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A Hurricane Record of Jekyll Island, Georgia

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A HURRICANE RECORD OF JEKYLL ISLAND, GEORGIA

by

DANIEL MCCARTHA

Under the Direction of Dr. Lawrence Kiage

ABSTRACT

Jekyll Island, Georgia is located within the Georgia Bight, on the Atlantic coast of the United State. In recent history, the Georgia Bight has been less frequently hit by hurricanes compared to other areas along the Atlantic coast. To determine if Jekyll Island has had a more active hurricane past, a paleohurricane record was obtained from the northern tip of the island, within Waterfall Marsh. A 500 year old hurricane record was inferred from the sediment layers obtained from the marsh. In core JE-4, a sandy shell layer containing nearshore foraminifera was observed, providing evidence of a hurricane event. A radiocarbon date of 406 a BP was obtained for the sandy shell layer, providing a minimum age for the hurricane event. A hurricane return interval of one major hurricane per 500 years was also determined for the study area.

INDEX WORDS: Paleotempestology, Hurricanes, Jekyll Island, Georgia Coast

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by

DANIEL MCCARTHA

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of

Masters of Science

in the College of Arts and Sciences

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2013

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2013

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December 2013

DEDICATION

I'd like to dedicate my thesis to my mother and father, June and Larry McCartha. It would have not been possible for me to make it through college and graduate school without their support and encouragement.

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS		v
LIST OF TABLES		3
LIST OF FIGURES		4
1 INTRODUCTION		5
1.1 Purpose of the Study		10
1.2 Study Area		10
1.3 Historical Hurricanes within Proximity of the Study Area		12
1.4 Geology of the Study Area		13
2 METHODS		15
2.1 Fieldwork and Sample Collection		15
2.2 Sample Preparation		17
2.2.1 Loss on Ignition Analyses		17
2.2.2 X-Ray Fluorescence (XRF) analysis		19
2.2.3 Foraminifera Identification		19
2.2.4 Radiocarbon Dating		20
3 RESULTS		21
3.1 Stratigraphy, Loss on Ignition, and X-Ray Fluorescence		21
3.1.1 Loss on Ignition and X-Ray Fluorescence of Core JE-3		23
3.1.2 Loss on Ignition, X-Ray Fluorescence, and Radio Carbon Dates of Core JE-4		27
3.1.3 Loss on Ignition and X-Ray Fluorescence of Core JE-5		31

3.2	Foraminifera Analysis	34
3.2.1	Foraminifera Analysis of Core JE-3	36
3.2.2	Foraminifera Analysis of Core JE-4	38
4	DISCUSSION.....	40
5	CONCLUSION	47
6	FUTURE STUDIES.....	48
7	REFERENCES	50

LIST OF TABLES

Table 1. Radiocarbon dates of core JE-3.	25
Table 2. Radiocarbon dates of core JE-4.	29

LIST OF FIGURES

Figure 1. Creation of an overwash fan.....	6
Figure 2. A map of Georgia showing the location of the study area, Jekyll Island.	11
Figure 3. Image of Waterfall Marsh, Jekyll Island, GA.	11
Figure 4. Hurricane paths within proximity of Jekyll Island, Georgia	13
Figure 5. Erosion at Driftwood Beach, on Jekyll Island.	14
Figure 6. Transect showing the locations of cores JE-3, JE-4, and JE-5 within the study area	16
Figure 7. Image of a Livingstone corer being used in the field (Left), and a Russian Peat core taken in the field (Right).	17
Figure 8. Splitting cores using a table saw.	19
Figure 9. Stratigraphic correlation of cores JE-3, JE-4, and JE-5.	22
Figure 10. Photographic log, loss on ignition (LOI), chemostratigraphy, and radiocarbon dates of core JE-3.....	26
Figure 11. Photographic log, loss on ignition (LOI), chemostratigraphy, and radiocarbon dates of core JE-4.	30
Figure 12. Photographic log, loss on ignition, and chemostratigraphy of core JE-5.	33
Figure 13. Images of near shore foraminifera found within Core JE-4.	34
Figure 14. Images of lagoonal foraminifera found within cores JE-3 and JE-4.	35
Figure 15. Foraminifera assemblage of core JE-3.	37
Figure 16. Foraminifera assemblage of core JE-4.	39
Figure 17. Suggested future transects within Waterfall Marsh.	49

