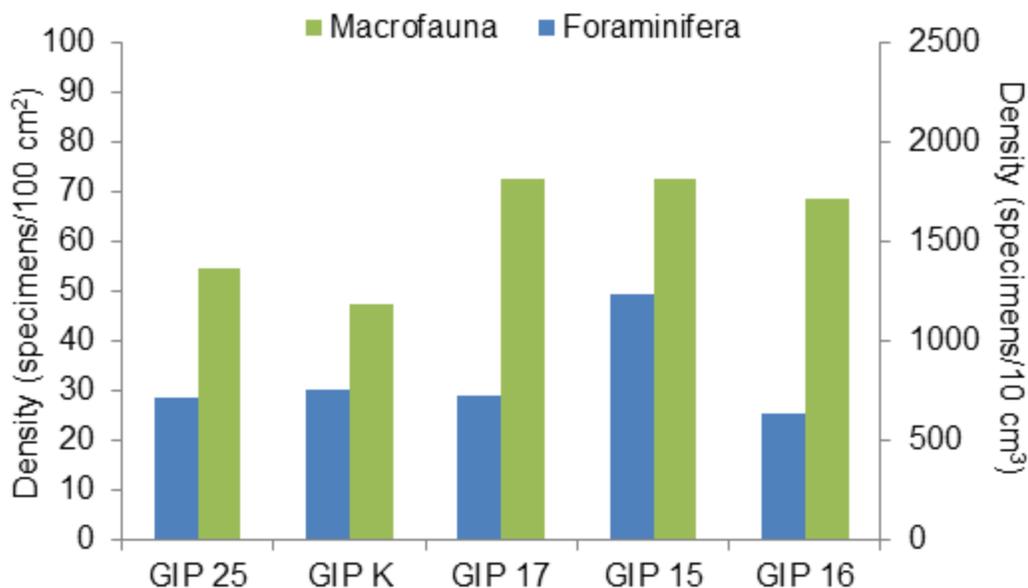
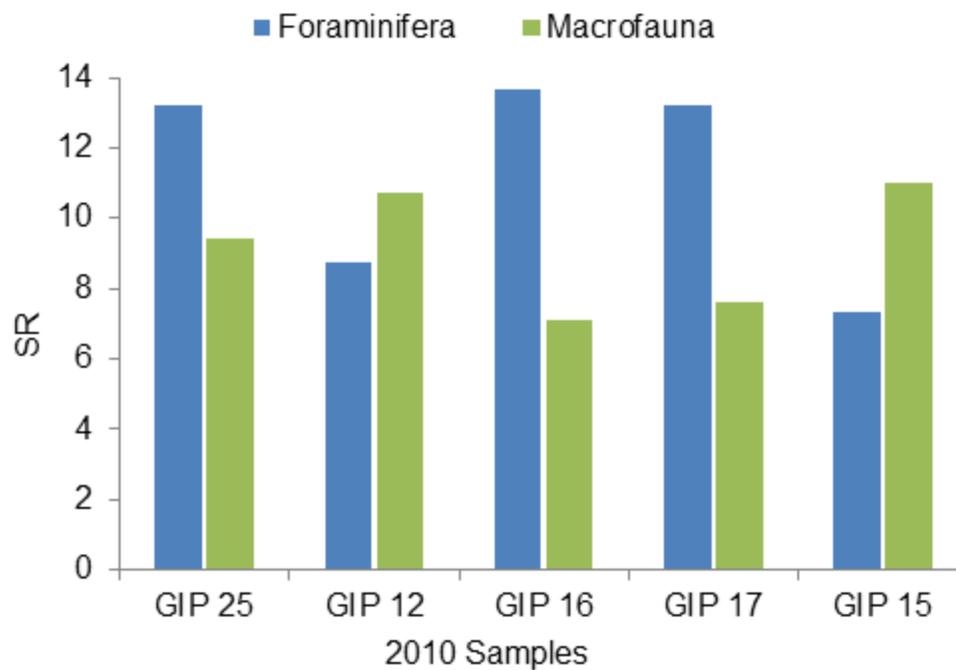
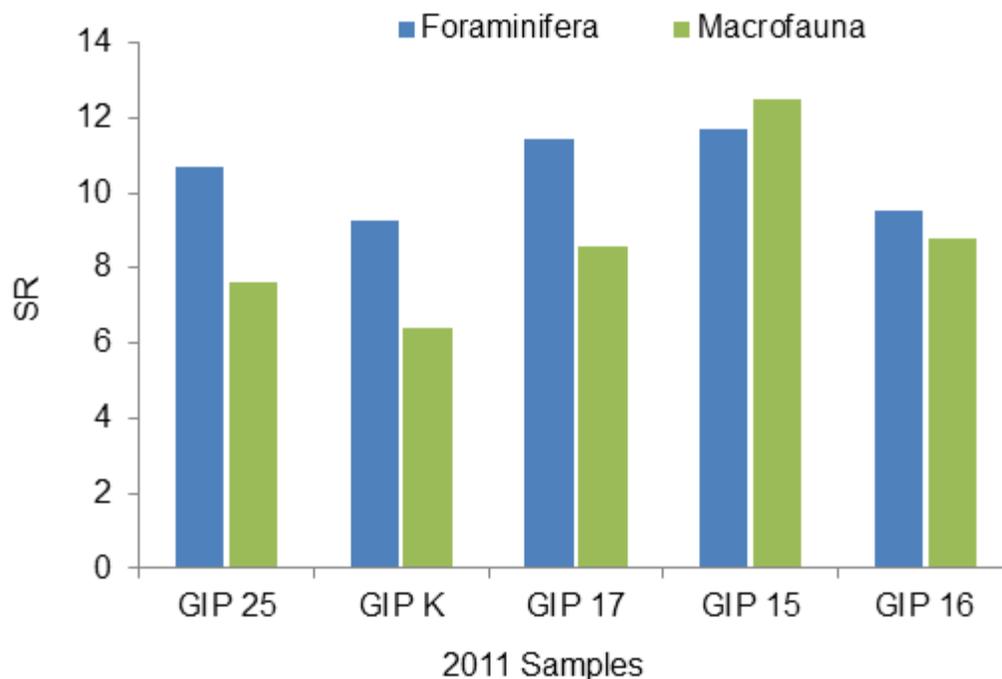


Figure 53. Specimen density trends of Foraminifera and macrofauna (2011). All samples have [TPAH] <1,000 ng/g (background concentrations) and are ordered from left to right by increasing [TPAH]. Macrofaunal and foraminiferal densities are on the left and right axes, respectively.

*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.



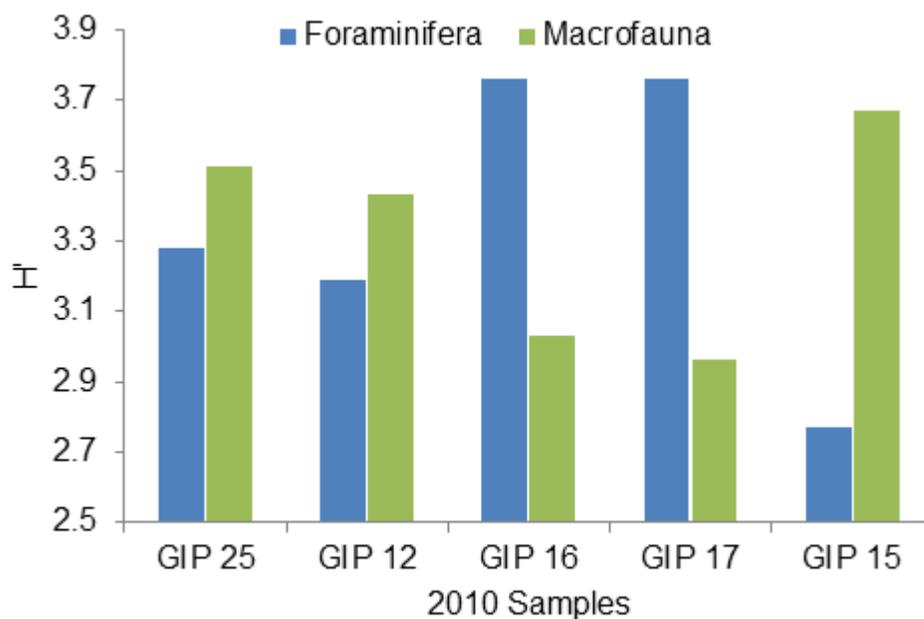
*Figure 54.* SR index trends of Foraminifera and macrofauna (2010). Samples are ordered from left to right by increasing [TPAH]. Foraminiferal and macrofaunal SR index values are on a single axis.



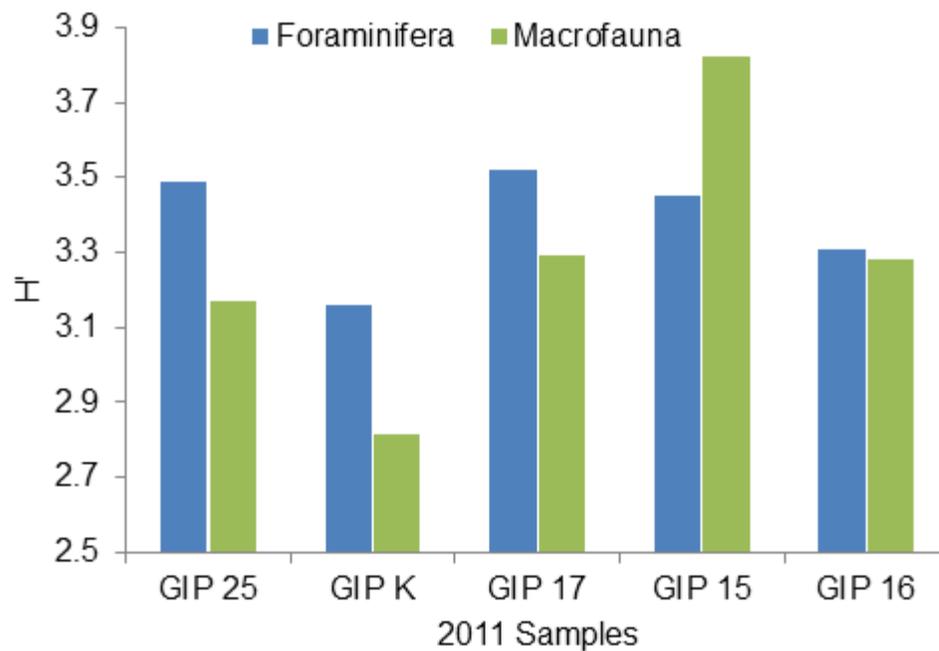
*Figure 55.* SR index trends of Foraminifera and macrofauna (2011). All samples have [TPAH] <1,000 ng/g (background concentrations) and are ordered from left to right by increasing [TPAH]. Foraminiferal and macrofaunal SR index values are on a single axis.

*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].

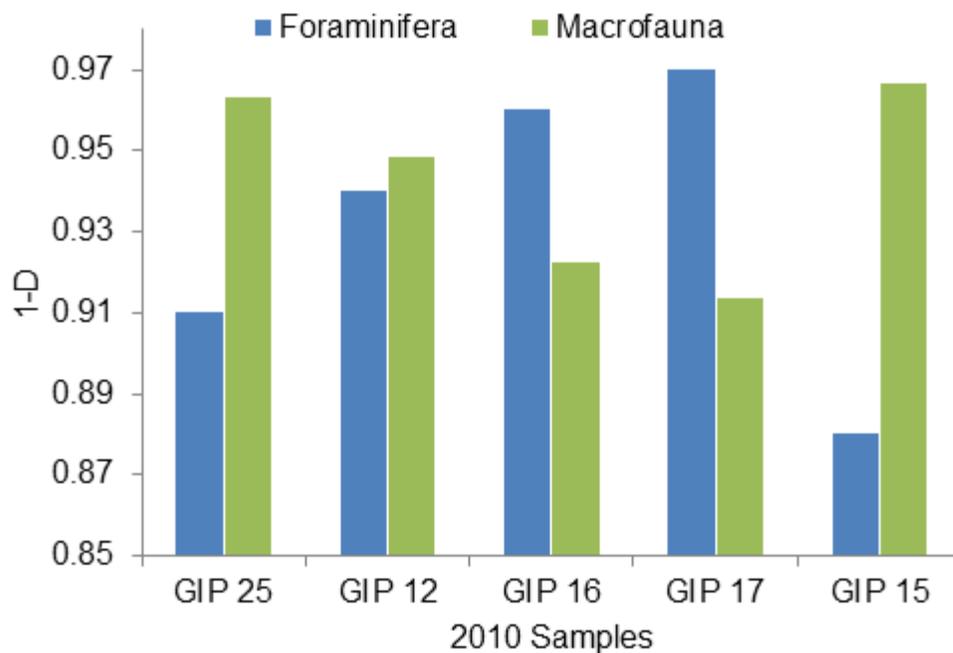


Figure 58. 1-D index trends of Foraminifera and macrofauna (2010). Samples are ordered from left to right by increasing [TPAH].

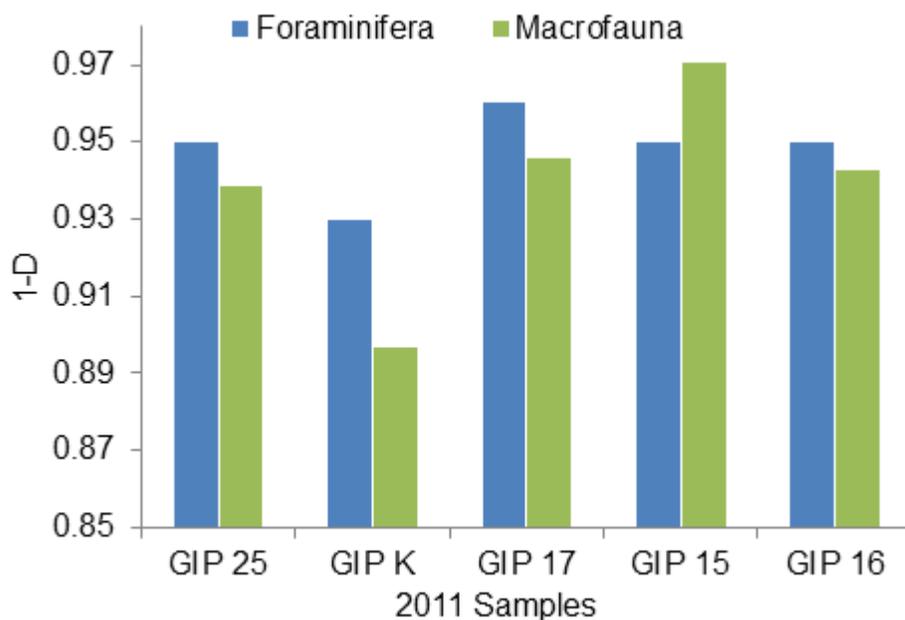


Figure 59. 1-D index trends of Foraminifera and macrofauna (2011). All samples have [TPAH] <1,000 ng/g (background concentrations) and are ordered from left to right by increasing [TPAH].

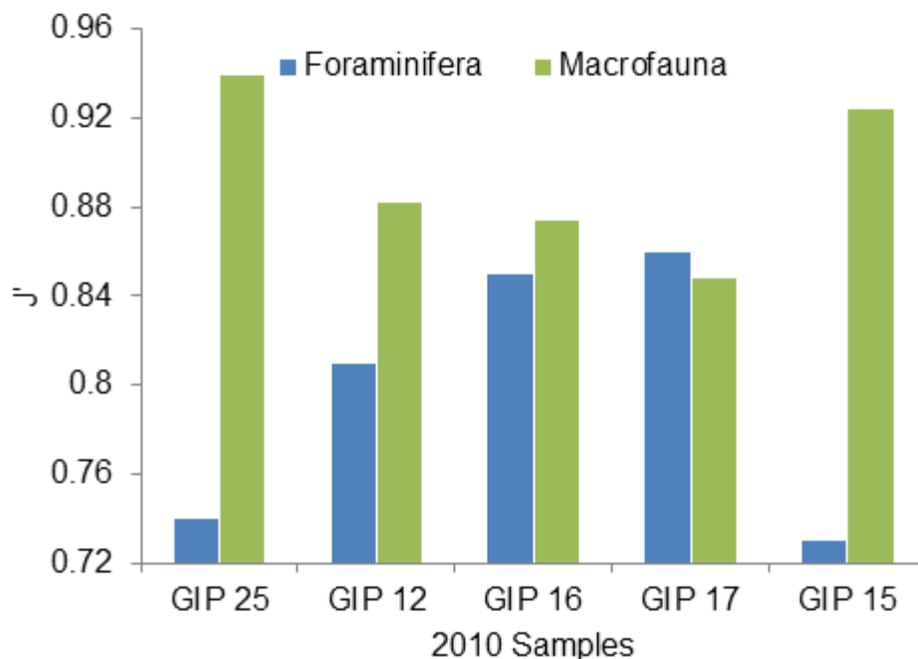


Figure 60. J' index trends of Foraminifera and macrofauna (2010). Samples are ordered from left to right by increasing [TPAH].

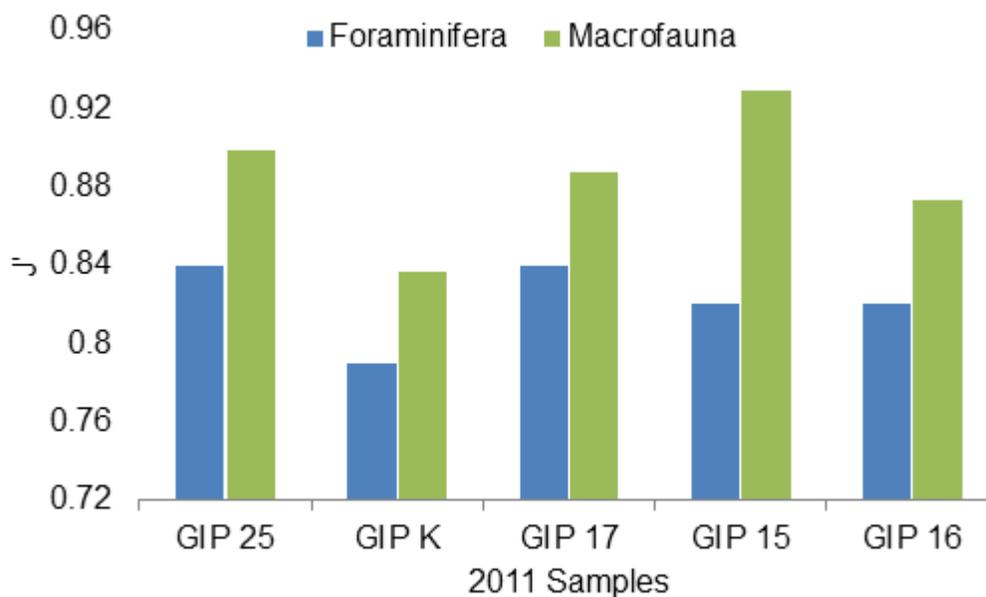


Figure 61. J' index trends of Foraminifera and macrofauna (2011). All samples have [TPAH] <1,000 ng/g (background concentrations) and are ordered from left to right by increasing [TPAH].