1 INTRODUCTION

Paleotempestology is a relatively new science coined in the 1990s focusing on the study of past hurricanes and other storm events. Paleotempestology utilizes proxy techniques to create paleohurricane records that extend from hundreds to thousands of years ago (DaiDu and Kam-biu, 2008). As the most frequent of all natural disasters, hurricanes, also referred to as typhoons, cause the largest amount of loss of insured property and death worldwide (Cheung, *et al.*, 2007). It has been suggested that there could be an increase in the frequency and the destructiveness of hurricanes resulting in the loss of life and property due to an increase in the population living along the coast and erratic climate mechanisms associated with climate change (Kiage, *et al.*, 2011). To help mitigate the issues of loss of life and property due to hurricanes, paleohurricane records are collected.

By obtaining paleohurricane records it is possible for a return interval to be calculated for major hurricanes. A return interval can be calculated by dividing the number of hurricanes by a chronos-stratigraphic unit (DaiDu and Kam-biu, 2008). The return interval is useful for creating models that delineate the risk of hurricanes, “emergency management, planning and zoning, and insurance under-writing” (Kiage, *et al.*, 2011). In order for these models to be created, paleohurricane data must be collected and deciphered through the use of proxies, such as overwash layers, chemostratigraphy, and microfossils. To create the hurricane return interval dating must be performed on stratigraphic material.

When a barrier island is struck by a hurricane of category three or higher (on the Saffir-Simpson scale), the storm surge will go over sand dunes, transporting sediment to the back barriers island and depositing the sediment. This movement of sediment creates an overwash

layer. It should be noted that an overwash layer typically is created when a storm surge exceeds the height of the sand dunes (Liu and Fearn, 2000). When the storm surge exceeds the height of the sand dunes a breach will form, allowing for the transport of sand and water into a marsh, figure 1. However, sand can also be brought into marshes by tidal processes. Tides can transport sand into marshes via tidal creeks, leaving behind deposits of sand (Nolan, Kelsey, and Marron, 1995). Sand layers created by tidal processes makes identifying overwash layers complex, requiring multiple analyses to be performed to accurately identify overwash layers.

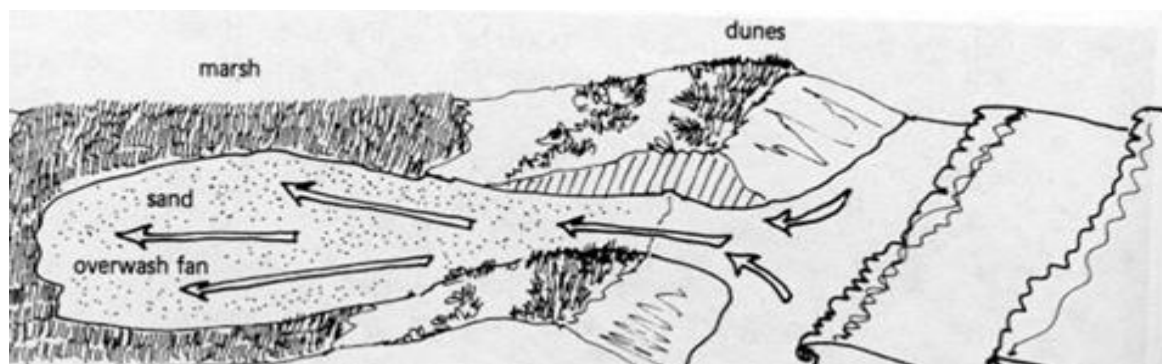


Figure 1. Creation of an overwash fan.

This figure illustrates that once the storm surge exceeds the height of the dunes, a breach will occur. The breach will allow for the movement of sand and water from the beach face. This image was obtained and modified from Gibson, 2013.