*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].

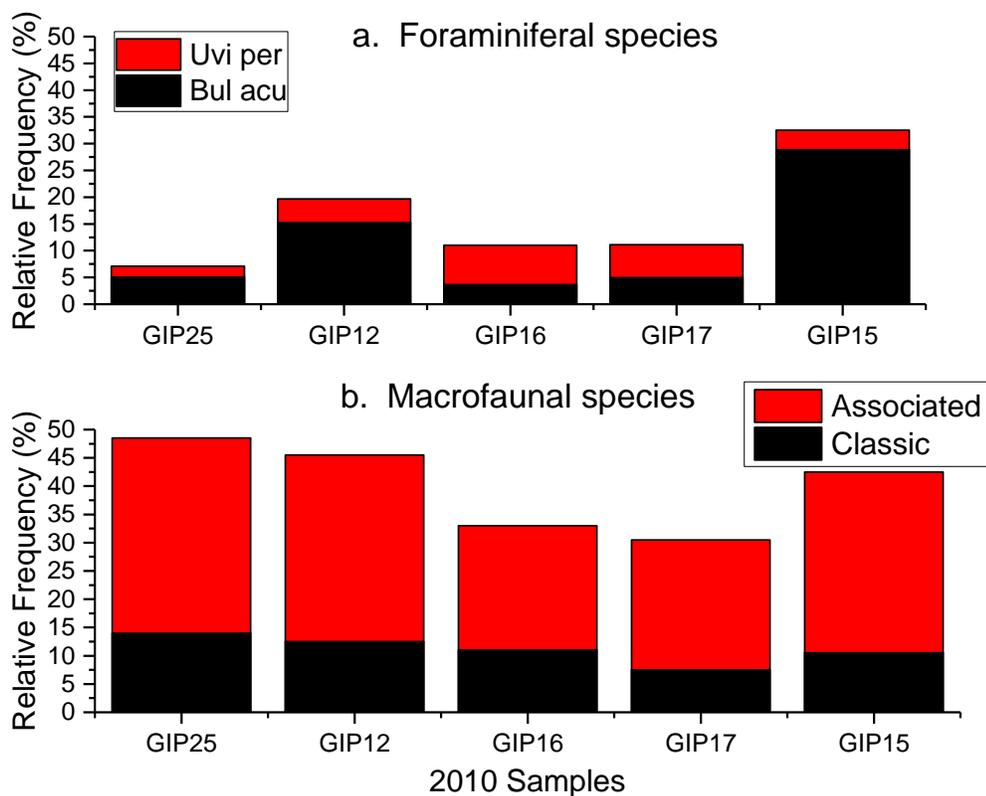
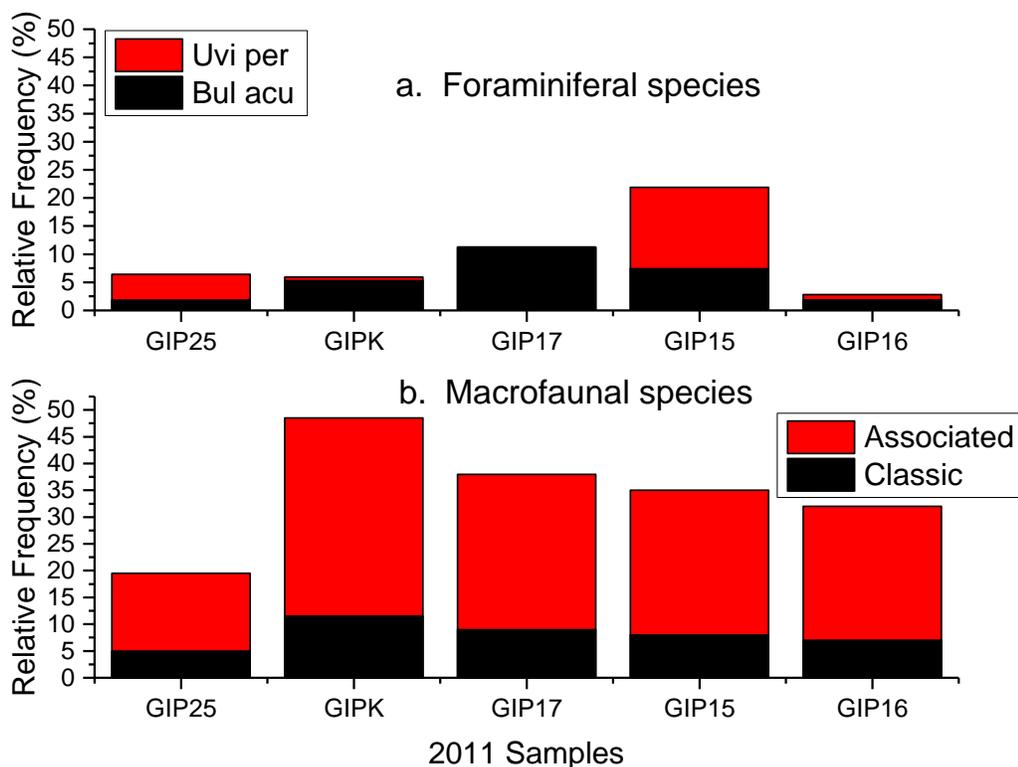


Figure 62. Opportunistic species trends of Foraminifera and macrofauna (2010). Samples and are ordered from left to right by increasing [TPAH]. The top portion (a) consists of foraminiferal species: *Bulimina aculeata* (Bul acu) and *Uvigerina peregrina* (Uvi per). The bottom portion (b) includes species 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  $\mu\text{m}$  size fraction at the GIP sites was substantially larger than populations reported in studies that used a >63 or

>74  $\mu\text{m}$  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

*Usbekistania 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 Rhumbler, 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 agglutinus* Cushman

*Reophax agglutinus* 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 SPIROPLECTAMMINACEA 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 boschiana* d'Orbigny*Quinqueloculina boschiana* 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 Wedekind, 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 &gt;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 *Cibicidooides* Thalmann, 1939

*Cibicidooides 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.

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

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

| Taxa                                  | Number of Samples |
|---------------------------------------|-------------------|
| <i>Globobulimina mississippiensis</i> | 8                 |
| <i>Globocassidulina subglobosa</i>    | 32                |
| <i>Globotextularia</i> sp. A          | 20                |
| <i>Gyroidina bradyi</i>               | 2                 |
| <i>Gyroidina orbicularis</i>          | 19                |
| <i>Gyroidinoides altiformis</i>       | 2                 |
| <i>Gyroidinoides polius</i>           | 3                 |
| <i>Haplophragmoides bradyi</i>        | 27                |
| <i>Haplophragmoides kirki</i>         | 19                |
| <i>Haplophragmoides subinvolutum</i>  | 2                 |
| <i>Haynesina germanica</i>            | 34                |
| <i>Hoeglundina elegans</i>            | 1                 |
| <i>Hormosinella distans</i>           | 15                |
| <i>Hormosina globulifera</i>          | 1                 |
| <i>Hormosinella guttifera</i>         | 9                 |
| <i>Hormosinella pilulifera</i>        | 16                |
| <i>Hyperammia friabilis</i>           | 6                 |
| <i>Hyperammia</i> spp.                | 15                |
| <i>Ioanella tumidula</i>              | 1                 |
| <i>Karrerulina apicularis</i>         | 4                 |
| Lagenaid sp. A                        | 4                 |
| Lagenaid sp. B                        | 2                 |
| Lagenaid sp. C                        | 1                 |
| Lagenaid sp. D                        | 1                 |
| Lagenaid sp. E                        | 1                 |
| <i>Lagena hispidula</i>               | 2                 |
| <i>Lagena</i> sp. B                   | 1                 |
| <i>Lagenammia difflugiformis</i>      | 23                |
| <i>Lagenammia tubulata</i>            | 10                |
| <i>Laminononion tumidum</i>           | 3                 |
| <i>Laticarinina pauperata</i>         | 1                 |
| <i>Lenticulina convergens</i>         | 2                 |
| <i>Lenticulina gibba</i>              | 2                 |
| <i>Lenticulina peregrina</i>          | 1                 |
| <i>Lenticulina</i> sp. A              | 1                 |
| <i>Lituola lituolinoidea</i>          | 2                 |
| <i>Lituotuba lituiformis</i>          | 2                 |
| <i>Loxostomum abruptum</i>            | 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                 |
| <i>Miliolinella antarctica</i>                     | 3                 |
| <i>Miliolinella californica</i>                    | 5                 |
| <i>Miliolinella oblonga</i>                        | 6                 |
| <i>Miliolinella warreni</i>                        | 5                 |
| <i>Neocrosbyia minuta</i>                          | 10                |
| <i>Neolenticulina chathamensis</i>                 | 5                 |
| <i>Neolenticulina variabilis</i>                   | 3                 |
| <i>Nonionella atlantica</i>                        | 6                 |
| <i>Nonionella iridea</i>                           | 33                |
| <i>Nonionella opima</i>                            | 35                |
| <i>Nonionoides grateloupi</i>                      | 1                 |
| <i>Oolina ovum</i>                                 | 3                 |
| <i>Oolina sp. A</i>                                | 1                 |
| <i>Oridorsalis tenera</i>                          | 1                 |
| <i>Oridorsalis umbonatus</i>                       | 7                 |
| <i>Osangularia culter</i>                          | 37                |
| <i>Osangularia rugosa</i>                          | 34                |
| <i>Pandaglandulina dinapolii</i>                   | 1                 |
| <i>Parafissurina kerguelenensis</i>                | 1                 |
| <i>Parafissurina lateralis</i>                     | 1                 |
| <i>Planispirinoides bucculentus placentiformis</i> | 2                 |

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

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

| Taxa                             | Number of Samples |
|----------------------------------|-------------------|
| <i>Trochammina sp. E</i>         | 1                 |
| <i>Trochamminoides coronatus</i> | 5                 |
| <i>Usbekistania charoides</i>    | 19                |
| <i>Uvigerina auberiana</i>       | 5                 |
| <i>Uvigerina bellula</i>         | 2                 |
| <i>Uvigerina peregrina</i>       | 38                |
| <i>Uvigerina sp. E</i>           | 1                 |
| <i>Uvigerina sp. F</i>           | 2                 |
| <i>Valvulineria glabra</i>       | 11                |
| <i>Veleroninoides wiesneri</i>   | 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 |
| <i>Adercotryma glomerata</i>                     | 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     |
| <i>Alveolophragmium</i> sp. A                    | 0     | 0     | 1     | 0     | 1     | 0     |
| <i>Ammobaculites filiformis</i>                  | 0     | 0     | 0     | 0     | 6     | 0     |
| <i>Ammodiscus tenuis</i>                         | 0     | 0     | 0     | 0     | 1     | 2     |
| <i>Anomalinoidea mexicana</i>                    | 0     | 0     | 0     | 1     | 0     | 0     |
| <i>Bolivina albatrossi</i>                       | 4     | 8     | 4     | 12    | 0     | 8     |
| <i>Bolivina</i> c.f. <i>ordinaria</i>            | 0     | 0     | 1     | 1     | 0     | 1     |
| <i>Bolivina minima</i>                           | 4     | 4     | 2     | 4     | 0     | 1     |
| <i>Bolivina paula</i>                            | 3     | 2     | 4     | 11    | 4     | 3     |
| <i>Bolivina pusilla</i>                          | 0     | 0     | 0     | 0     | 3     | 0     |
| <i>Bolivina striatula</i>                        | 1     | 1     | 7     | 0     | 0     | 0     |
| <i>Bolivina translucens</i>                      | 33    | 24    | 1     | 2     | 0     | 3     |
| <i>Brizalina subspinescens</i>                   | 0     | 0     | 0     | 0     | 3     | 0     |
| <i>Bulimina aculeata</i>                         | 51    | 103   | 17    | 17    | 3     | 25    |
| <i>Bulimina alazanensis</i>                      | 6     | 9     | 2     | 3     | 2     | 5     |
| <i>Bulimina marginata</i>                        | 1     | 0     | 3     | 3     | 0     | 0     |
| <i>Bulimina spicata</i>                          | 1     | 4     | 1     | 0     | 0     | 19    |
| <i>Buzasina ringens</i>                          | 0     | 0     | 0     | 0     | 1     | 0     |
| <i>Cassidulina carinata</i>                      | 18    | 22    | 2     | 7     | 0     | 22    |
| <i>Cassidulina laevigata</i>                     | 0     | 2     | 0     | 0     | 0     | 0     |
| <i>Cassidulina obtusa</i>                        | 0     | 0     | 0     | 0     | 1     | 0     |
| <i>Chilostomella oolina</i>                      | 0     | 0     | 0     | 1     | 0     | 1     |
| <i>Cibicides kullenbergi</i>                     | 1     | 1     | 0     | 0     | 3     | 2     |
| <i>Cibicides wuellerstorfi</i>                   | 0     | 0     | 0     | 1     | 1     | 0     |

## Samples of 2010 Continued.

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

## Samples of 2010 Continued.

| Taxa                                | GIP12 | GIP15 | GIP16 | GIP17 | GIP21 | GIP25 |
|-------------------------------------|-------|-------|-------|-------|-------|-------|
| <i>Lagena hispidula</i>             | 0     | 0     | 0     | 0     | 0     | 1     |
| Lagenaid sp. D                      | 0     | 0     | 0     | 0     | 1     | 0     |
| <i>Lagenammima difflugiformis</i>   | 1     | 0     | 3     | 0     | 31    | 6     |
| <i>Lagenammima tubulata</i>         | 0     | 1     | 5     | 0     | 0     | 0     |
| <i>Laticarinina pauperata</i>       | 0     | 0     | 0     | 1     | 0     | 0     |
| <i>Lenticulina convergens</i>       | 0     | 0     | 0     | 2     | 0     | 0     |
| <i>Loxostomum abruptum</i>          | 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     |
| <i>Miliolinella antarctica</i>      | 0     | 0     | 4     | 1     | 0     | 0     |
| <i>Miliolinella californica</i>     | 0     | 0     | 3     | 0     | 2     | 0     |
| <i>Miliolinella oblonga</i>         | 0     | 0     | 3     | 0     | 4     | 0     |
| <i>Miliolinella warreni</i>         | 0     | 0     | 0     | 0     | 1     | 0     |
| <i>Neocrosbyia minuta</i>           | 0     | 0     | 1     | 2     | 0     | 0     |
| <i>Neolenticulina chathamensis</i>  | 4     | 0     | 1     | 0     | 0     | 2     |
| <i>Nonionella atlantica</i>         | 0     | 0     | 0     | 0     | 0     | 7     |
| <i>Nonionella iridea</i>            | 8     | 3     | 12    | 1     | 2     | 17    |
| <i>Nonionella opima</i>             | 2     | 4     | 3     | 11    | 1     | 3     |
| <i>Nonionoides grateloupi</i>       | 0     | 0     | 0     | 0     | 2     | 0     |
| <i>Oolina ovum</i>                  | 0     | 0     | 1     | 0     | 0     | 0     |
| <i>Oridorsalis tenera</i>           | 0     | 0     | 0     | 0     | 0     | 3     |
| <i>Oridorsalis umbonatus</i>        | 0     | 0     | 1     | 0     | 1     | 0     |
| <i>Osangularia culter</i>           | 0     | 1     | 3     | 2     | 3     | 3     |
| <i>Osangularia rugosa</i>           | 1     | 0     | 5     | 1     | 1     | 0     |
| <i>Planispirinoides bucculentus</i> | 0     | 0     | 0     | 1     | 0     | 0     |
| <i>placentiformis</i>               | 0     | 0     | 0     | 1     | 0     | 0     |
| <i>Plectina apicularis</i>          | 0     | 2     | 0     | 0     | 0     | 0     |
| <i>Portatrochammina antarctica</i>  | 1     | 0     | 6     | 1     | 0     | 2     |
| <i>Praeglobobulimina ovata</i>      | 0     | 0     | 0     | 2     | 0     | 0     |
| <i>Praeglobobulimina ovula</i>      | 0     | 0     | 0     | 5     | 0     | 0     |

## Samples of 2010 Continued.

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

| Samples of 2010 Continued.          |       |       |       |       |       |       |
|-------------------------------------|-------|-------|-------|-------|-------|-------|
| Taxa                                | GIP12 | GIP15 | GIP16 | GIP17 | GIP21 | GIP25 |
| <i>Trochammina japonica</i>         | 0     | 0     | 9     | 4     | 2     | 2     |
| <i>Trochammina quadriloba</i>       | 2     | 1     | 2     | 0     | 0     | 1     |
| <i>Trochammina</i> sp. E            | 0     | 0     | 0     | 0     | 3     | 0     |
| <i>Trochammina subturbinata</i>     | 0     | 0     | 2     | 1     | 0     | 0     |
| <i>Trochammina tasmanica</i>        | 0     | 0     | 7     | 1     | 0     | 2     |
| <i>Trochamminoides coronatus</i>    | 0     | 0     | 1     | 1     | 0     | 0     |
| <i>Uzbekistania charoides</i>       | 0     | 0     | 3     | 1     | 1     | 1     |
| <i>Uvigerina peregrina</i>          | 2     | 19    | 2     | 10    | 0     | 37    |
| <i>Valvulineria glabra</i>          | 0     | 1     | 0     | 0     | 0     | 2     |
| <i>Veleroninoides wiesneri</i>      | 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 <sup>3</sup> )           | 97    | 59    | 70    | 54    | 72    | 70    |
| Density (spec/ 10 cm <sup>3</sup> ) | 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 |
|---------------------------------------|------|-------|-------|-------|-------|
| <i>Adercotryma glomerata</i>          | 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     |
| <i>Alveolophragmium</i> sp. A         | 0    | 1     | 0     | 3     | 0     |
| <i>Ammodiscus tenuis</i>              | 0    | 0     | 0     | 0     | 3     |
| <i>Anomalinoidea mexicana</i>         | 0    | 1     | 0     | 1     | 0     |
| <i>Bolivina albatrossi</i>            | 4    | 12    | 12    | 16    | 9     |
| <i>Bolivina</i> c.f. <i>ordinaria</i> | 0    | 0     | 2     | 0     | 1     |
| <i>Bolivina lanceolata</i>            | 0    | 0     | 0     | 0     | 1     |
| <i>Bolivina lowmani</i>               | 0    | 0     | 1     | 0     | 0     |
| <i>Bolivina minima</i>                | 2    | 1     | 0     | 0     | 2     |
| <i>Bolivina paula</i>                 | 0    | 2     | 2     | 0     | 3     |
| <i>Bolivina striatula</i>             | 0    | 0     | 3     | 2     | 0     |
| <i>Bolivina translucens</i>           | 3    | 11    | 0     | 0     | 13    |
| <i>Brizalina subspinescens</i>        | 0    | 0     | 0     | 1     | 0     |
| <i>Bulimina aculeata</i>              | 16   | 23    | 6     | 36    | 6     |
| <i>Bulimina alazanensis</i>           | 3    | 0     | 1     | 1     | 5     |
| <i>Bulimina</i> sp. D                 | 1    | 0     | 0     | 0     | 0     |
| <i>Bulimina spicata</i>               | 0    | 1     | 0     | 0     | 5     |
| <i>Buliminella bassendorffensis</i>   | 0    | 0     | 0     | 0     | 1     |
| <i>Buzasina ringens</i>               | 1    | 2     | 0     | 0     | 0     |
| <i>Cassidulina carinata</i>           | 30   | 15    | 0     | 2     | 26    |
| <i>Chilostomella oolina</i>           | 0    | 2     | 0     | 0     | 1     |
| <i>Cibicides kullenbergi</i>          | 0    | 1     | 0     | 0     | 0     |
| <i>Cibicides wuellerstorfi</i>        | 0    | 1     | 0     | 0     | 0     |
| <i>Cibicoides pachydermus</i>         | 0    | 2     | 0     | 0     | 0     |
| <i>Cornuspira involvens</i>           | 2    | 0     | 0     | 0     | 1     |
| <i>Cribrostomoides nitidum</i>        | 15   | 1     | 0     | 0     | 1     |
| <i>Cribrostomoides scitulus</i>       | 1    | 1     | 0     | 0     | 0     |

## Samples of 2011 Continued.

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

## Samples of 2011 Continued.

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

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 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     |
| <i>Rutherfordoides mexicanus</i>      | 6    | 2     | 0     | 0     | 27    |
| <i>Seabrookia earlandi</i>            | 0    | 1     | 0     | 0     | 0     |
| <i>Sphaeroidina bulloides</i>         | 0    | 2     | 0     | 0     | 0     |
| <i>Spiroplectammina</i> sp.           | 16   | 4     | 23    | 20    | 2     |
| <i>Stainforthia complanata</i>        | 0    | 1     | 0     | 0     | 1     |
| <i>Textularia earlandi</i>            | 16   | 13    | 0     | 1     | 53    |
| <i>Textularia wiesneri</i>            | 0    | 3     | 0     | 0     | 0     |
| <i>Textulariaceae</i> sp. A           | 0    | 1     | 0     | 0     | 0     |
| <i>Triloculina tricarinata</i>        | 1    | 0     | 1     | 1     | 0     |
| <i>Trochammina</i> c.f. <i>advena</i> | 12   | 13    | 50    | 25    | 9     |
| <i>Trochammina globigeriniformis</i>  | 2    | 0     | 0     | 0     | 0     |
| <i>Trochammina globulosa</i>          | 9    | 1     | 1     | 4     | 0     |
| <i>Trochammina inflata</i>            | 0    | 0     | 1     | 0     | 0     |
| <i>Trochammina japonica</i>           | 0    | 2     | 0     | 0     | 0     |
| <i>Trochammina quadriloba</i>         | 0    | 0     | 2     | 6     | 0     |
| <i>Trochammina squamata</i>           | 0    | 1     | 0     | 0     | 0     |
| <i>Trochammina tasmanica</i>          | 0    | 2     | 1     | 9     | 0     |
| <i>Trochamminoides coronatus</i>      | 0    | 4     | 0     | 0     | 0     |
| <i>Uzbekistania charoides</i>         | 0    | 0     | 3     | 5     | 3     |
| <i>Uvigerina auberiana</i>            | 0    | 1     | 0     | 2     | 1     |
| <i>Uvigerina peregrina</i>            | 2    | 45    | 3     | 0     | 15    |
| <i>Valvulineria glabra</i>            | 0    | 0     | 0     | 0     | 10    |
| <i>Veleroninoides wiesneri</i>        | 0    | 0     | 8     | 6     | 4     |
| Indeterminate                         | 5    | 4     | 0     | 0     | 0     |

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| 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  |

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 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 <sup>3</sup> )           | 87   | 39    | 90    | 63    | 83    |
| Density (spec/ 10 cm <sup>3</sup> ) | 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  |

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## Raw Counts for Obs0 (0-1 cm).

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

## Obs0 Continued.

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

## Obs0 Continued.

| Taxa                                  | Obs0a | Obs0c | Obs0c |
|---------------------------------------|-------|-------|-------|
| <i>Reophax</i> sp. B                  | 4     | 3     | 1     |
| <i>Reophax</i> sp. G                  | 2     | 0     | 0     |
| <i>Reticulophragmium venezuelanum</i> | 3     | 0     | 2     |
| <i>Rhizammina indivisa</i>            | 4     | 1     | 3     |
| <i>Robertinoides bradyi</i>           | 0     | 1     | 1     |
| Rotalid sp. A                         | 0     | 0     | 1     |
| <i>Seabrookia earlandi</i>            | 0     | 1     | 0     |
| <i>Sphaeroidina bulloides</i>         | 2     | 1     | 0     |
| <i>Spiroloculina</i> sp. A            | 1     | 0     | 0     |
| <i>Spiroplectammina</i> sp.           | 9     | 15    | 14    |
| <i>Stainforthia complanata</i>        | 1     | 0     | 0     |
| <i>Textularia earlandi</i>            | 15    | 36    | 10    |
| <i>Textularia wiesneri</i>            | 0     | 0     | 2     |
| <i>Triloculina tricarinata</i>        | 1     | 1     | 0     |
| <i>Trochammina</i> c.f. <i>advena</i> | 25    | 26    | 19    |
| <i>Trochammina globulosa</i>          | 0     | 1     | 1     |
| <i>Trochammina inflata</i>            | 0     | 0     | 3     |
| <i>Trochammina japonica</i>           | 2     | 1     | 1     |
| <i>Trochammina tasmanica</i>          | 1     | 3     | 1     |
| <i>Usbekistania charoides</i>         | 7     | 2     | 1     |
| <i>Uvigerina auberiana</i>            | 0     | 1     | 0     |
| <i>Uvigerina peregrina</i>            | 25    | 10    | 22    |
| <i>Valvulineria glabra</i>            | 1     | 0     | 1     |
| <i>Veleroninoides wiesneri</i>        | 0     | 0     | 2     |
| Indeterminate                         | 2     | 2     | 3     |
| <b>Suborders</b>                      |       |       |       |
| 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 <sup>3</sup> )             | 82    | 19    | 64    |
| Density (spec/ 10 cm <sup>3</sup> )   | 1050  | 1276  | 890   |

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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  |

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## Raw counts for GIP 15 of 2010.

| Taxa                                  | 1-2 cm | 2-3 cm | 3-4 cm | 4-5 cm | 5-6 cm |
|---------------------------------------|--------|--------|--------|--------|--------|
| <i>Adercotryma glomerata</i>          | 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      |
| <i>Alveolphragmium</i> sp. A          | 0      | 0      | 2      | 0      | 0      |
| <i>Anomalinoides mexicana</i>         | 0      | 0      | 1      | 0      | 0      |
| <i>Biloculinella irregularis</i>      | 0      | 0      | 0      | 1      | 0      |
| <i>Bolivina albatrossi</i>            | 1      | 2      | 7      | 13     | 3      |
| <i>Bolivina minima</i>                | 2      | 4      | 11     | 13     | 59     |
| <i>Bolivina paula</i>                 | 0      | 3      | 1      | 0      | 0      |
| <i>Bolivina striatula</i>             | 0      | 0      | 2      | 0      | 1      |
| <i>Bolivina translucens</i>           | 33     | 12     | 3      | 5      | 2      |
| <i>Bulimina aculeata</i>              | 16     | 15     | 38     | 34     | 7      |
| <i>Bulimina alazanensis</i>           | 1      | 0      | 2      | 1      | 1      |
| <i>Buliminella bassendorfensis</i>    | 1      | 0      | 0      | 0      | 0      |
| <i>Bulimina spicata</i>               | 1      | 0      | 1      | 0      | 0      |
| <i>Cassidulina carinata</i>           | 1      | 1      | 3      | 5      | 2      |
| <i>Cassidulina laevigata</i>          | 0      | 0      | 1      | 0      | 0      |
| <i>Cassidulina obtusa</i>             | 0      | 0      | 1      | 0      | 0      |
| <i>Chilostomella oolina</i>           | 5      | 4      | 0      | 1      | 0      |
| <i>Cibicides kullenbergi</i>          | 0      | 1      | 3      | 2      | 0      |
| <i>Cibicides rugosus</i>              | 0      | 0      | 0      | 0      | 2      |
| <i>Cibicidoides pachydermus</i>       | 0      | 0      | 0      | 0      | 1      |
| <i>Cornuspira involvens</i>           | 0      | 0      | 0      | 1      | 0      |
| <i>Cribrostomoides scitulus</i>       | 0      | 0      | 0      | 1      | 0      |
| <i>Epistominella exigua</i>           | 0      | 1      | 3      | 5      | 3      |
| <i>Epistominella levicula</i>         | 16     | 43     | 49     | 47     | 68     |
| <i>Epistominella vitrea</i>           | 0      | 0      | 2      | 0      | 3      |
| <i>Fissurina aradasii</i>             | 0      | 0      | 0      | 1      | 1      |
| <i>Fissurina flintiana</i>            | 0      | 0      | 1      | 0      | 0      |
| <i>Fursenkoina tessellata</i>         | 40     | 77     | 53     | 34     | 10     |
| <i>Gaudryina minuta</i>               | 0      | 0      | 1      | 1      | 0      |
| <i>Gavelinopsis basilica</i>          | 0      | 0      | 1      | 0      | 1      |
| <i>Gavelinopsis translucens</i>       | 3      | 3      | 9      | 19     | 6      |
| <i>Globobulimina affinis</i>          | 3      | 0      | 1      | 3      | 0      |
| <i>Glomospira irregularis</i>         | 0      | 0      | 2      | 1      | 0      |
| <i>Globobulimina mississippiensis</i> | 3      | 4      | 0      | 0      | 0      |
| <i>Globocassidulina subglobosa</i>    | 0      | 0      | 6      | 4      | 1      |
| <i>Globotextularia</i> 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 |
|--------------------------------------|--------|--------|--------|--------|--------|
| <i>Gyroidina orbicularis</i>         | 0      | 0      | 0      | 1      | 0      |
| <i>Haplophragmoides bradyi</i>       | 0      | 0      | 2      | 0      | 1      |
| <i>Haplophragmoides kirki</i>        | 0      | 1      | 0      | 0      | 0      |
| <i>Haynesina germanica</i>           | 1      | 2      | 3      | 3      | 2      |
| <i>Lagenammia difflugiformis</i>     | 1      | 0      | 2      | 1      | 0      |
| <i>Lagenammia tubulata</i>           | 0      | 0      | 1      | 0      | 0      |
| <i>Laminononion tumidum</i>          | 0      | 0      | 1      | 0      | 0      |
| <i>Lenticulina</i> sp. A             | 0      | 0      | 0      | 0      | 1      |
| <i>Loxostomum abruptum</i>           | 2      | 4      | 6      | 7      | 2      |
| <i>Miliolinella warreni</i>          | 0      | 0      | 0      | 1      | 0      |
| <i>Nonionella atlantica</i>          | 1      | 1      | 0      | 0      | 0      |
| <i>Nonionella iridea</i>             | 0      | 0      | 0      | 0      | 1      |
| <i>Nonionella opima</i>              | 15     | 4      | 3      | 2      | 0      |
| <i>Oolina ovum</i>                   | 0      | 0      | 0      | 0      | 1      |
| <i>Oolina</i> sp. A                  | 0      | 0      | 0      | 2      | 0      |
| <i>Osangularia culter</i>            | 0      | 1      | 8      | 11     | 21     |
| <i>Osangularia rugosa</i>            | 1      | 4      | 5      | 19     | 34     |
| <i>Portatrochammina antarctica</i>   | 0      | 0      | 0      | 1      | 1      |
| <i>Praeglobobulimina ovata</i>       | 1      | 0      | 0      | 0      | 0      |
| <i>Praeglobobulimina ovula</i>       | 1      | 1      | 1      | 0      | 0      |
| <i>Prolixoplecta parvula</i>         | 0      | 0      | 2      | 2      | 0      |
| <i>Procerolagena</i> sp. A           | 0      | 0      | 1      | 0      | 0      |
| <i>Pullenia quinqueloba</i>          | 0      | 0      | 0      | 0      | 4      |
| <i>Pyrgo</i> sp. B                   | 0      | 0      | 1      | 0      | 0      |
| <i>Pyrgo</i> c.f. <i>williamsoni</i> | 0      | 0      | 0      | 1      | 0      |
| <i>Pyrgoella sphaera</i>             | 0      | 0      | 0      | 1      | 0      |
| <i>Quinqueloculina seminulum</i>     | 0      | 0      | 0      | 2      | 0      |
| <i>Recurvoides trochamminiforme</i>  | 0      | 0      | 1      | 0      | 0      |
| <i>Reophax agglutinatus</i>          | 1      | 0      | 0      | 0      | 0      |
| <i>Reophax</i> sp. A                 | 1      | 1      | 0      | 0      | 0      |
| <i>Reophax</i> sp. G                 | 0      | 0      | 0      | 1      | 0      |
| <i>Rhizammina indivisa</i>           | 0      | 1      | 1      | 1      | 0      |
| Rotalid sp. A                        | 0      | 1      | 0      | 0      | 0      |
| Rotalid sp. F                        | 0      | 0      | 0      | 0      | 3      |
| <i>Rutherfordoides mexicanus</i>     | 139    | 121    | 43     | 26     | 2      |
| <i>Seabrookia earlandi</i>           | 2      | 0      | 1      | 2      | 0      |
| <i>Siphonodosaria calomorpha</i>     | 0      | 1      | 1      | 0      | 0      |
| <i>Sphaeroidina bulloides</i>        | 1      | 0      | 2      | 0      | 0      |
| <i>Spiroplectammina</i> sp.          | 0      | 1      | 4      | 21     | 42     |
| <i>Spiroloculina</i> 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 |
|-------------------------------------|--------|--------|--------|--------|--------|
| <i>Stainforthia complanata</i>      | 0      | 0      | 1      | 0      | 0      |
| <i>Textularia earlandi</i>          | 0      | 0      | 0      | 0      | 1      |
| <i>Triloculina tricarinata</i>      | 0      | 0      | 1      | 2      | 1      |
| <i>Trochammina c.f. advena</i>      | 3      | 2      | 2      | 1      | 1      |
| <i>Trochammina globulosa</i>        | 0      | 0      | 1      | 1      | 0      |
| <i>Trochammina quadriloba</i>       | 0      | 0      | 1      | 1      | 0      |
| <i>Uvigerina peregrina</i>          | 4      | 2      | 6      | 4      | 0      |
| <i>Uvigerina sp. E</i>              | 0      | 0      | 0      | 0      | 1      |
| Indeterminate                       | 1      | 7      | 6      | 3      | 1      |
| <b>Suborders</b>                    |        |        |        |        |        |
| 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 <sup>3</sup> )           | 51     | 64     | 65     | 53     | 67     |
| Density (spec/ 10 cm <sup>3</sup> ) | 1066   | 609    | 202    | 118    | 90     |
| <b>Diversity Indices</b>            |        |        |        |        |        |
| 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 |
|---------------------------------|--------|--------|--------|--------|--------|
| <i>Adercotryma glomerata</i>    | 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      |
| <i>Alveolophragmium</i> sp. A   | 1      | 0      | 0      | 0      | 0      |
| <i>Anomalinoides globulosus</i> | 0      | 0      | 0      | 1      | 0      |
| <i>Anomalinoides mexicana</i>   | 2      | 0      | 0      | 0      | 0      |
| Bagginidae sp. A                | 0      | 0      | 0      | 0      | 1      |
| <i>Bolivina albatrossi</i>      | 13     | 0      | 11     | 3      | 6      |
| <i>Bolivina minima</i>          | 0      | 8      | 15     | 15     | 23     |
| <i>Bolivina paula</i>           | 0      | 3      | 0      | 1      | 2      |
| <i>Bolivina striatula</i>       | 0      | 0      | 2      | 2      | 0      |
| <i>Bolivina translucens</i>     | 23     | 12     | 2      | 3      | 2      |
| <i>Brizalina subspinescens</i>  | 0      | 0      | 0      | 0      | 1      |
| <i>Bulimina aculeata</i>        | 14     | 31     | 46     | 57     | 52     |
| <i>Bulimina alazanensis</i>     | 0      | 1      | 0      | 2      | 4      |
| <i>Bulimina spicata</i>         | 0      | 0      | 1      | 0      | 0      |
| <i>Cassidulina carinata</i>     | 7      | 5      | 10     | 3      | 7      |
| <i>Cibicides kullenbergi</i>    | 4      | 1      | 0      | 1      | 1      |
| <i>Cornuspira involvens</i>     | 1      | 0      | 0      | 0      | 0      |
| <i>Cribrostomoides nitidum</i>  | 0      | 0      | 1      | 0      | 0      |
| <i>Cribrostomoides scitulus</i> | 1      | 0      | 0      | 0      | 0      |
| <i>Cystamina pauciloculata</i>  | 2      | 0      | 0      | 0      | 1      |
| <i>Epistominella exigua</i>     | 4      | 2      | 3      | 3      | 8      |
| <i>Epistominella levicula</i>   | 35     | 74     | 120    | 79     | 84     |
| <i>Epistominella vitrea</i>     | 1      | 1      | 3      | 10     | 14     |
| <i>Fissurina incomposita</i>    | 0      | 0      | 0      | 1      | 0      |
| <i>Fissurina</i> sp. A          | 0      | 0      | 0      | 0      | 1      |
| <i>Fissurina</i> sp. B          | 0      | 0      | 1      | 0      | 0      |
| <i>Fursenkoina obliqua</i>      | 1      | 0      | 0      | 0      | 0      |
| <i>Fursenkoina tessellata</i>   | 42     | 69     | 41     | 30     | 17     |
| <i>Gaudryina minuta</i>         | 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 |
|---------------------------------------|--------|--------|--------|--------|--------|
| <i>Gavelinopsis translucens</i>       | 0      | 2      | 2      | 2      | 2      |
| <i>Globobulimina affinis</i>          | 12     | 5      | 3      | 2      | 1      |
| <i>Globobulimina mississippiensis</i> | 3      | 0      | 0      | 0      | 0      |
| <i>Globocassidulina subglobosa</i>    | 0      | 0      | 0      | 1      | 0      |
| <i>Globotextularia</i> sp. A          | 2      | 2      | 4      | 4      | 4      |
| <i>Glomospira irregularis</i>         | 0      | 0      | 0      | 1      | 0      |
| <i>Haplophragmoides bradyi</i>        | 6      | 1      | 0      | 0      | 5      |
| <i>Haplophragmoides kirki</i>         | 4      | 2      | 4      | 0      | 0      |
| <i>Haplophragmoides subinvolutum</i>  | 2      | 0      | 0      | 0      | 0      |
| <i>Haynesina germanica</i>            | 5      | 0      | 5      | 5      | 1      |
| <i>Hormosinella distans</i>           | 0      | 0      | 0      | 0      | 1      |
| <i>Hormosinella pilulifera</i>        | 1      | 0      | 0      | 0      | 0      |
| <i>Hyperammia</i> spp.                | 2      | 0      | 0      | 0      | 0      |
| <i>Karrerulina apicularis</i>         | 0      | 0      | 0      | 1      | 1      |
| <i>Lagenammia difflugiformis</i>      | 0      | 1      | 0      | 0      | 0      |
| <i>Loxostomum abruptum</i>            | 6      | 4      | 7      | 2      | 3      |
| <i>Nonionella iridea</i>              | 2      | 0      | 0      | 4      | 0      |
| <i>Nonionella opima</i>               | 20     | 17     | 4      | 3      | 2      |
| <i>Osangularia culter</i>             | 2      | 7      | 9      | 3      | 6      |
| <i>Osangularia rugosa</i>             | 3      | 2      | 4      | 2      | 3      |
| <i>Portatrochammina antarctica</i>    | 1      | 0      | 0      | 2      | 0      |
| <i>Praeglobobulimina ovula</i>        | 1      | 0      | 0      | 0      | 0      |
| <i>Prolixoplecta parvula</i>          | 0      | 0      | 5      | 3      | 7      |
| <i>Pullenia quinqueloba</i>           | 0      | 0      | 0      | 0      | 1      |
| <i>Recurvoides trochamminiforme</i>   | 0      | 0      | 0      | 2      | 0      |
| <i>Reophax agglutinatus</i>           | 1      | 0      | 0      | 0      | 0      |
| <i>Reophax scotti</i>                 | 11     | 0      | 0      | 0      | 2      |
| <i>Reophax</i> sp. D                  | 1      | 0      | 0      | 0      | 0      |
| Rotalid sp. A                         | 8      | 0      | 1      | 1      | 1      |
| <i>Rutherfordoides mexicanus</i>      | 22     | 28     | 12     | 11     | 5      |
| <i>Seabrookia earlandi</i>            | 0      | 0      | 1      | 0      | 2      |
| <i>Spiroplectammina</i> sp.           | 4      | 7      | 7      | 21     | 23     |
| <i>Stainforthia complanata</i>        | 0      | 0      | 0      | 0      | 1      |
| <i>Textularia earlandi</i>            | 6      | 0      | 0      | 2      | 0      |
| <i>Textularia wiesneri</i>            | 1      | 0      | 0      | 0      | 0      |
| <i>Trochammina</i> c.f. <i>advena</i> | 12     | 2      | 1      | 3      | 5      |
| <i>Trochammina globulosa</i>          | 1      | 1      | 1      | 0      | 0      |
| <i>Trochammina japonica</i>           | 1      | 0      | 1      | 0      | 0      |
| <i>Trochammina quadriloba</i>         | 2      | 0      | 2      | 1      | 0      |
| <i>Trochammina</i> 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 |
| <i>Trochammina</i> sp. D            | 0      | 0      | 0      | 1      | 0      |
| <i>Trochammina tasmanica</i>        | 1      | 0      | 0      | 0      | 1      |
| <i>Trochamminoides coronatus</i>    | 2      | 0      | 1      | 0      | 0      |
| <i>Uzbekistania charoides</i>       | 0      | 1      | 1      | 0      | 1      |
| <i>Uvigerina peregrina</i>          | 14     | 2      | 5      | 4      | 8      |
| <i>Veleroninoides wiesneri</i>      | 8      | 0      | 0      | 0      | 1      |
| Indeterminate                       | 1      | 0      | 0      | 1      | 0      |
| <b>Suborders</b>                    |        |        |        |        |        |
| 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 <sup>3</sup> )           | 87     | 74     | 65     | 74     | 72     |
| Density (spec/ 10 cm <sup>3</sup> ) | 1027   | 619    | 381    | 223    | 161    |
| <b>Diversity Indices</b>            |        |        |        |        |        |
| 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 |
|---|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| <i>Adercotryma glomerata</i>                        | 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       |
| <i>Alveolophragmium</i> sp. A                       | 0      | 0      | 0      | 1      | 1      | 0      | 0      | 0      | 0       |
| <i>Bolivina albatrossi</i>                          | 6      | 3      | 14     | 8      | 7      | 2      | 3      | 9      | 6       |
| <i>Bolivina barbata</i>                             | 0      | 0      | 0      | 0      | 0      | 0      | 2      | 0      | 0       |
| <i>Bolivina</i> c.f. <i>ordinaria</i>               | 0      | 0      | 0      | 0      | 1      | 1      | 0      | 0      | 1       |
| <i>Bolivina</i> c.f. <i>subaenariensis mexicana</i> | 0      | 0      | 1      | 0      | 1      | 0      | 0      | 0      | 0       |
| <i>Bolivina minima</i>                              | 0      | 3      | 18     | 16     | 12     | 13     | 19     | 35     | 11      |
| <i>Bolivina paula</i>                               | 1      | 4      | 5      | 3      | 2      | 0      | 3      | 1      | 1       |
| <i>Bolivina striatula</i>                           | 0      | 0      | 0      | 0      | 2      | 0      | 0      | 1      | 1       |
| <i>Bolivina translucens</i>                         | 22     | 16     | 5      | 3      | 6      | 5      | 3      | 2      | 2       |
| <i>Bulimina aculeata</i>                            | 3      | 4      | 14     | 12     | 5      | 10     | 11     | 7      | 6       |
| <i>Bulimina alazanensis</i>                         | 3      | 2      | 3      | 5      | 7      | 5      | 14     | 12     | 13      |
| <i>Bulimina</i> sp. I                               | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 1       |
| <i>Bulimina spicata</i>                             | 3      | 2      | 3      | 5      | 5      | 2      | 6      | 5      | 4       |
| <i>Cassidulina carinata</i>                         | 4      | 1      | 20     | 30     | 32     | 38     | 26     | 29     | 39      |
| <i>Cassidulina obtusa</i>                           | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 1      | 2       |
| <i>Chilostomella oolina</i>                         | 3      | 2      | 2      | 1      | 0      | 0      | 0      | 0      | 0       |
| <i>Cibicides kullenbergi</i>                        | 0      | 2      | 12     | 6      | 4      | 3      | 3      | 5      | 5       |