Typically the sand in an overwash is thicker towards the beach, and progressively decreases in thickness as the overwash goes inland (Liu and Fearn, 2000). The thickness and the extent of the overwash layers are controlled by multiple factors. These factors include the abundance of sand supply, hurricane intensity, tidal height, height of storm surge, and angle of hurricane landfall (Boldt *et al.*, 2010; woodruff *et al.*, 2008b; Kiage *et al.*, 2011). Furthermore, when a hurricane is in the northern hemisphere, the storm surge is usually highest in the right front quadrant due to rotational winds and translational speed causing an increase in water levels (Wood-

ruff *et al.*, 2008). While stronger storms can create larger and thicker sediment layers, the deposition of the sediment depends on the height and width of the beach at the barrier island (Donnelly, *et al.*, 2001). It would be expected that barrier islands with higher and wider beaches would be less susceptible to overwash than barrier islands with narrower and shorter beaches. Also, barrier islands with taller dunes are also less susceptible to overwash (Donnelly, *et al.*, 2001).

To obtain overwash data, cores must be taken, usually in a marsh or a lake. After the core is obtained, loss on ignition (LOI) will be performed to identify sand layers. Sand layers deposited in a marsh or a lake will accumulate organic sediment that will overlay the transported sand. Sand in between the organic layers marks a paleohurricane event (Boldt, *et al.*, 2010). It should be noted that not every hurricane event can be accounted for due to undercounting. Undercounting of paleohurricane events occurs when multiple hurricane events are counted as one. If hurricanes occur close enough in time, organic matter will not be laid down in between events, causing multiple events to appear as one (Woodruff, *et al.*, 2008).

The organic layers not only mark the paleohurricane boundaries, but they also are useful in dating the time that a paleohurricane event took place. Organic layers that lie above the overwash deposits can be radiocarbon-dated, giving a minimum age of the hurricane event. Over time, the amount of carbon fourteen has changed requiring that “radiocarbon ages be calibrated to calendar years when interpreting paleoenvironmental records” (Donnelly, *et al.*, 2001). Radiocarbon dates can be calibrated using a program from the University of Washington called CALIB (Kiage *et al.*, 2011). It should also be noted that radiocarbon dating can have an uncer-

tainty, due to a relationship between radiocarbon and calendar times that have a nonlinear relationship (Donnelly, *et al.*, 2001).

The concentrations of chlorine, sulfur, titanium, and iron can give clues as to the origins of sediment. This information can then be used to help identify paleohurricane events. Using a portable X-ray Fluorescence (XRF), the concentrations of chlorine and titanium can be measured from a core. Chlorine and sulfur are marine indicators, while titanium and iron are terrestrial metals (McCloskey and Liu, 2012). Concentrations of chlorine and sulfur are used as proxies for processes associated with hurricanes. High concentrations of chlorine and sulfur are typically found in seawater. In seawater, chlorine is associated with sodium chloride (NaCl), and sulfur is typically found as sulfate (SO₄) (Poisson and Papaud, 1983). Typically, seawater has a chlorine concentration of 35,000 ppm (Moser *et al.*, 2011), and a sulfate concentration of 28,000 ppm (Jamieson *et al.*, 2012). When concentrations of chlorine and sulfur match or exceed typical seawater concentrations, they may provide evidence of a paleohurricane event. As stated earlier, when a hurricane strikes the coast, seawater is pushed inland, creating an overwash layer. Once the seawater has retreated or evaporated, chlorine and sulfur will be left behind, marking the paleohurricane event. Chlorine concentrations in marshes along the Georgia coast, however; typically do not exceed 17,000 ppm (Moser *et al.*, 2011). Chlorine in marshes is also associated with the presence of sodium chloride. Sulfur is present in marshes in various forms such hydrogen sulfide (H₂S) (Holland and Turekian, 2011) and pyrite (FeS₂) (Roychoudhurya, Kostkab, and Cappellenc, 2003). Sulfur concentration in marshes is variable, due to the various forms of sulfur found within marsh environments. Meyer (2013) observed that sulfur concentrations in marshes on St. Catherines Island, Georgia had varying concentrations