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| 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 |
|---------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| <i>Cibicides wuellerstorfi</i>        | 0      | 0      | 0      | 1      | 0      | 0      | 0      | 0      | 1       |
| <i>Cibicoides pachydermus</i>         | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 1       |
| <i>Cornuspira involvens</i>           | 0      | 0      | 0      | 0      | 0      | 1      | 0      | 0      | 0       |
| <i>Cribr stomoides nitidum</i>        | 0      | 0      | 0      | 0      | 0      | 0      | 1      | 0      | 0       |
| <i>Cystamina pauciloculata</i>        | 0      | 0      | 1      | 0      | 1      | 1      | 0      | 1      | 0       |
| <i>Discorbis bulbosa</i>              | 0      | 1      | 0      | 1      | 3      | 0      | 6      | 5      | 2       |
| <i>Dorothia scabra</i>                | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 1       |
| <i>Epistominella exigua</i>           | 2      | 2      | 9      | 9      | 21     | 39     | 36     | 14     | 14      |
| <i>Epistominella levicula</i>         | 7      | 8      | 20     | 19     | 28     | 40     | 30     | 20     | 20      |
| <i>Epistominella vitrea</i>           | 0      | 6      | 0      | 0      | 0      | 0      | 0      | 1      | 4       |
| <i>Eponides regularis</i>             | 0      | 0      | 0      | 1      | 1      | 0      | 2      | 2      | 0       |
| <i>Fissurina flintiana</i>            | 0      | 0      | 0      | 4      | 0      | 0      | 0      | 0      | 0       |
| <i>Fissurina</i> sp. F                | 1      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Fursenkoina obliqua</i>            | 9      | 3      | 2      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Fursenkoina tessellata</i>         | 27     | 56     | 34     | 33     | 3      | 1      | 3      | 2      | 0       |
| <i>Gaudryina minuta</i>               | 0      | 0      | 2      | 1      | 2      | 0      | 1      | 3      | 1       |
| <i>Gavelinopsis translucens</i>       | 3      | 4      | 5      | 6      | 5      | 6      | 6      | 9      | 8       |
| <i>Globobulimina affinis</i>          | 1      | 0      | 0      | 2      | 1      | 0      | 0      | 0      | 0       |
| <i>Globobulimina mississippiensis</i> | 0      | 2      | 0      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Globocassidulina subglobosa</i>    | 4      | 3      | 5      | 4      | 5      | 8      | 3      | 2      | 8       |
| <i>Globotextularia</i> sp. A          | 0      | 0      | 0      | 1      | 0      | 1      | 0      | 0      | 1       |
| <i>Glomospira irregularis</i>         | 0      | 0      | 0      | 1      | 1      | 1      | 0      | 0      | 0       |
| <i>Gyroidina orbicularis</i>          | 0      | 0      | 0      | 2      | 4      | 4      | 0      | 1      | 2       |
| <i>Gyroidinoides polius</i>           | 0      | 0      | 0      | 0      | 0      | 0      | 2      | 0      | 0       |
| <i>Haplophragmoides bradyi</i>        | 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 |
|------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| <i>Haplophragmoides kirki</i>      | 3      | 0      | 0      | 0      | 1      | 0      | 2      | 0      | 0       |
| <i>Haynesina germanica</i>         | 1      | 3      | 1      | 11     | 2      | 4      | 3      | 1      | 3       |
| <i>Hormosinella distans</i>        | 1      | 0      | 1      | 1      | 0      | 0      | 0      | 0      | 0       |
| <i>Hormosinella pilulifera</i>     | 0      | 0      | 2      | 0      | 0      | 1      | 0      | 0      | 0       |
| <i>Hyperammina</i> spp.            | 1      | 2      | 0      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Karrerulina apicularis</i>      | 1      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0       |
| Lagenaid sp. C                     | 0      | 0      | 0      | 0      | 1      | 0      | 0      | 0      | 0       |
| <i>Lagenammina difflugiformis</i>  | 2      | 2      | 3      | 4      | 2      | 0      | 2      | 0      | 0       |
| <i>Laminononion tumidum</i>        | 0      | 0      | 0      | 0      | 0      | 0      | 1      | 0      | 1       |
| <i>Loxostomum abruptum</i>         | 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       |
| <i>Miliolinella antarctica</i>     | 0      | 0      | 1      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Miliolinella californica</i>    | 0      | 0      | 0      | 0      | 1      | 1      | 0      | 0      | 0       |
| <i>Miliolinella oblonga</i>        | 0      | 0      | 0      | 0      | 1      | 0      | 0      | 0      | 0       |
| <i>Neocrosbyia minuta</i>          | 0      | 0      | 1      | 0      | 1      | 0      | 2      | 1      | 1       |
| <i>Neolenticulina chathamensis</i> | 0      | 0      | 0      | 0      | 0      | 1      | 0      | 0      | 0       |
| <i>Neolenticulina variabilis</i>   | 0      | 0      | 0      | 1      | 0      | 0      | 0      | 0      | 0       |
| <i>Nonionella atlantica</i>        | 3      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0       |

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

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

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| 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 <sup>3</sup> )           | 51     | 62     | 67     | 70     | 66     | 73     | 76     | 68     | 67      |
| Density (spec/ 10 cm <sup>3</sup> ) | 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 |
|---|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| <i>Adercotryma glomerata</i>                        | 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       |
| <i>Alveolophragmium subglobosum</i>                 | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 1      | 0       |
| <i>Angulogerina jamaicensis</i>                     | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 1      | 0       |
| <i>Bolivina albatrossi</i>                          | 11     | 4      | 12     | 16     | 10     | 9      | 6      | 9      | 5       |
| <i>Bolivina</i> c.f. <i>ordinaria</i>               | 0      | 0      | 3      | 0      | 0      | 0      | 1      | 0      | 0       |
| <i>Bolivina</i> c.f. <i>subaenariensis mexicana</i> | 0      | 0      | 0      | 0      | 1      | 0      | 1      | 0      | 0       |
| <i>Bolivina lanceolata</i>                          | 0      | 1      | 1      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Bolivina minima</i>                              | 4      | 4      | 13     | 28     | 31     | 40     | 22     | 30     | 15      |
| <i>Bolivina paula</i>                               | 3      | 1      | 0      | 2      | 3      | 0      | 2      | 1      | 3       |
| <i>Bolivina striatula</i>                           | 0      | 0      | 2      | 2      | 1      | 6      | 0      | 0      | 1       |
| <i>Bolivina translucens</i>                         | 41     | 22     | 8      | 9      | 5      | 6      | 7      | 9      | 3       |
| <i>Bulimina aculeata</i>                            | 0      | 3      | 8      | 4      | 10     | 10     | 9      | 12     | 21      |
| <i>Bulimina alazanensis</i>                         | 2      | 1      | 2      | 2      | 4      | 12     | 12     | 13     | 7       |
| <i>Bulimina spicata</i>                             | 0      | 0      | 1      | 2      | 5      | 2      | 5      | 4      | 1       |

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| 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 |
|------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| <i>Cassidulina carinata</i>        | 3      | 2      | 11     | 12     | 30     | 17     | 24     | 35     | 34      |
| <i>Cassidulinoides tenuis</i>      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 1      | 0       |
| <i>Chilostomella oolina</i>        | 11     | 1      | 4      | 4      | 0      | 1      | 0      | 0      | 0       |
| <i>Cibicides corpulentus</i>       | 1      | 1      | 1      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Cibicides kullenbergi</i>       | 1      | 0      | 4      | 1      | 1      | 1      | 1      | 1      | 1       |
| <i>Cibicides mollis</i>            | 0      | 0      | 0      | 0      | 0      | 0      | 1      | 0      | 0       |
| <i>Cibicidoides pachydermus</i>    | 0      | 0      | 0      | 1      | 0      | 0      | 0      | 0      | 0       |
| <i>Cibicidoides robertsonianus</i> | 1      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Cribrostomoides nitidum</i>     | 1      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Cruciloculina triangularis</i>  | 1      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Cystammina pauciloculata</i>    | 3      | 2      | 0      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Discorbis bulbosa</i>           | 0      | 0      | 0      | 1      | 2      | 2      | 1      | 1      | 1       |
| <i>Dorothia scabra</i>             | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 2       |
| <i>Eggerella bradyi</i>            | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 1       |
| <i>Epistominella exigua</i>        | 0      | 1      | 2      | 8      | 14     | 13     | 27     | 21     | 22      |
| <i>Epistominella levicula</i>      | 8      | 13     | 19     | 49     | 44     | 41     | 46     | 46     | 38      |
| <i>Epistominella vitrea</i>        | 2      | 0      | 0      | 0      | 2      | 0      | 0      | 0      | 0       |
| <i>Eponides regularis</i>          | 0      | 1      | 0      | 1      | 2      | 2      | 0      | 1      | 1       |
| <i>Fissurina fissa</i>             | 0      | 0      | 0      | 0      | 0      | 1      | 0      | 0      | 0       |
| <i>Fissurina incomposita</i>       | 0      | 0      | 0      | 0      | 0      | 1      | 0      | 0      | 0       |
| <i>Fursenkoina obliqua</i>         | 3      | 5      | 7      | 5      | 0      | 1      | 0      | 0      | 0       |
| <i>Fursenkoina tessellata</i>      | 39     | 31     | 49     | 41     | 16     | 6      | 2      | 2      | 6       |
| <i>Gaudryina minuta</i>            | 1      | 2      | 4      | 1      | 4      | 0      | 1      | 3      | 3       |
| <i>Gavelinopsis translucens</i>    | 2      | 1      | 7      | 8      | 11     | 24     | 16     | 14     | 13      |
| <i>Globobulimina affinis</i>       | 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 |
|---------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| <i>Globobulimina mississippiensis</i> | 0      | 2      | 0      | 5      | 0      | 0      | 0      | 0      | 0       |
| <i>Globocassidulina subglobosa</i>    | 0      | 2      | 0      | 5      | 2      | 5      | 5      | 1      | 2       |
| <i>Globotextularia</i> sp. A          | 0      | 0      | 2      | 1      | 1      | 2      | 3      | 0      | 0       |
| <i>Glomospira irregularis</i>         | 0      | 0      | 1      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Gyroidina orbicularis</i>          | 1      | 0      | 0      | 0      | 2      | 0      | 0      | 3      | 0       |
| <i>Haplophragmoides bradyi</i>        | 2      | 3      | 3      | 2      | 3      | 0      | 0      | 0      | 1       |
| <i>Haplophragmoides kirki</i>         | 2      | 0      | 2      | 1      | 0      | 0      | 0      | 1      | 0       |
| <i>Haynesina germanica</i>            | 1      | 4      | 4      | 11     | 10     | 9      | 4      | 5      | 4       |
| <i>Hormosinella guttifer</i>          | 1      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Hormosinella pilulifera</i>        | 0      | 0      | 1      | 0      | 0      | 0      | 0      | 1      | 0       |
| <i>Hyperammia friabilis</i>           | 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       |
| <i>Lagenammia difflugiformis</i>      | 0      | 0      | 3      | 1      | 4      | 1      | 1      | 0      | 0       |
| <i>Lagenammia tubulata</i>            | 0      | 0      | 0      | 0      | 1      | 0      | 0      | 0      | 0       |
| <i>Lenticulina gibba</i>              | 0      | 0      | 1      | 2      | 0      | 0      | 0      | 0      | 0       |
| <i>Loxostomum abruptum</i>            | 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       |
| <i>Neocrosbyia minuta</i>             | 0      | 0      | 0      | 1      | 0      | 0      | 0      | 1      | 0       |
| <i>Neolenticulina variabilis</i>      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 1       |
| <i>Nonionella atlantica</i>           | 1      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Nonionella iridea</i>              | 0      | 1      | 2      | 3      | 3      | 1      | 1      | 5      | 2       |
| <i>Nonionella opima</i>               | 26     | 6      | 16     | 7      | 0      | 0      | 1      | 3      | 5       |
| <i>Oridorsalis umbonatus</i>          | 0      | 0      | 0      | 0      | 1      | 0      | 0      | 1      | 1       |

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

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| 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 |
|----------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| <i>Rutherfordoides mexicanus</i> | 133    | 175    | 85     | 18     | 16     | 1      | 3      | 2      | 0       |
| <i>Seabrookia earlandi</i>       | 0      | 2      | 0      | 1      | 1      | 1      | 0      | 2      | 0       |
| <i>Siphonodosaria calomorpha</i> | 0      | 0      | 2      | 0      | 0      | 0      | 1      | 0      | 0       |
| <i>Sphaeroidina bulloides</i>    | 0      | 0      | 1      | 1      | 0      | 0      | 0      | 2      | 1       |
| <i>Spirillina vivipara</i>       | 0      | 0      | 0      | 0      | 1      | 0      | 0      | 0      | 0       |
| <i>Spiroplectammina sp.</i>      | 3      | 1      | 2      | 3      | 15     | 22     | 27     | 30     | 40      |
| <i>Stainforthia complanata</i>   | 0      | 0      | 1      | 0      | 0      | 0      | 0      | 1      | 0       |
| <i>Textularia earlandi</i>       | 7      | 5      | 6      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Trifarina bradyi</i>          | 0      | 0      | 1      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Trochammina c.f. advena</i>   | 1      | 0      | 3      | 1      | 2      | 2      | 0      | 5      | 3       |
| <i>Trochammina globulosa</i>     | 1      | 0      | 3      | 0      | 0      | 0      | 1      | 0      | 1       |
| <i>Trochammina japonica</i>      | 0      | 0      | 2      | 0      | 1      | 0      | 0      | 0      | 0       |
| <i>Trochammina quadriloba</i>    | 0      | 1      | 2      | 0      | 0      | 1      | 0      | 1      | 0       |
| <i>Trochammina tasmanica</i>     | 1      | 0      | 0      | 0      | 4      | 5      | 3      | 2      | 1       |
| <i>Usbekistania charoides</i>    | 0      | 3      | 0      | 1      | 0      | 0      | 0      | 0      | 0       |
| <i>Uvigerina peregrina</i>       | 2      | 2      | 0      | 3      | 6      | 7      | 4      | 3      | 1       |
| <i>Valvulineria glabra</i>       | 3      | 1      | 0      | 1      | 0      | 0      | 0      | 0      | 0       |
| <i>Veleroninoides wiesneri</i>   | 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 |
|-------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| <b>Suborders</b>                    |        |        |        |        |        |        |        |        |         |
| 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 <sup>3</sup> )           | 69     | 67     | 58     | 73     | 60     | 66     | 60     | 70     | 58      |
| Density (spec/ 10 cm <sup>3</sup> ) | 300    | 281    | 233    | 165    | 279    | 276    | 453    | 578    | 627     |
| <b>Diversity Indices</b>            |        |        |        |        |        |        |        |        |         |
| 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 |
|------------------------------------|-------|-------|-------|-------|-------|-------|-------|--------|--------|--------|--------|-------|-------|-------|
| <i>Ammodiscus tenuis</i>           | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0      | 0      | 0      | 1      | 0     | 0     | 0     |
| <i>Bolivina albatrossi</i>         | 3     | 2     | 2     | 4     | 0     | 3     | 1     | 7      | 10     | 10     | 4      | 0     | 11    | 9     |
| <i>Bolivina minima</i>             | 2     | 1     | 0     | 1     | 0     | 0     | 1     | 1      | 0      | 0      | 1      | 0     | 0     | 2     |
| <i>Bolivina translucens</i>        | 14    | 11    | 1     | 2     | 0     | 0     | 2     | 2      | 0      | 0      | 9      | 0     | 1     | 0     |
| <i>Bulimina aculeata</i>           | 20    | 31    | 8     | 17    | 0     | 3     | 1     | 3      | 2      | 24     | 0      | 2     | 1     | 2     |
| <i>Bulimina alazanensis</i>        | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0      | 0      | 0      | 0      | 0     | 0     | 0     |
| <i>Bulimina marginata</i>          | 0     | 0     | 1     | 1     | 0     | 0     | 0     | 0      | 0      | 0      | 0      | 0     | 0     | 0     |
| <i>Cassidulina carinata</i>        | 8     | 8     | 0     | 2     | 0     | 0     | 13    | 8      | 0      | 0      | 5      | 3     | 4     | 7     |
| <i>Cibicides kullenbergi</i>       | 0     | 0     | 0     | 0     | 3     | 0     | 0     | 0      | 0      | 0      | 0      | 0     | 2     | 1     |
| <i>Epistominella exigua</i>        | 4     | 0     | 0     | 0     | 0     | 0     | 0     | 0      | 0      | 0      | 0      | 0     | 0     | 0     |
| <i>Fursenkoina tessellata</i>      | 0     | 0     | 1     | 2     | 0     | 0     | 0     | 0      | 0      | 0      | 1      | 1     | 0     | 0     |
| <i>Gaudryina minuta</i>            | 0     | 0     | 6     | 1     | 4     | 0     | 0     | 0      | 11     | 9      | 2      | 3     | 2     | 4     |
| <i>Gavelinopsis translucens</i>    | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 0      | 0      | 0      | 0      | 0     | 0     | 0     |
| <i>Hormosinella guttifer</i>       | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0      | 0      | 0      | 0      | 5     | 0     | 3     |
| <i>Hormosinella pilulifera</i>     | 1     | 0     | 4     | 0     | 0     | 0     | 0     | 0      | 3      | 0      | 2      | 0     | 1     | 0     |
| <i>Lenticulina convergens</i>      | 0     | 0     | 0     | 2     | 0     | 0     | 0     | 0      | 1      | 0      | 0      | 0     | 0     | 0     |
| <i>Loxostomum abruptum</i>         | 1     | 0     | 0     | 0     | 0     | 0     | 1     | 0      | 0      | 0      | 0      | 0     | 4     | 0     |
| <i>Neolenticulina chathamensis</i> | 2     | 0     | 0     | 0     | 0     | 0     | 0     | 0      | 0      | 0      | 0      | 0     | 0     | 0     |
| <i>Osangularia culter</i>          | 0     | 0     | 1     | 0     | 0     | 1     | 0     | 3      | 0      | 0      | 0      | 1     | 0     | 0     |
| <i>Osangularia rugosa</i>          | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0      | 0      | 0      | 0      | 0     | 8     | 0     |

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Surface Counts Continued

| Taxa                             | GIP12 | GIP15 | GIP16 | GIP17 | GIP21 | GIP25 | GIPK* | GIP15* | GIP16* | GIP17* | GIP25* | Obs0a | Obs0b | Obs0c |
|----------------------------------|-------|-------|-------|-------|-------|-------|-------|--------|--------|--------|--------|-------|-------|-------|
| <i>Reophax scorpiurus</i>        | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0      | 0      | 1      | 0      | 0     | 0     | 0     |
| <i>Rutherfordoides mexicanus</i> | 10    | 11    | 1     | 1     | 0     | 9     | 6     | 2      | 0      | 0      | 12     | 0     | 0     | 0     |
| <i>Textularia earlandi</i>       | 1     | 4     | 0     | 0     | 0     | 10    | 0     | 5      | 0      | 0      | 16     | 4     | 12    | 1     |
| <i>Uvigerina peregrina</i>       | 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    |

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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 |
|----------------------------------|--------|--------|--------|--------|--------|--------|
| <i>Bolivina albatrossi</i>       | 2      | 0      | 0      | 1      | 4      | 2      |
| <i>Bolivina minima</i>           | 1      | 1      | 2      | 4      | 8      | 22     |
| <i>Bolivina translucens</i>      | 11     | 17     | 6      | 1      | 1      | 2      |
| <i>Bulimina aculeata</i>         | 31     | 10     | 11     | 24     | 14     | 4      |
| <i>Cassidulina carinata</i>      | 8      | 0      | 0      | 1      | 1      | 0      |
| <i>Cibicides kullenbergi</i>     | 0      | 0      | 1      | 2      | 0      | 0      |
| <i>Cibicidoides pachydermus</i>  | 0      | 0      | 0      | 0      | 0      | 1      |
| <i>Epistominella levicula</i>    | 0      | 0      | 0      | 0      | 0      | 2      |
| <i>Fursenkoina tessellata</i>    | 0      | 7      | 18     | 13     | 7      | 2      |
| <i>Gavelinopsis translucens</i>  | 0      | 0      | 1      | 1      | 0      | 2      |
| <i>Lenticulina</i> sp. A         | 0      | 0      | 0      | 0      | 0      | 1      |
| <i>Loxostomum abruptum</i>       | 0      | 2      | 4      | 4      | 6      | 2      |
| <i>Osangularia culter</i>        | 0      | 0      | 0      | 1      | 3      | 15     |
| <i>Osangularia rugosa</i>        | 0      | 0      | 1      | 1      | 0      | 18     |
| <i>Rutherfordoides mexicanus</i> | 11     | 36     | 29     | 12     | 9      | 1      |
| <i>Textularia earlandi</i>       | 4      | 0      | 0      | 0      | 0      | 0      |
| <i>Uvigerina peregrina</i>       | 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 |
|------------------------------------|--------|--------|--------|--------|--------|--------|
| <i>Bolivina albatrossi</i>         | 7      | 8      | 0      | 9      | 1      | 4      |
| <i>Bolivina minima</i>             | 1      | 0      | 2      | 10     | 8      | 12     |
| <i>Bolivina translucens</i>        | 2      | 11     | 8      | 2      | 0      | 1      |
| <i>Bulimina aculeata</i>           | 3      | 5      | 13     | 24     | 29     | 24     |
| <i>Cassidulina carinata</i>        | 8      | 5      | 3      | 2      | 0      | 4      |
| <i>Cibicides kullenbergi</i>       | 0      | 1      | 0      | 0      | 0      | 0      |
| <i>Fursenkoina tessellata</i>      | 0      | 9      | 17     | 5      | 0      | 0      |
| <i>Gavelinopsis translucens</i>    | 0      | 0      | 0      | 0      | 1      | 0      |
| <i>Globobulimina affinis</i>       | 0      | 4      | 0      | 0      | 0      | 0      |
| <i>Globocassidulina subglobosa</i> | 0      | 0      | 0      | 0      | 1      | 0      |
| <i>Loxostomum abruptum</i>         | 0      | 6      | 4      | 7      | 2      | 3      |
| <i>Osangularia culter</i>          | 3      | 1      | 5      | 6      | 2      | 1      |
| <i>Osangularia rugosa</i>          | 0      | 0      | 0      | 0      | 0      | 3      |
| <i>Rutherfordoides mexicanus</i>   | 2      | 8      | 10     | 4      | 3      | 0      |
| <i>Spiroplectammina</i> spp.       | 0      | 0      | 0      | 0      | 0      | 2      |
| <i>Textularia earlandi</i>         | 5      | 0      | 0      | 0      | 0      | 0      |
| <i>Uvigerina peregrina</i>         | 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 |
|----------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| <i>Bolivina albatrossi</i>       | 3      | 0      | 1      | 0      | 1      | 2      | 1      | 0      | 0      | 2       |
| <i>Bolivina minima</i>           | 0      | 0      | 0      | 2      | 1      | 2      | 4      | 6      | 7      | 4       |
| <i>Bolivina translucens</i>      | 0      | 5      | 2      | 1      | 0      | 3      | 0      | 1      | 0      | 0       |
| <i>Bulimina aculeata</i>         | 3      | 0      | 0      | 0      | 0      | 1      | 2      | 2      | 1      | 0       |
| <i>Bulimina spicata</i>          | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 2      | 0       |
| <i>Cassidulina carinata</i>      | 0      | 0      | 0      | 1      | 0      | 6      | 9      | 6      | 3      | 9       |
| <i>Cibicides kullenbergi</i>     | 0      | 0      | 1      | 2      | 1      | 1      | 1      | 0      | 1      | 0       |
| <i>Fursenkoina obliqua</i>       | 0      | 1      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Fursenkoina tessellata</i>    | 0      | 1      | 6      | 2      | 2      | 1      | 0      | 1      | 0      | 0       |
| <i>Gaudryina minuta</i>          | 0      | 0      | 0      | 0      | 0      | 1      | 0      | 0      | 0      | 1       |
| <i>Gavelinopsis translucens</i>  | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 1      | 0       |
| <i>Hormosinella pilulifera</i>   | 0      | 0      | 0      | 1      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Loxostomum abruptum</i>       | 0      | 0      | 0      | 0      | 1      | 2      | 4      | 4      | 3      | 3       |
| <i>Osangularia culter</i>        | 1      | 0      | 0      | 0      | 0      | 0      | 1      | 2      | 1      | 1       |
| <i>Osangularia rugosa</i>        | 0      | 0      | 0      | 0      | 0      | 0      | 3      | 0      | 2      | 0       |
| <i>Prolixoplecta parvula</i>     | 0      | 0      | 0      | 0      | 0      | 3      | 1      | 2      | 0      | 1       |
| <i>Rutherfordoides mexicanus</i> | 9      | 12     | 8      | 6      | 1      | 5      | 5      | 0      | 0      | 0       |
| <i>Textularia earlandi</i>       | 10     | 0      | 1      | 0      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Uvigerina peregrina</i>       | 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 |
|---------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| <i>Ammodiscus tenuis</i>              | 1      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Bolivina albatrossi</i>            | 4      | 4      | 1      | 4      | 7      | 4      | 5      | 3      | 2      | 3       |
| <i>Bolivina c.f. ordinaria</i>        | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 1      | 0      | 0       |
| <i>Bolivina minima</i>                | 1      | 0      | 4      | 6      | 13     | 13     | 21     | 8      | 10     | 10      |
| <i>Bolivina striatula</i>             | 0      | 0      | 0      | 0      | 0      | 0      | 1      | 0      | 0      | 0       |
| <i>Bolivina translucens</i>           | 9      | 16     | 10     | 4      | 3      | 2      | 2      | 5      | 7      | 1       |
| <i>Bulimina aculeata</i>              | 0      | 0      | 2      | 2      | 3      | 4      | 3      | 5      | 2      | 8       |
| <i>Cassidulina carinata</i>           | 5      | 0      | 0      | 1      | 5      | 6      | 4      | 4      | 11     | 14      |
| <i>Cibicides kullenbergi</i>          | 0      | 0      | 0      | 2      | 0      | 1      | 1      | 1      | 1      | 0       |
| <i>Epistominella exigua</i>           | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 2       |
| <i>Epistominella levicula</i>         | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 3      | 0      | 0       |
| <i>Fursenkoina obliqua</i>            | 0      | 0      | 0      | 0      | 1      | 0      | 0      | 0      | 0      | 0       |
| <i>Fursenkoina tessellata</i>         | 1      | 11     | 9      | 19     | 17     | 1      | 1      | 0      | 2      | 2       |
| <i>Gaudryina minuta</i>               | 2      | 0      | 0      | 0      | 0      | 1      | 0      | 0      | 0      | 0       |
| <i>Gavelinopsis translucens</i>       | 0      | 0      | 0      | 0      | 0      | 2      | 2      | 2      | 0      | 1       |
| <i>Globobulimina mississippiensis</i> | 0      | 0      | 0      | 0      | 1      | 0      | 0      | 0      | 0      | 0       |
| <i>Hormosinella pilulifera</i>        | 2      | 0      | 0      | 1      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Loxostomum abruptum</i>            | 0      | 1      | 0      | 4      | 1      | 5      | 10     | 9      | 2      | 6       |
| <i>Osangularia culter</i>             | 0      | 0      | 0      | 1      | 0      | 1      | 0      | 1      | 1      | 2       |
| <i>Osangularia rugosa</i>             | 0      | 0      | 0      | 0      | 0      | 2      | 4      | 1      | 3      | 4       |

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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 |
|----------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| <i>Rutherfordoides mexicanus</i> | 12     | 33     | 26     | 13     | 3      | 6      | 1      | 1      | 1      | 0       |
| <i>Textularia earlandi</i>       | 16     | 0      | 0      | 1      | 0      | 0      | 0      | 0      | 0      | 0       |
| <i>Uvigerina peregrina</i>       | 6      | 2      | 2      | 0      | 2      | 5      | 5      | 4      | 3      | 1       |
| Total                            | 59     | 67     | 54     | 58     | 56     | 53     | 60     | 48     | 45     | 54      |

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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 |
|------------------------------------|-------|-------|-------|-------|-------|-------|-------|--------|--------|--------|--------|-------|-------|-------|
| <i>Adercotryma glomerata</i>       | 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   |
| <i>Bolivina albatrossi</i>         | 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   |
| <i>Bolivina translucens</i>        | 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   |
| <i>Bulimina aculeata</i>           | 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   |
| <i>Cassidulina carinata</i>        | 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   |
| <i>Cystammina pauciloculata</i>    | 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   |
| <i>Epistominella exigua</i>        | 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   |
| <i>Epistominella levicula</i>      | 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   |
| <i>Gaudryina minuta</i>            | 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   |
| <i>Haplophragmoides bradyi</i>     | 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   |
| <i>Lagenammina difflugiformis</i>  | 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   |
| <i>Portatrochammina antarctica</i> | 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   |
| <i>Recurvoides trochaminiforme</i> | 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   |
| <i>Reophax sp. A</i>               | 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   |
| <i>Rutherfordoides mexicanus</i>   | 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   |
| <i>Spiroplectammina sp.</i>        | 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   |
| <i>Textularia earlandi</i>         | 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   |
| <i>Trochammina cf. advena</i>      | 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   |
| <i>Uvigerina peregrina</i>         | 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.

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

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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 |
|----------------------------------|--------|--------|--------|--------|--------|
| <i>Bolivina minima</i>           | 0.0    | 2.7    | 4.4    | 4.7    | 7.1    |
| <i>Bolivina translucens</i>      | 6.9    | 4.0    | 0.6    | 0.9    | 0.6    |
| <i>Bulimina aculeata</i>         | 4.2    | 10.3   | 13.4   | 17.8   | 16.1   |
| <i>Epistominella levicula</i>    | 10.6   | 24.6   | 34.9   | 24.6   | 26.1   |
| <i>Fursenkoina tessellata</i>    | 12.7   | 22.9   | 11.9   | 9.3    | 5.3    |
| <i>Nonionella opima</i>          | 6.0    | 5.6    | 1.2    | 0.9    | 0.6    |
| <i>Rutherfordoides mexicanus</i> | 6.6    | 9.3    | 3.5    | 3.4    | 1.6    |
| <i>Spiroplectammia sp.</i>       | 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 |
|----------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| <i>Bolivina minima</i>           | 0.0    | 1.0    | 5.7    | 5.3    | 4.0    | 4.1    | 5.6    | 11.1   | 3.6     |
| <i>Bolivina translucens</i>      | 7.2    | 5.1    | 1.6    | 1.0    | 2.0    | 1.6    | 0.9    | 0.6    | 0.7     |
| <i>Cassidulina carinata</i>      | 1.3    | 0.3    | 6.4    | 10.0   | 10.6   | 12.1   | 7.6    | 9.2    | 12.9    |
| <i>Epistominella exigua</i>      | 0.7    | 0.6    | 2.9    | 3.0    | 7.0    | 12.4   | 10.6   | 4.4    | 4.6     |
| <i>Epistominella levicula</i>    | 2.3    | 2.5    | 6.4    | 6.3    | 9.3    | 12.7   | 8.8    | 6.3    | 6.6     |
| <i>Fursenkoina tessellata</i>    | 8.8    | 17.8   | 10.8   | 11.0   | 1.0    | 0.3    | 0.9    | 0.6    | 0.0     |
| <i>Nonionella opima</i>          | 6.5    | 2.9    | 0.3    | 0.0    | 0.7    | 0.0    | 0.3    | 0.0    | 0.3     |
| <i>Prolixoplecta parvula</i>     | 0.0    | 0.0    | 0.0    | 3.3    | 9.3    | 7.3    | 4.7    | 2.5    | 2.0     |
| <i>Rutherfordoides mexicanus</i> | 39.7   | 39.4   | 23.9   | 4.7    | 6.0    | 1.6    | 0.6    | 2.5    | 1.7     |
| <i>Spiroplectammina sp.</i>      | 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 |
|----------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| <i>Bolivina albatrossi</i>       | 3.2    | 1.3    | 3.6    | 5.3    | 3.1    | 3.0    | 2.0    | 2.7    | 1.7     |
| <i>Bolivina minima</i>           | 1.2    | 1.3    | 3.8    | 9.3    | 9.5    | 13.2   | 7.3    | 8.9    | 5.0     |
| <i>Bolivina translucens</i>      | 11.9   | 7.1    | 2.4    | 3.0    | 1.5    | 2.0    | 2.3    | 2.7    | 1.0     |
| <i>Bulimina aculeata</i>         | 0.0    | 1.0    | 2.4    | 1.3    | 3.1    | 3.3    | 3.0    | 3.6    | 6.9     |
| <i>Cassidulina carinata</i>      | 0.9    | 0.6    | 3.3    | 4.0    | 9.2    | 5.6    | 7.9    | 10.4   | 11.2    |
| <i>Epistominella exigua</i>      | 0.0    | 0.3    | 0.6    | 2.6    | 4.3    | 4.3    | 8.9    | 6.2    | 7.3     |
| <i>Epistominella levicula</i>    | 2.3    | 4.2    | 5.6    | 16.2   | 13.5   | 13.5   | 15.2   | 13.6   | 12.5    |
| <i>Fursenkoina tessellata</i>    | 11.3   | 9.9    | 14.5   | 13.6   | 4.9    | 2.0    | 0.7    | 0.6    | 2.0     |
| <i>Gavelinopsis translucens</i>  | 0.6    | 0.3    | 2.1    | 2.6    | 3.4    | 7.9    | 5.3    | 4.2    | 4.3     |
| <i>Nonionella opima</i>          | 7.5    | 1.9    | 4.7    | 2.3    | 0.0    | 0.0    | 0.3    | 0.9    | 1.7     |
| <i>Osangularia culter</i>        | 0.0    | 0.3    | 0.9    | 1.7    | 2.2    | 2.3    | 5.6    | 2.7    | 2.6     |
| <i>Osangularia rugosa</i>        | 0.0    | 0.0    | 1.2    | 2.3    | 5.5    | 4.9    | 3.6    | 5.9    | 5.0     |
| <i>Rutherfordoides mexicanus</i> | 38.6   | 56.1   | 25.1   | 6.0    | 4.9    | 0.3    | 1.0    | 0.6    | 0.0     |
| <i>Spiroplectammina sp.</i>      | 0.9    | 0.3    | 0.6    | 1.0    | 4.6    | 7.2    | 8.9    | 8.9    | 13.2    |