ranging from 2,000 ppm to 32,000 ppm. Unlike chlorine and sulfur, titanium and iron are associated with terrestrial sediment (McCloskey and Liu, 2012). Meyer (2013) observed that overwash fans have higher concentrations of titanium than marsh sediments; however, iron concentrations are higher in marsh sediments than overwash layers. The larger titanium concentration within overwash layers may be attributed to heavy minerals being washed over from the beach face, such as ilmenite (FeTiO_3) and rutile (TiO_2) (Force, 1976). Higher iron concentrations observed in marsh sediments may be attributed to deposition of terrestrial sediment. Because marshes are reducing environments, iron within marshes is reduced to pyrite (FeS_2) and iron oxyhydroxide (variable compound) (Luther *et al.*, 1982). Meyer (2013) observed that iron concentrations ranged from a few thousand to 136,000 ppm within marshes on Saint Catherines Island. An overwash layer examined by Meyer (2013) contained sulfur concentrations ranging from a few thousand ppm to more than 20,000 ppm, titanium concentrations ranged from a few thousand to more than 10,000 ppm, and iron concentrations ranged from around 2,000 to 7,000 ppm.

To provide more confidence that an overwash layer corresponds to a paleohurricane event, microfossil are often analyzed. Foraminifera are found in lacustrine, nearshore, backbarrier, and marine environments. In lacustrine, nearshore, and backbarrier environments, foraminifera are not commonly found in great abundance or diversity (DaiDu and Kam-biu, 2008). However; hurricane events can create storm surges that bring marine foraminifera onshore, adding to the variety and profusion of foraminifera. The presence of foraminifera in large diversity and abundance in lacustrine, nearshore, or backbarrier environments is used as an indicator of hurricane events (DaiDu and Kam-biu, 2008).

By performing LOI, XRF, and foraminifera analysis on cores collected from Jekyll Island, Georgia, it will be possible to identify overwash layers created by hurricanes. Once overwash layers are identified, organic material will be collected right above the overwash layers. The organic material will then be radio carbon dated, providing a minimum age of the hurricane event. From the radio carbon dates, a paleohurricane record and a return interval can be created for Jekyll Island, Georgia.

1.1 Purpose of the Study

Currently there are a limited number of paleohurricane records for the Atlantic coast of the United States. While there are few paleohurricane records for the Atlantic coast of the U.S., the majority of the records have been collected in areas that have been frequented by hurricane activity, such as Florida and the coast of New England. While the coasts of New England and Florida are susceptible to hurricane strikes, the Georgia coast is not. The Georgia coast is less frequently struck by hurricanes, due to the curved shape of the coast which makes a direct hurricane strike more difficult (Pavey, 2006). By conducting the study, it was possible to fill in some of the missing gaps in the paleohurricane record of the Southeastern coast of the United States.

1.2 Study Area

The study area is located on the northern tip of Jekyll Island, Georgia, within Waterfall Marsh. The coordinates of the exact location of the study area is 31.1189°N, 81.41071°W. The location of the study area can be seen in figure 2, and a photograph of the study area within Waterfall Marsh can be seen in figure 3.