APPENDIX F  
FORAMINIFERAL PLATES

Plate 1

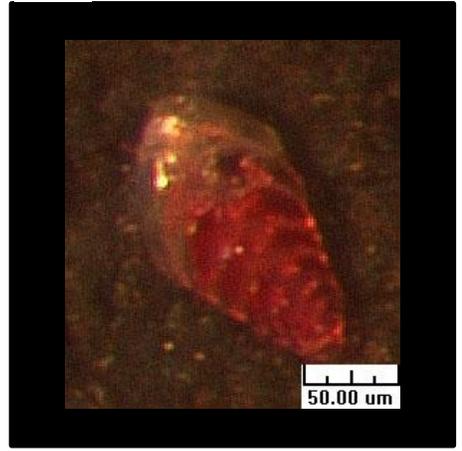
- Figures a, b      *Bolivina minima* Phleger and Parker, 1951: a. side view; b. side view.
- Figures c, d      *Bolivina translucens* Phleger and Parker, 1951: c. side view; d. side view.
- Figures e, f      *Bulimina aculeata* d'Orbigny, 1826: e. aperture view; f. side view.

Plate 1

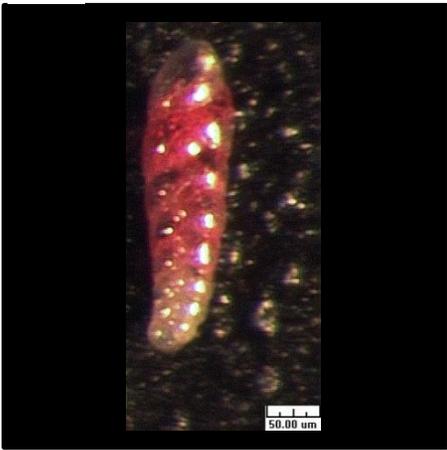
a.



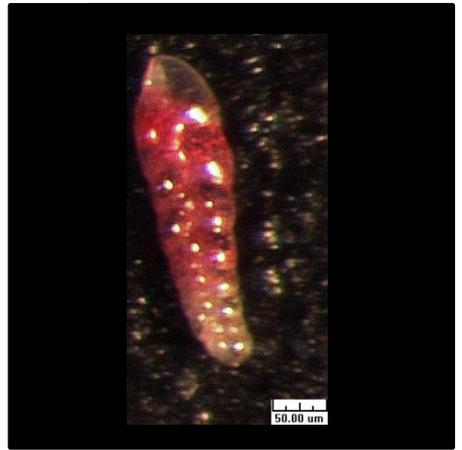
b.



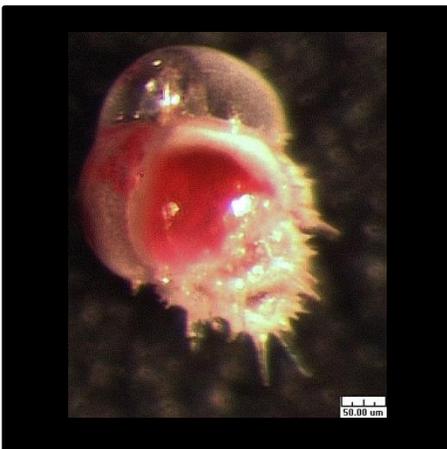
c.



d.



e.



f.

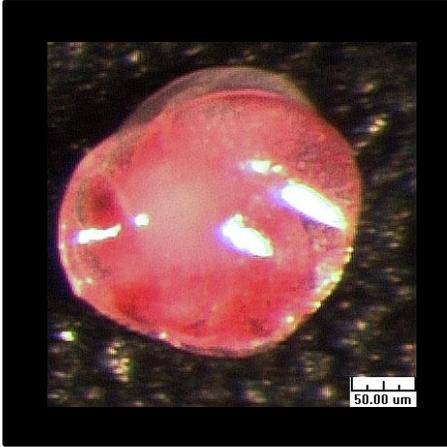


## Plate 2

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

Plate 2

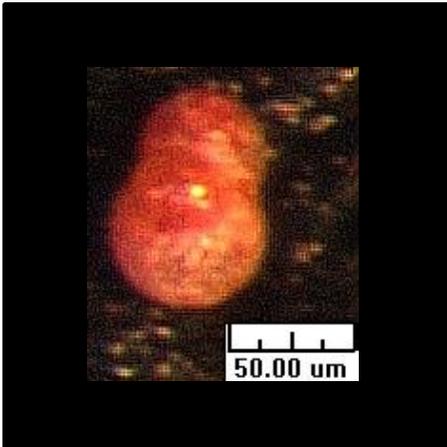
a.



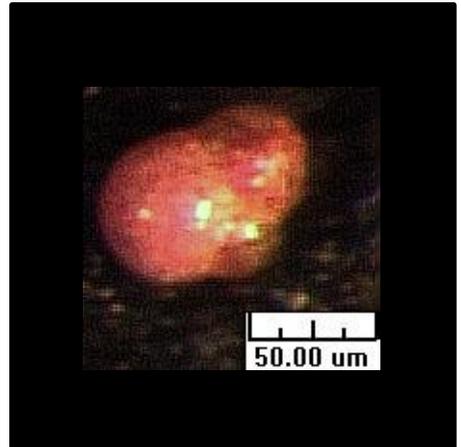
b.



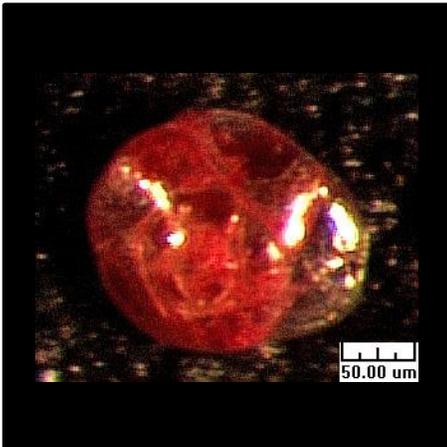
c.



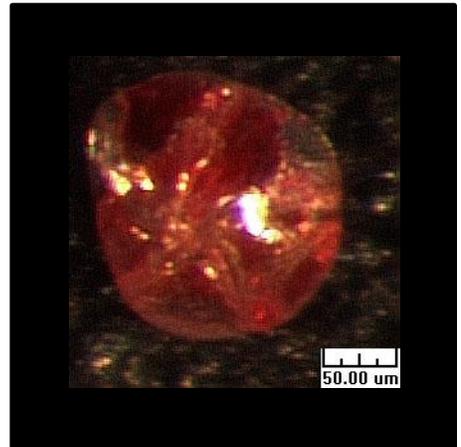
d.



e.



f.

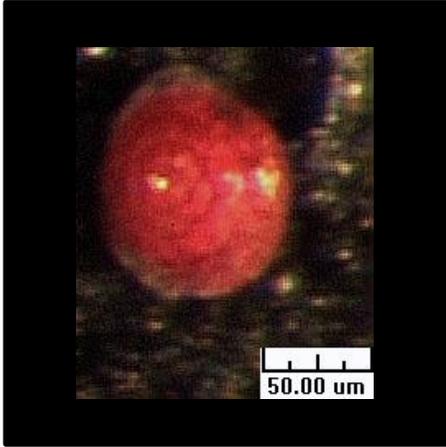


## Plate 3

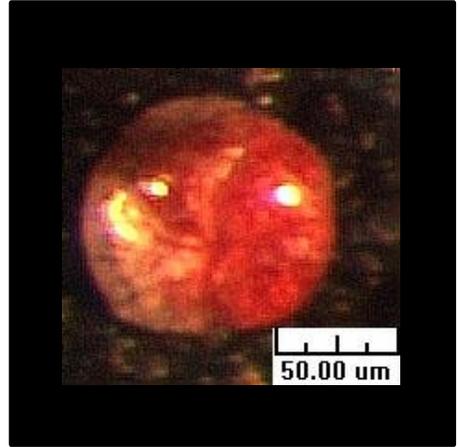
- Figures a, b      *Epistominella levicula* Resig, 1958: a. spiral view; b. umbilical view.
- Figures c, d      *Fursenkoina tessellata* (Phleger and Parker), 1951: c. side view; d. side view.
- Figures e, f      *Osangularia rugosa* (Phleger and Parker), 1951: e. spiral view; f. umbilical view.

Plate 3

a.



b.



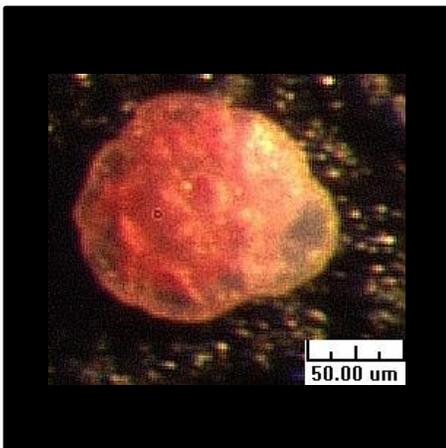
c.



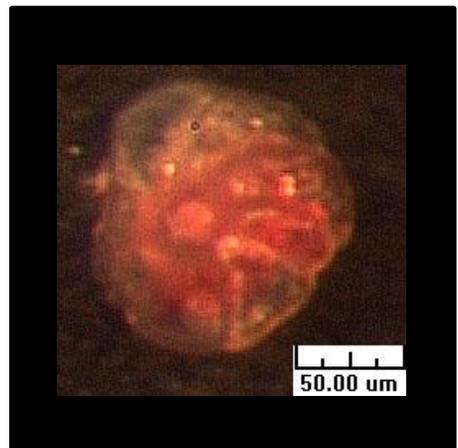
d.



e.



f.

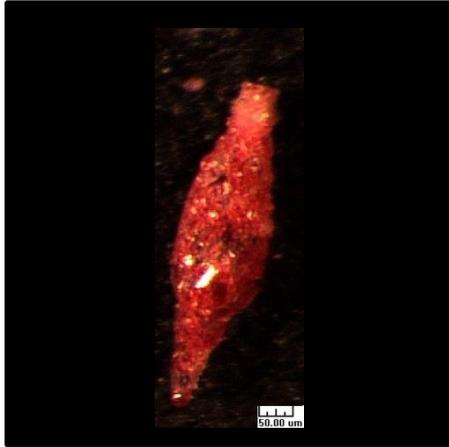


## Plate 4

- 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

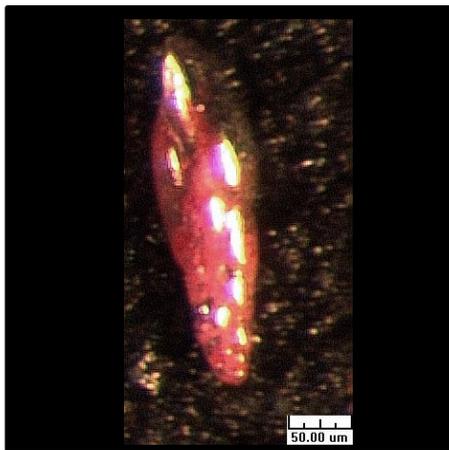
a.



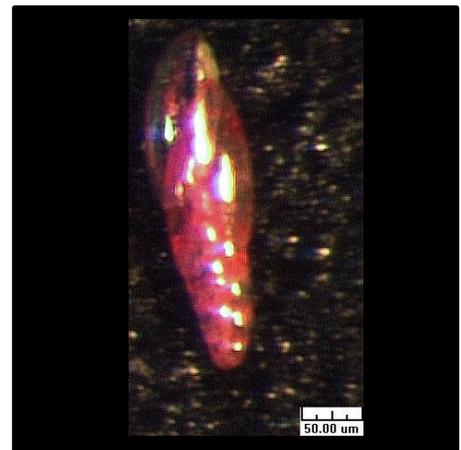
b.



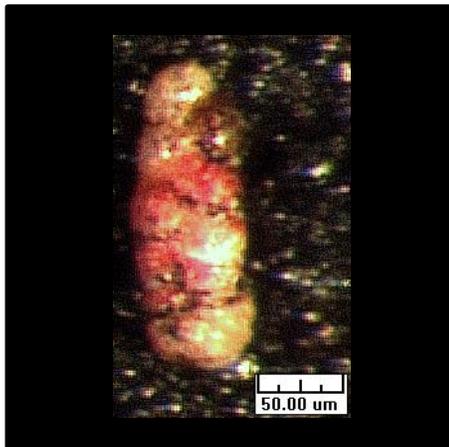
c.



d.



e.



f.



## Plate 5

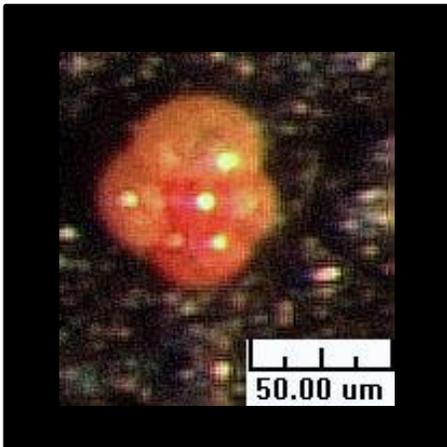
- Figure a                    *Textularia earlandi* Parker, 1952: a. side view.
- Figures b, c                *Trochammia advena* Cushman, 1922: b. spiral view; c. umbilical view.
- Figures d, e                *Uvigerina peregrina* Cushman, 1923: d. side view; e. side view.

Plate 5

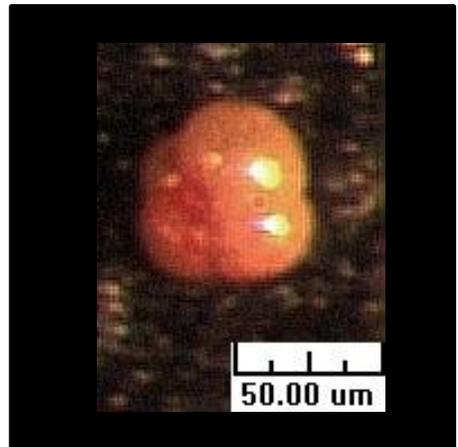
a.



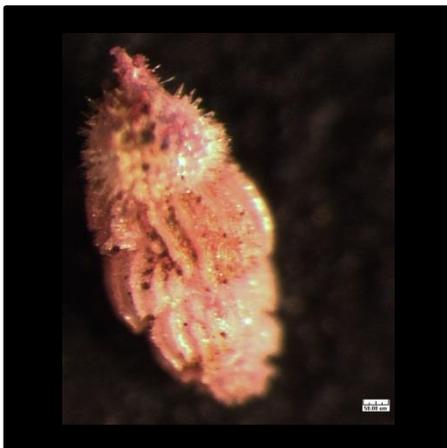
b.



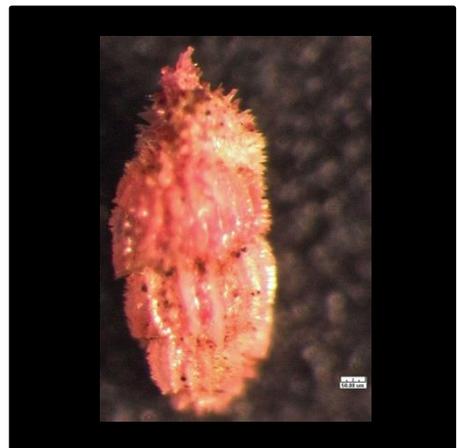
c.



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)



GIP 25 (2011)



## APPENDIX H

## PERMISSION FOR FIGURE 1



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**Title:** Effects of Oil from the 2010 Macondo Well Blowout on Marsh Foraminifera of Mississippi and Louisiana, USA

**Author:** Charlotte A. Brunner, Kevin M. Yeager, Rachel Hatch, Sondra Simpson, Joseph Keim, Kevin B. Briggs, and Patrick Louchouart

**Publication:** Environmental Science & Technology

**Publisher:** American Chemical Society

**Date:** Aug 1, 2013

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## REFERENCES

- Alve, E., 1995. Benthic foraminiferal responses to estuarine pollution: A review. *Journal of Foraminiferal Research* 25 (3), 190-203.
- Anderson, H. V., 1961. Genesis and paleontology of the Mississippi River mudlumps: Part II - Foraminifera of the mudlumps, lower Mississippi River Delta. Louisiana Department of Conservation, Geological Bulletin 35, 1-208.
- Bandy, O. L., 1956. A shorter contribution to general geology: Ecology of Foraminifera in northeaster Gulf of Mexico. Geological Survey Professional Paper 274, 179-202.
- Bandy, O. L., Ingle, J. C., Resig, J. M., 1964a. Foraminifera, Los Angeles County outfall area. California: *Limnology and Oceanography* 9, 124-137.
- Bandy, O. L., Ingle, J. C., Resig, J. M., 1964b. Foraminiferal trends, Laguna Beach outfall area. California: *Limnology and Oceanography* 9, 112-123.
- Bandy, O. L., Ingle, J. C., Resig, J. M., 1965. Foraminiferal trends, Hyperion outfall, California. *Limnology and Oceanography* 10, 314-332.
- Banner, F. T., Culver, S. J., 1978. Quaternary *Haynesina* n. gen. and Paleogene *Protelphidium* Haynes: Their morphology, affinities, and distribution. *Journal of Foraminiferal Research* 8 (3), 177-207.
- Barker, R. W., 1960. Taxonomic notes on the species figured by H. B. Brady in his report on the foraminifera dredged by H. M. S. Challenger during the years 1873-1876. Soc. Econ. Pal. Min., Special Publications (9), 1-238.
- Bartholomew, D. J., Steele, F., Moustaki, I., Galbraith, J. I., 2008. Analysis of Multivariate Social Science Data. Eds. Andrew Gelman, J. Scott Long,

- Sophia Rabe-Hesketh, and Anders Skrondal. Fl: Taylor & Francis Group, LLC, 2008, 371 pp.
- Bates, R. L., Jackson, J. A., 1995. Glossary of Geology. American Geological Institute, Alexandria, Va.
- Berkeley, A., Perry, C. T., Smithers, S. G., Horton, B. P., Taylor, K. G., 2007. A review of the ecological and taphonomic controls on foraminiferal assemblage development in intertidal environments. *Earth-Science* 83, 205-230.
- Bernhard, J. M., 1988. Postmortem vital staining in benthic Foraminifera. Duration and importance in population and distributional studies. *Journal of Foraminiferal Research* 18 (2), 143-146.
- Bernhard, J. M, Sen Gupta, B. K., Baguley, J. G., 2008. Benthic foraminifera living in Gulf of Mexico bathyal and abyssal sediments: community analysis and comparison to metazoan meiofaunal biomass and density. *Deep-Sea Research II* 55, 2617–2626.
- Bernhard, J. M., 2000. Distinguishing live from dead foraminifera: Methods review and proper applications. *Micropaleontology* (46) sup. 1: Advances in the Biology of Foraminifera, 38-46.
- Boltovskoy, E., Scott, D. B., Medioli, F. S., 1991. Morphological variations of benthic foraminiferal tests in response to changes in ecological parameters: A review. *Journal of Paleontology* 65 (2), 175-185.

- Bornemann, J. G., 1855. Die mikroskopische fauna des septarienthones von Hermsdorf bei Berlin. *Zeitschrift der Deutschen Geologischen Gesellschaft* 7, 307-371.
- Bouchet, V. M. P., Alve, E., Rygg, B., Telford, R. J., 2012. Benthic foraminifera provide a promising tool for ecological quality assessment of marine waters. *Ecological Indicators* 23, 65-75.
- Brady, H.B., 1878. On the Reticularian and Radiolarian Rhizopoda (Foraminifera and Polycystina) of the North Polar Expedition of 1875-76. *Annals and Magazine of Natural History* 1, ser. 5, 425-440.
- Brady, H. B., 1879. Notes on some of the reticularian Rhizopoda of the "Challenger" Expedition. *Quaternary Journal of Microscopical Science* 19, new ser., 20-63.
- Brady, H. B., 1881. Notes on some of the reticularian Rhizopoda of the "Challenger" Expedition: Part III. *Quarterly Journal Microscopical Science* 21, new series, 31-71.
- Brady, H. B., 1884. Report on the Foraminifera dredged by H. M. S. Challenger, during the years 1873-1876. Report on the Scientific Results of the Voyage of the H. M. S. Challenger during the years 1873-1876. *Zoology* 9, 1-814.
- Brunner, C. A., Yeager, K. M., Hatch, R., Simpson, S., Keim, J., Briggs, K. B., Louchouart, P., 2013. Effects of oil from the Macondo well blowout on marsh Foraminifera of Mississippi and Louisiana, USA. *Environmental Science and Technology* 47 (16), 9115-9123.

- Brunner, C. A., Yeager, K. M., Hatch, R., Simpson, S., Keim, J., Briggs, K. B., Louchouart, P., 2013. "Models of standing stock in relation to a point source of pollution." Effects of oil from the Macondo well blowout on marsh Foraminifera of Mississippi and Louisiana, USA. *American Chemical Society, Environmental Science and Technology* 47 (16), 9121.
- Bubenshchikova N., Nürnberg, D., Lembke-Jene, L., Pavlova, G., 2008. Living benthic foraminifera of the Okhotsk Sea: Faunal composition, standing stocks and microhabitats. *Marine Micropaleontology* 69, 314–333.
- Buzas, M. A., Carle, K. J., 1979. Predators of Foraminifera in the Indian River, Florida. *Journal of Foraminiferal Research* 9 (4), 336-340.
- Chapman, F., Parr, W. J., 1937. Foraminifera. *Australasian Antarctic Expedition 1911-1914. Scientific Reports. Zoology* 1, ser. C.
- Chaster, G. W., 1892. Report upon the Foraminifera of the Southport Society of Natural Science District. *First Report Southport Society of Natural Science (1890-1891)*, 54-72.
- Corliss, B. H., Emerson, S., 1990. Distribution of rose Bengal stained deep-sea benthic foraminifera from the Nova Scotian Continental Margin and Gulf of Maine. *Deep-Sea Research* 37 (3), 381-400.
- Cornelius, N., Gooday, A. J., 2004. 'Live' (stained) deep-sea benthic foraminiferans in the western Weddell Sea: Trends in abundance, diversity and taxonomic composition along a depth transect. *Deep-Sea Research II* 51, 1571-1602.

- Crone, T. J., Tolstoy, M., 2010. Magnitude of the 2010 Gulf of Mexico oil leak. *Science* 330 (6004), 634.
- Culver, S. J., Buzas, M. A., 1981. Foraminifera distribution of provinces in the Gulf of Mexico. *Nature* 290, 328-329.
- Culver, S. J., Buzas, M. A., 1983. Recent benthic foraminiferal provinces in the Gulf of Mexico. *Journal of Foraminiferal Research* 13 (1), 21-31.
- Cushman, J. A., 1910. A monograph of the Foraminifera of the North Pacific Ocean: Part I-Astrorhizidae and Lituolidae. *Bulletin of the United States National Museum* 71 (2), 1-134.
- Cushman, J. A., 1911. A monograph of the Foraminifera of the North Pacific Ocean: Part II-Textulariidae. *Bulletin of the United States National Museum* 71 (2), 1-108.
- Cushman, J. A., 1913a. A monograph of the Foraminifera of the North Pacific Ocean: Part III-Lagenidae. *Bulletin of the United States National Museum* 71 (3), 1-125.
- Cushman, J. A., 1913b. New Textulariidae and other arenaceous foraminifera from the Philippine Islands and contiguous waters. *Proceedings of the United States National Museum* 44, 633-638.
- Cushman, J. A., 1920. The foraminifera of the Atlantic Ocean: Part II-Lituolidae. *Bulletin United States National Museum* 104 (2), 1-111.
- Cushman, J. A., 1922a. Shallow-water foraminifera of the Tortugas region. *Publications of the Carnegie Institution of Washington* (311). *Department of Marine Biology* 17, 1-85.

- Cushman, J. A., 1922b. The Foraminifera of the Atlantic Ocean: Part III-  
Textulariidae. Bulletin United States National Museum 104 (3), 1-143.
- Cushman, J. A., 1923. The foraminifera of the Atlantic Ocean: Part IV--  
Lagenidae. Bulletin United States National Museum 104 (4), 1-228.
- Cushman, J. A., 1927a. An outline of a re-classification of the foraminifera.  
Contributions from the Cushman Laboratory for Foraminiferal Research 3,  
1-105.
- Cushman, J. A., 1927b. Recent foraminifera from off the West Coast of America.  
Bulletin of Scripps Institution of Oceanography, Technical Series 1, 119-  
188.
- Cushman, J. A., 1927c. Some characteristic Mexican fossil foraminifera. Journal  
of Paleontology 1 (2), 147-172.
- Cushman, J. A., 1947. *Ammobaculites paleocenicus* Cushman, a new name.  
Contributions from the Cushman Laboratory for Foraminiferal Research  
23, 77.
- Cushman, J. A., Edwards, P. G., 1937. *Astrononion* a new genus of the  
Foraminifera, and its species. Contributions from the Cushman  
Laboratory for Foraminiferal Research 13, 29-36.
- Cushman, J. A., McCulloch, I., 1939. A report on some arenaceous  
Foraminifera. Allan Hancock Pacific Expeditions 6 (1), 1-113.
- Cushman, J. A., Parker, F. L., 1936. Notes on some Cretaceous species of  
*Buliminella* and *Neobulimina*. Contributions from the Cushman Laboratory  
for Foraminiferal Research 12, 5-10.

- Cushman, J. A., Parker, F. L., 1937. Notes on some European species of *Bulimina*. Contributions from the Cushman Laboratory for Foraminiferal Research 13, 46-54.
- Cushman, J. A., Todd, R., 1945. Miocene Foraminifera from Buff Bay, Jamaica. Cushman Laboratory for Foraminiferal Research Special Publications 15, 1-73.
- Cushman, J. A., Valentine, W. W., 1930. Shallow-water foraminifera from the Channel Islands of Southern California. Volume 1, Stanford University Press.
- Debenay, J. P., Sigura, A., Justine, J. L., 2011. Foraminifera in the diet of coral reef fish from the lagoon of New Caledonia: Predation, digestion, dispersion. *Revue de Micropaléontologie* 54, 87-103.
- Denne, R. A., Sen Gupta, B. K., 1989. Effects of taphonomy and habitat on the record of benthic foraminifera in modern sediments. *PALAIOS* 4 (5), 414-423.
- Denne, R. A., Sen Gupta, B. K., 1991. Association of bathyal foraminifera with water masses in the northwestern Gulf of Mexico. *Marine Micropaleontology* 17, 173-193.
- Denne, R. A., Sen Gupta, B. K., 2003. The benthic foraminiferal record from the bathyal Gulf of Mexico during the last glacial-postglacial transition. *SEPM Special Publication* (75), 63-80.
- Denoyelle, M., Jorissen, F. J., Martin, D., Galgani, F., Miné, J., 2010. Comparison of benthic foraminifera and macrofaunal indicators of the

impact of oil-based drill mud disposal. *Marine Pollution Bulletin* 60, 2007–2021.

Denys de Montfort, P., 1808. *Conchyliologie systématique et classification méthodique des coquilles*. F. Schoell 1, Paris.

Dignes, T. W., 1978. *Late Quaternary abyssal foraminifera of the Gulf of Mexico*. Doctoral thesis University of Maine, 179 pp.

d'Orbigny, A., 1826. *Tableau méthodique de la classe des Céphalopodes*. *Annales des Sciences Naturelles* 7, 245-314.

d'Orbigny, A., 1839a. "Foraminifères." *Histoire Physique et Naturelle de L'île de Cuba*. Ramón de la Sagra, Paris.

d'Orbigny, A., 1839b. *Voyage dans l'Amérique Méridionale: Foraminifères*. Strasbourg, France, Levrault (5) pt. 5, pp. 1-86.

d'Orbigny, A., 1846. *Foraminifères fossiles du Bassin Tertiaire de Vienne (Autriche)*. Gide et Comp, Paris.

Earland, A., 1933. *Foraminifera: Part II-South Georgia*. *Discovery Reports* 10, 27-138.

Earland, A., 1934. *Foraminifera: Part III-The Falklands sector of the Antarctic (excluding South Georgia)*. *Discovery Reports* 10, 1-208.

Egger, J. G., 1893. *Foraminiferen aus meeresgrundproben, gelothet von 1874 bis 1876 von S. M. Sch. Gazelle*. *Abhandlungen der Bayerishchen Akademie der Wissenschaften, München, Math-Phys.*, Cl. 18 (2), 193-458.

Ehrenberg, C. G., 1841. *Über verbreitung und einfluss des mikroskopischen lebens in Süd- und Nordamerika*. *Bericht über die zu Bekannimachung*

geeigneten Verhandlungen der Königlich Preussischen Akademie der Wissenschaften zu Berlin, 139-145.

Ehrenberg, C. G., 1843. Einfluss der mikroskopischen neeres-organismen auf den Boden des Elbbettes bis Oberhalb Hamburg. Akademie der Wissenschaften zu Berlin.

Eimer, G. H. T., Fickert, C., 1899. Die Artbildung und Verwandtschaft bei den Foraminiferen, Entwurf einer natürlichen Eintheilung derselben. Zeitschrift für Wissenschaftliche Zoologie 65, 599-708.

Ellis and Messina, 1941-, Micropaleontology Project. Web. 1 Aug. 2013.  
<<http://www.micropress.org/>>.

Ernst, S. R., Morvan, J., Geslin, E., Bihan, A. L., Jorissen, F. J., 2006. Benthic foraminiferal response to experimentally induced Erika oil pollution. Marine Micropaleontology 61, 76–93.

Fontanier, C., Jorissen, F. J., Licari, L., Alexandre, A., Anschutz, P., Carbonel, P., 2002. Live benthic foraminiferal faunas from the Bay of Biscay: faunal density, composition, and microhabitats. Deep-Sea Research I 49, 751-785.

Fontanier, C., Jorissen, F. J., Chaillou, G., David, C., Anschutz, P., Lafon, V., 2003. Seasonal and interannual variability of benthic foraminiferal faunas at 550 m depth in the Bay of Biscay. Deep-Sea Research I 50, 457-494.

Foster, W. J., Arminot du Châtelet, E., Rogerson, M., 2012. Testing benthic foraminiferal distribution as a contemporary quantitative approach to

biomonitoring estuarine heavy metal pollution. *Marine Pollution Bulletin*.

doi: 10.1016/i.marpolbul.2012.01.021

Frontalini, F., Coccioni, R., 2011. Benthic foraminifera as bioindicators of pollution: A review of Italian research over the last three decades. *Revue de Micropaléontologie* 54, 115–127.

Gabellini, M., 2009. Preface. *Marine Pollution Bulletin* 59, 219-220.

Goës, A., 1882. On the reticularian rhizopoda of the Caribbean Sea. *Kongl. Sveska Vetenskaps-Akademiens Handlinger* 19 (4), 1-151.

Goës, A., 1896. The Foraminifera XX. Reports on the dredging operations off the West Coast of Central America to the Galapagos, to the West Coast of Mexico, and in the Gulf of California, in charge of Alexander Agassiz, carried on by the U.S. Fish Commission Steamer "Albatross," during 1891, Lieut. Commander Z. L. Tanner, U.S.N.. *Bulletin of the Museum of Comparative Zoology at Harvard College* 29 (1), 1-103.

Goldbeck, E. J., Houben, C., Langer, M. R., 2005. Survival of Foraminifera in the gut of holothuroids from Elba Island (Mediterranean Sea). *Revue de Micropaléontologie* 48, 169-174.

Goldstein, S., T., 1999. "Foraminifera: A biological overview." *Modern Foraminifera*. Ed. Barun K. Sen Gupta. Great Britain: Kluwer Academic Publishers, 37-55.

Goldstein, S. T., Barker, W. W., 1988. Test ultrastructure and taphonomy of the monothalamous agglutinated foraminifer *Cribrothalammina*, n. gen.,

- alba* (Heron-Allen and Earland). *Journal of Foraminiferal Research* 18 (2), 130-136.
- Goldstein, S. T., Corliss, B. H., 1994. Deposit feeding in selected deep-sea and shallow-water benthic foraminifera. *Deep-Sea Research I* 41 (2), 229-41.
- Goldstein, S. T., Watkins, G. T., 1999. Taphonomy of salt marsh Foraminifera: An example from coastal Georgia. *Palaeogeography, Palaeoclimatology, Palaeoecology* 149, 103-114.
- Gooday, A. J., 1986. Meiofaunal foraminiferans from the bathyal Porcupine Seabight (North-East Atlantic): Size structure, standing stock, taxonomic composition, species diversity and vertical distribution in the sediment. *Deep-Sea Research* 33 (10), 1345-1373.
- Gooday, A. J., Rathburn, A. E., 1999. Temporal variability in living deep-sea benthic foraminifera: A review. *Earth-Science Reviews* 46, 187–212.
- Grzybowski, J., 1898. Otwornice pokładów naftonośnych okolicy Krosna, *Rozprawy, Akademia Umiejętności w Krakowie, Wydział Matematyczno-Przyrodniczy, Kraków*, 10, ser. 2, 261-308.
- Gudmundsson, G., Schmalensee, M., Svavarsson, J., 2000. Are foraminifers (Protozoa) important food for small isopods (Crustacea) in the deep sea? *Deep-Sea Research I* 47, 2093-2109.
- Gutzmann, E., Martinez Arbizu, P., Rose, A., Veit-Köhler, G., 2004. Meiofauna communities along an abyssal depth gradient in the Drake Passage. *Deep-Sea Research II* 51, 1617-1628.

- Hayek, L. A. C., Buzas, M.A., 1997. "Thirteen: Diversity Indices." Surveying natural Populations. New York: Columbia University Press, 346-77.
- Henkel, J. R., Sigel, B. J., Taylor, C. M., 2012. Deepwater Horizon Oil Spill: Can local disturbance affect distant ecosystems through migratory shorebirds. *BioScience* 62 (7), 676-685.
- Heron-Allen, E., Earland, A., 1922. Protozoa: Part II-Foraminifera. British Antarctic ("Terra Nova") Expedition. *Zoology* 6 (2), 25-268.
- Heron-Allen, E., Earland, A., 1932. Foraminifera: Part I-The ice-free area of the Falkland Islands and adjacent seas. *Discovery Reports* 4, 291-460.
- Hickman, C. S., Lipps, J. H., 1983. Foraminiferivory: Selective ingestion of Foraminifera and test alterations produced by the neogastropod *Olivella*. *Journal of Foraminiferal Research* 13 (2), 108-114.
- Hill, M. O., 1973. Diversity and evenness: A unifying notation and its consequences. *Ecology* 54 (2), 427-432.
- Höglund, H., 1947. Foraminifera in the Gullmar Fjord and the Skagerak. *Zoologiskag Från Uppsala* 26, 1-328.
- Hurlbert, S. H., 1984. Pseudoreplication and the design of ecological field experiments. *Ecological Monographs* 54 (2), 187-211.
- Ishiwada, Y., 1950. Foraminiferal death assemblages from the mouth of Toyama Bay (Studies on Recent marine sediments-No. 1). *Bulletin of the Geological Survey of Japan* 1 (4), 182-194.