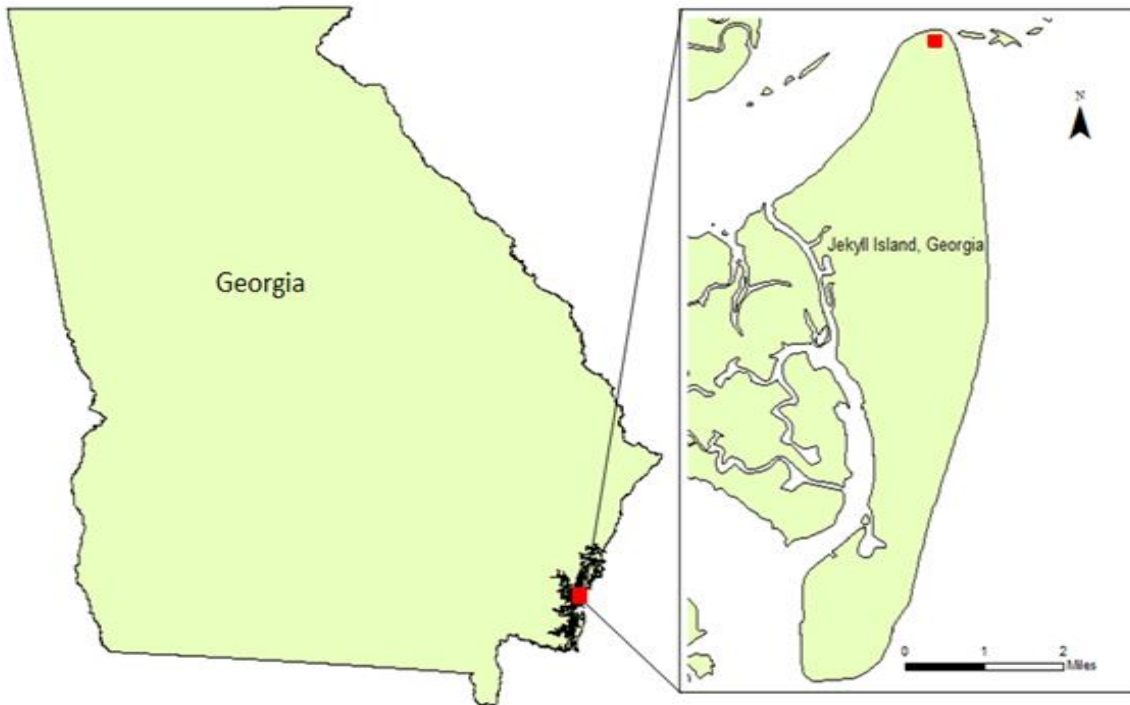


Figure 2. A map of Georgia showing the location of the study area, Jekyll Island. The red square identifies the location of the core sites within the study area.



Figure 3. Image of Waterfall Marsh, Jekyll Island, GA.

1.3 Historical Hurricanes within Proximity of the Study Area

Using hurricane data from The North Atlantic hurricane database (HURDAT), it was possible to identify hurricanes that had struck the coast within 60 nautical miles of Jekyll Island, Georgia from 1850 through 2013. Hurricanes that were of category three through five were focused on since these hurricanes would have had the capability of creating overwash layers. In the late 1800's, there were four unnamed category three hurricanes, and one unnamed category four hurricane. The category three hurricanes occurred in 1854, 1885, 1893, and 1896, and the category four hurricane occurred in 1898. None of these hurricanes made direct landfall on Jekyll Island, the paths of these hurricanes can be seen in figure 4. Also, it should be noted that since the late 1800's, there has not been a hurricane within 60 nautical miles of Jekyll Island that was of category three or higher.