- Jannink, N. T., Zachariasse, W. J., Van der Zwann, G. J., 1998. Living (rose Bengal stained) benthic Foraminifera from the Pakistan continental margin (northern Arabian Sea). *Deep-Sea Research I* 45, 1483-1513.
- Jones, R. W., 1994. *The Challenger Foraminifera*. Oxford University Press, 1-149.
- Jones, T. R., Parker, W. K., 1860. On the Rhizopodal fauna of the Mediterranean, compared with that of the Italian and some other Tertiary deposits. *Quarterly Journal of the Geological Society of London* 16, 292-307.
- Jorissen, F. J., de Stigter, H. C., Widmark, J. G. V., 1995. A conceptual model explaining benthic foraminiferal microhabitats. *Marine Micropaleontology* 26, 3-15.
- Kaesler, R. L., 1966. Quantitative re-evaluation of ecology and distribution of recent foraminifera and ostracoda of Todos Santos bay, Baja California, Mexico. *The University of Kansas Paleontological Contributions* 10, 1-47.
- Kennett, J. P., 1967. New foraminifera from the upper Miocene and lower Pliocene of New Zealand. *New Zealand Journal of Geology and Geophysics* 10, 989-1008.
- Kurbjeweit, F., Schmiedl, G., Schiebel, R., Hemleben, Ch., Pfannkuche, O., Wallmann, K., Schäfer, P., 2000. Distribution, biomass and diversity of benthic foraminifera in relation to sediment geochemistry in the Arabian Sea. *Deep-Sea Research II* 47, 2913-2955.

- Lagoe, M. B., 1979. Recent benthonic foraminiferal biofacies in the Arctic Ocean. *Micropaleontology* 25 (2), 214-224.
- Langer, M. R., Lipps, J. H., Moreno, G., 1995. Predation on Foraminifera by the dentaliid deep-sea scaphopod *Fissidentalium megathyris*. *Deep-Sea Research I* 42 (6), 849-857.
- LeRoy, D. O., Hodgkinson, K. A., 1975. Benthonic foraminifera and some pteropoda from a deep-water dredge sample, northern Gulf of Mexico. *Micropaleontology* 21 (4), 420-447.
- Linné, C., 1758. *Systema Naturae*, vol. 1. L. Salvii, 10th edition, Stockholm.
- Lipps, J. H., 1988. Predation on Foraminifera by Coral Reef Fish: Taphonomic and Evolutionary Implications. *PALAIOS* 3 (3), 315-326.
- Lobegeier, M. K., Sen Gupta, B. K., 2008. Foraminifera of hydrocarbon seeps, Gulf of Mexico. *Journal of Foraminiferal Research* 38 (2), 93-116.
- Loeblich, A. R., Tappan, H., 1955. A revision of some glanduline Nodosariidae (Foraminifera). *Smithsonian Institute, Miscellaneous Collection* 126 (3), 1-9.
- Loeblich, A. R., Tappan, H., 1987. *Foraminiferal genera and their classification*. New York: Van Nostrand Reinhold Co., 212 pp.
- Loeblich, A.T., Tappan, H., 1998. *Foraminiferal genera and their classification*. Van Nostrand Reinhold, New York.
- Long, E. R., Morgan, L. G., 1991. The potential for biological effects of sediment-absorbed contaminants tested in the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 52, US Department of

Commerce, National Oceanographic and Atmospheric Administration,  
Seattle, WA.

- Martínez-Colón, M., Hallock, P., Green-Ruíz, C., 2009. Strategies for using shallow-water benthic foraminifers as bioindicators of potentially toxic elements: A review. *Journal of Foraminiferal Research* 39 (4), 278-99.
- Maync, W., 1952. *Alveolophragmium venezuelanum* new species from the Oligo-Miocene of Venezuela (with discussion of other species of the genus). *Contributions from the Cushman Foundation of Foraminiferal Research* 3, 141-144.
- McCulloch, I., 1977. Qualitative observations on recent foraminiferal tests with emphasis on the eastern Pacific: Parts 1-3. University of Southern California, Los Angeles.
- Mello, J.F., Buzas, M. A., 1968. An application of cluster analysis as a method of determining biofacies. *Journal of Paleontology* 42 (3), 747-758.
- Mendes, I, Alveirinho Dias, J., Schönfeld, J., Ferreira, O., 2012. Distribution of living benthic foraminifera on the northern Gulf of Cadiz continental shelf. *Journal of Foraminiferal Research* 42 (1), 13-38.
- Mojtahid, M., Jorissen, F., Durrieu, J., Galgani, F., Howa, H., Redois, F., Camps, R., 2006. Benthic foraminifera as bio-indicators of drill cutting disposal in tropical east Atlantic out shelf environments. *Marine Micropaleontology* 61, 58-75.

- Mojtahid, M., Jorissen, F., Pearson, T.H., 2008. Comparison of benthic foraminiferal and macrofaunal responses to organic pollution in the Firth of Clyde (Scotland). *Marine Pollution Bulletin* 56, 42-76.
- Montagna, P. A., Baguley, J. G., Cooksey, C., Hartwell, I., Hyde, L. J., Hyland, J. L., Kalke, R. D., Kracker, L. M., Reuscher, M., Rhodes, A. C. E., 2013. Deep-Sea Benthic Footprint of the Deepwater Horizon Blowout. *PLoS ONE* 8 (8): doi:10.1371/journal.pone.0070540
- Montagu, G., 1803. *Testacea Britannica or Natural History of British Shells, Marine, Land and Fresh Water: Including the Most Minute.* J. S. Hollis, England.
- Montagu, G., 1808. *Testacea Britannica: supplement.* S. Woolmer, England.
- Morvan, J., Le Cadre, V., Jorissen, F., Debenay, J. P., 2004. Foraminifera as potential bio-indicators of the “Erika” oil spill in the Bay of Bourgneuf: Field and experimental studies. *Aquatic Living Resources* 17, 317-322.
- Murray, J.W., Bowser, S.S., 2000. Mortality, protoplasm decay rate, and reliability of staining techniques to recognize ‘living’ foraminifera: A review. *Journal of Foraminiferal Research* 30 (1), 66–70.
- Narayan, Y. R., Pandolfi, J. M., 2010. Benthic foraminiferal assemblages from Moreton Bay, south-east Queensland, Australia: Applications in monitoring water and substrate quality in subtropical estuarine environments. *Marine Pollution Bulletin* in press.

- National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011. Deepwater: The gulf oil disaster and the future of offshore drilling. Report to the President, 398 pp.
- Nomaki, H., Heinz, P., Nakatsuka, T., Shimanaga, M., Ohkouchi, N., Ogawa, N. O., Kogure, K., Ikemoto, E., Kitazato, H., 2006. Different ingestion patterns of <sup>13</sup>C-labeled bacteria and algae by deep-sea benthic foraminifera. *Marine Ecology Progress Series* 310, 95-108.
- Nozawa, F., Kitazato, H., Tsuchiya, M., Gooday, A. J., 2006. 'Live' benthic foraminifera at an abyssal site in the equatorial Pacific nodule province: Abundance, diversity and taxonomic composition. *Deep-Sea Research Part I* 53, 1406-1422.
- Operational Science Advisory Team (OSAT), 2010. Summary report for sub-sea and sub-surface oil and dispersant detection: Sampling and monitoring. Unified Area Command, 131 pp.
- Panieri, G., Camerlenghi, A., Cacho, I., Sanchez Cervera, C., Canals, M., Lafuerza, S., Herrera, G., 2012. Tracing seafloor methane emissions with benthic foraminifera: Results from the Ana submarine landslide (Eivissa Channel, Western Mediterranean Sea). *Marine Geology* 291-294, 97–112.
- Parker, F. L., 1954. Distribution of the foraminifera in the northeastern Gulf of Mexico. *Harvard Collection Bulletin: Museum of Comparative Zoology* 111 (10), 453-588.

- Parker, F. L., Phleger, F. B., Peirson, J. F., 1953. Ecology of Foraminifera from San Antonio Bay and Environs, Southwest Texas. Cushman Foundation for Foraminiferal Research, Special Publication 2, 1-75.
- Parker, W. K., 1952. Foraminifera species off Portsmouth, New Hampshire. Bulletin of the Museum of Comparative Zoology at Harvard College 106 (9), 391-423.
- Parker, W. K., 1954. Distribution of the foraminifera in the northeastern Gulf of Mexico. Bulletin of the Museum of Comparative Zoology at Harvard College 111 (10), 453-588.
- Parker, W. K., Jones, T. R., 1865. On some foraminifera from the North Atlantic and Arctic Oceans, including Davis Straights and Baffin's Bay. Philosophical Transactions of the Royal Society 155, 325-441.
- Parker, W. K., Jones, T. R., Brady, H. B., 1865. On the nomenclature of the foraminifera: Part XII-The species enumerated by d'Orbigny in the "Annales des Sciences Naturelles," vo. vii. 1826. Annals and Magazine of Natural History 16, ser. 3, 15-41.
- Parker, W. K., Jones, T. R., Brady, H. B., 1871. XVIII: On the nomenclature of the Foraminifera. The Annals and Magazine of Natural History 8, ser. 4, 145-179.
- Parr, W. J., 1950. Foraminifera. Reports B.A.N.Z. Antarctic Research Expedition 1929-1931 5 (6), ser. B, 232-392.

- Patterson, R. T., Pettis, R. H., 1986. *Galwayella*, a new foraminiferal genus and new names for two foraminiferal homonyms. *Journal of Foraminiferal Research* 16, 74-75.
- Pawlowski, J., 1991. Distribution and taxonomy of some benthic tiny foraminifers from the Bermuda Rise. *Micropaleontology* 37 (2), 163-172.
- Pearson, T. H., Rosenberg, R., 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanography and Marine Biology Annual Review* 16, 229-311.
- Phleger, F. B., Parker, F. L., 1951. Ecology of foraminifera, northwest Gulf of Mexico: Part II - Foraminifera species. *Memoirs of the Geological Society of America* no. 46, pl. 7, figs. 4-6
- Phleger, F. B., Parker, F. L., 1952. New names for northwestern Gulf of Mexico foraminifera. *Contributions from the Cushman Foundation of Foraminiferal Research* 3.
- Phleger, F. B., 1954. Ecology of foraminifera and associated microorganisms from Mississippi Sound and Environs. *Bulletin of the American Association of Petroleum Geologist* 38 (4), 584-647.
- Poag, C. W., 1981. *Ecological Atlas of Benthic Foraminifera of the Gulf of Mexico*. Woods Hole, MA: Marine Science International, 175 pp.
- Polovodova, I., Schönfeld, J., 2008. Foraminiferal test abnormalities in the western Baltic Sea. *Journal of Foraminiferal Research* 38 (4), 318-336.

- Resig, J. M., 1960. "Foraminiferal ecology around ocean outfalls of southern California." *Disposal in the Marine Environment*. Ed. E. Person. London: Pergamon Press, 104-121.
- Reuss, A. E., 1850. Neues Foraminiferen aus den Schichten des österreichischen Tertiärbeckens. *Denkschriften der Kaiserlichen Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche Classe 1*, 365-390.
- Reuss, A. E., 1851. Ueber die fossilen Foraminiferen und Entomostraceen der Septarienthone der Umgegend von Berlin. *Zeitschrift der Deutschen Geologischen Gesellschaft, Berlin 3*, 49-91.
- Reuss, A. E., 1866. Die Foraminiferen und Ostracoden der Kreide am Kanara-See bei Küstendsche. *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften in Wien, Mathematisch-Naturwissenschaftliche Classe (1865) 52 (1)*, 445-470.
- Rhumbler, L., 1931. Über das Schicksal der von der Buchenrindenwollaus (*Cryptococcus fagi* (Bsp.)) befallene Buchen. *Zeitschrift f. Angew. Entomologie 18*, 590-614.
- Rhumbler, L., 1936. Rhizopoden der Kieler Bucht, gesammelt durch A. Remane, II Teil. (*Ammodisculinidae* bis einschl. *Textulinidae*). *Kieler Meeresforschungen 1*, 179-242.
- Roberston, D., 1891. *Trochammina* Bradyi, n. n. *Annals and Magazine of Natural History* 7, ser. 6.

- Robinson, C. A., Bernhard, J. M., Levin, L. A., Mendoza, G. F., Blanks, J. K.,  
2004. Surficial hydrocarbon seep infauna from the Blake Ridge (Atlantic  
Ocean, 2150 m) and the Gulf of Mexico (690–2240 m). *Marine Ecology*  
25 (4), 313-336.
- Rom, C., 2011. Preliminary findings on the benthic biodiversity and abundance  
of macroinvertebrates around the Deepwater Horizon/Macondo well-head  
after the oil spill in 2010. Science and Engineering Apprentice Program,  
Naval Research Laboratory, SSC, MS. Unpublished Report
- Rowe, G. T., Kennicutt II, M. C., 2001. Deepwater Program: Northern Gulf of  
Mexico Continental Slope Habitats and Benthic Ecology Study. Year 1  
Interim Report. OCS Study MMS 2001-xx. U.S. Department of Interior,  
Minerals Management Service, Gulf of Mexico OCS Region, New Orleans,  
L. A., 417 pp.
- Rowe, G.T., Wei, C., Nunnally, C., Haedrich, R., Montagna, P., Baguley, J.,  
Bernhard, J.M., Wicksten, M., Ammons, A., Escobar Briones, E., Soliman,  
Y., Deming, J.W., 2008. Comparative biomass structure and estimated  
carbon flow in food webs in the deep Gulf of Mexico. *Deep-Sea Research*  
II 55, 2699–2711.
- Ryerson, T.B., Camilli, R., Kessler, J. D., Kujawinski, E. B., Reddy, C. M.,  
Valentine, D. L., Atlas, E., Blake, D. R., de Gouw, J., Meinardi, S., Parrish,  
D. D., Peischl, J., Seewald, J. S., Warneke, C., 2012. Chemical data  
quantify Deepwater Horizon hydrocarbon flow rate and environmental  
distribution. *PNAS*, 1-8.

- Rzehak, A., 1886. Ueber Foraminiferen. Verhandlungen des Naturforschenden Vereins in Brünn, Sitzungberichte 24.
- Saffert, H., Thomas, E., 1998. Living Foraminifera and total populations in salt marsh peat cores: Kelsey Marsh (Clinton, CT) and the Great Marshes (Barnstable, MA). *Marine Micropaleontology* 33, 175-202.
- Saidova, K. M., 1975. Benthonic Foraminifera of the Pacific Ocean. Moscow: Akademiya Nauk SSSR, Institut Okeanologii P. P. Shirshova, 290 pp.
- Sarkar, S., Gupta, A. K., 2009. Deep-sea paleoceanography of the Maldives Islands (ODP Hole 716A), equatorial Indian Ocean during MIS 12-6. *Journal of Bioscience* 34 (5), 1-16.
- Schönfeld, J., Alve, E., Geslin, E., Jorissen, F., Korsun, S., Spezzaferri, S., 2012. The FOBIMO (FORaminiferal Blo-MONitoring) initiative—Towards a standardised protocol for soft-bottom benthic foraminiferal monitoring studies. *Marine Micropaleontology* 94-95, 1-13.
- Schröder, C. J., Scott, D. B., Medioli, F. S., 1987. Can smaller benthic foraminifera be ignored in paleoenvironmental analyses? *Journal of Foraminiferal Research* 17 (2), 101-105.
- Schröder-Adams, C. J., Van Rooyen, D., 2011. Response of recent benthic foraminiferal assemblages to contrasting environments in Baffin Bay and the northern Labrador Sea, northwest Atlantic. *Artic* 64 (3), 317-341.
- Schwager, C., 1866. Fossile Foraminiferen von Kar Nikobar, Reise der österreichischen Fregatte Novara um Erde in den Jahren 1857, 1858, 1859

- unter den Befehlen des Commodore B. Von Willerstorff-Urbair,  
Geologischer Theil 2 (1), Geologische Beobachtungen (2), 187-268.
- Schwager, C., 1878. Nota su alcuni foraminiferi nuovi del tufo di Stretto presso  
Girgeni. R. Com. Geol. Italy 9, 18-27.
- Scott, D. B., and Hermelin, J. O. R., 1993. A device for precision splitting of  
micropaleontological samples in liquid suspension. Journal of  
Paleontology 67 (1), 151-54.
- Scott, D. B., Schell, T., Rochon, A., Blasco, S., 2008. Modern benthic  
foraminifera in the surface sediments of the Beaufort shelf, slope and  
Mackenzie trough, Beaufort Sea, Canada: Taxonomy and summary of  
surficial distributions. Journal of Foraminiferal Research 38 (3), 228-250.
- Seguenza, G., 1862. Dei terreni Terziarii del distretto di Messina; Parte II -  
Descrizione dei foraminiferi monotalamici delle marne mioceniche del  
distretto di Messina. Messina, Italia, T. Capra, 59 pp.
- Sen Gupta, B. K., Lobegeier, M. K., Smith, L. E., 2009. Foraminiferal  
communities of bathyal hydrocarbon seeps, northern Gulf of Mexico: A  
Taxonomic, Ecologic, and Geologic Study. U.S. Dept. of the Interior,  
Minerals Management Service, Gulf of Mexico OCS Region, New Orleans,  
LA. OCS Study MMS 2009-013, 385
- Shannon, C. E., 1948. A mathematical theory of communication. Bell System  
Technical Journal 27, 379-423; 623-656.
- Silvestri, A., 1896. Foraminiferi pliocenici della Provincia di Siena: Parte I.  
Accad. Pont. Nuovi Lincei 12.

- Silvestri, A., 1923. Microfauna pliocenica a rizopodi reticolari di Capocolle presso Forli. Atii della Pontificia Accademia della Scienza, Nuovi Lincei, Roma (1922-1923) 76, 70-77.
- Simpson, E. H., 1949. Measurement of Diversity. Nature 163, 688.
- Soldani, A., 1789. Testaceographiae ac Zoophytographiae parvae et microscopicae. Tomus Primus. Senis: Rossi.
- Stewart, R. E., Stewart, K. C., 1930. Post-Miocene foraminifera from the Ventura Quadrangle, Ventura County, California. Journal of Paleontology 4 (1).
- Trauth, F., 1918. Das Eozänvorkommen bei Radstadt im Pongau und seine Beziehungen zu den gleichalterigen Ablagerungen bei Kirchberg am Wechsel und Wimpassing am Leithagebirge. DenKschriften der Kaiserlichen Akademie der Wissenschaften Wien, Mathematisch-Naturwissenschaftliche Classe 95, 171-278.
- Wade, T. L., Soliman, Y., Sweet, S. T., Wolff, G. A., Presley, B. J., 2008. Trace elements and polycyclic aromatic hydrocarbons (PAHs) concentrations in deep Gulf of Mexico sediments. Deep-Sea Research II 55, 2585-93.
- Walton, W. R., 1952. Techniques for recognition of living foraminifera. Contributions from the Cushman Foundation for Foraminiferal Research 3 (1), 56-60.
- Wickenden, R. T. D., 1932. New species of foraminifera from the Upper Cretaceous of the Prairie provinces. Transactions of the Royal Society of Canada 26 (4), ser. 3, 85-91.

Williamson, W. C., 1848. On the Recent British species of the genus *Lagena*.

Annals and Magazine of Natural History 1, ser. 2, 1-20.

Williamson, W. C., 1858. On the Recent foraminifera of Great Britain. Ray

Society, London.

Wright, J., 1891. Report on the foraminifera obtained off the south-west of

Ireland during the cruise of the "Flying Falcon," 1888. Roy. Irish Academy

1 (4), ser. 3.

Yanko, V., Arnold, A.J., Parker, W. C., 1999. "Effects of marine pollution on

benthic Foraminifera." Modern Foraminifera. Ed. Barun K. Sen Gupta.

Great Britain: Kluwer Academic Publishers, 217-235.