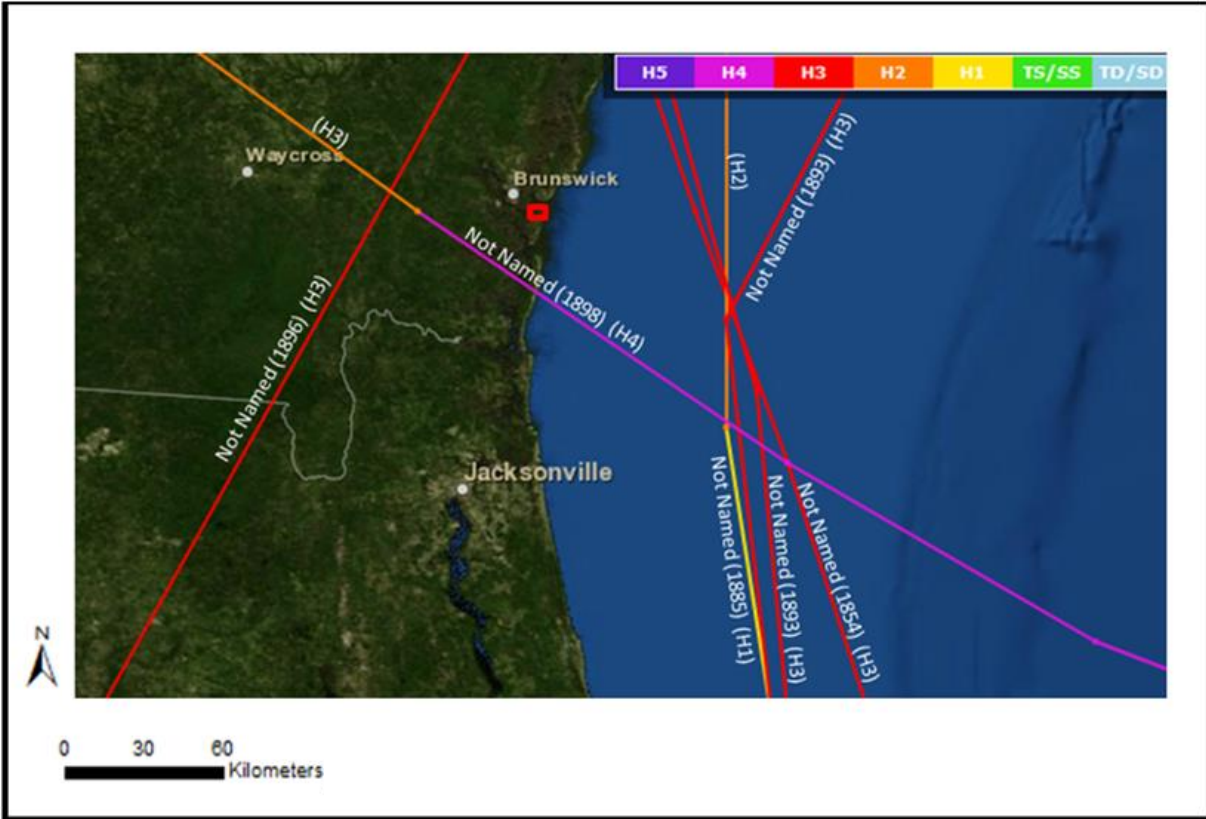


Figure 4. Hurricane paths within proximity of Jekyll Island, Georgia

This figure illustrates the paths taken by hurricanes that were within 60 nautical miles of Jekyll Island, Georgia. Hurricanes that had were of category three through five are shown. The study area is marked with a red rectangle. Source: The North Atlantic hurricane database (HURDAT), Data 2013.

1.4 Geology of the Study Area

Jekyll Island is a Pleistocene barrier island that was formed between 110,000 and 25,000 years before present (BP) (Howard, Depratrer, and Frey, 1980). Within the last 4000 to 5000 years, the amount of time it approximately took for sea level to reach its current position, Jekyll Island has gained a Holocene margin (Howard, Depratrer, and Frey, 1980).

Along the beaches of Jekyll Island there are depositional and erosional features; however, overall the coast is eroding. An example of erosion on Jekyll Island can be seen in figure 5, this figure illustrates the erosion taking place at Driftwood Beach. Driftwood Beach is located on the northern tip of Jekyll Island, and is directly seaward of the study area. The erosion is taking place due to increasing sea levels. Currently sea level is rising approximately two mm/year within the Georgia Bight (Howard, Depratrer, and Frey, 1980; Hicks, Debaugh, and Hickman, 1983). While erosion is taking place on Jekyll Island, it is spatially variable. Jekyll Island is eroding on the northern end of the island, and accreting sediment on the southern end.



Figure 5. Erosion at Driftwood Beach, on Jekyll Island.

2 METHODS

To create a paleohurricane record of Jekyll Island, fieldwork and lab analyses had to be performed. The lab analyses included LOI, X-ray Fluorescence (XRF), foraminifera identification, and radiocarbon dating.

2.1 Fieldwork and Sample Collection

The field work was carried out in June of 2012, on Jekyll Island, Georgia. In order to obtain a paleohurricane record, cores were taken. Two tidal creeks exist within Waterfall Marsh; cores were taken at least fifteen meters away from the creeks to avoid coring tidal deposits. Cores were taken along a transect starting in the marsh approximately 30 meters (m) away from the sand dunes and extending into the marsh approximately 195 meters from the dunes. It was chosen to start collecting cores 30 meters from the sand dunes because the corers that were used for this study would not penetrate the sediment at locations closer to the dunes. The closest core to the sand dunes was JE-3, and the furthest core taken from the beach was JE-5. A transect showing the locations where cores JE-3 through JE-5 were taken can be viewed in figure 6. The depth to which cores JE-3, JE-4, and JE-5 were collected was 126 cm, 96 cm, and 63 cm respectively.

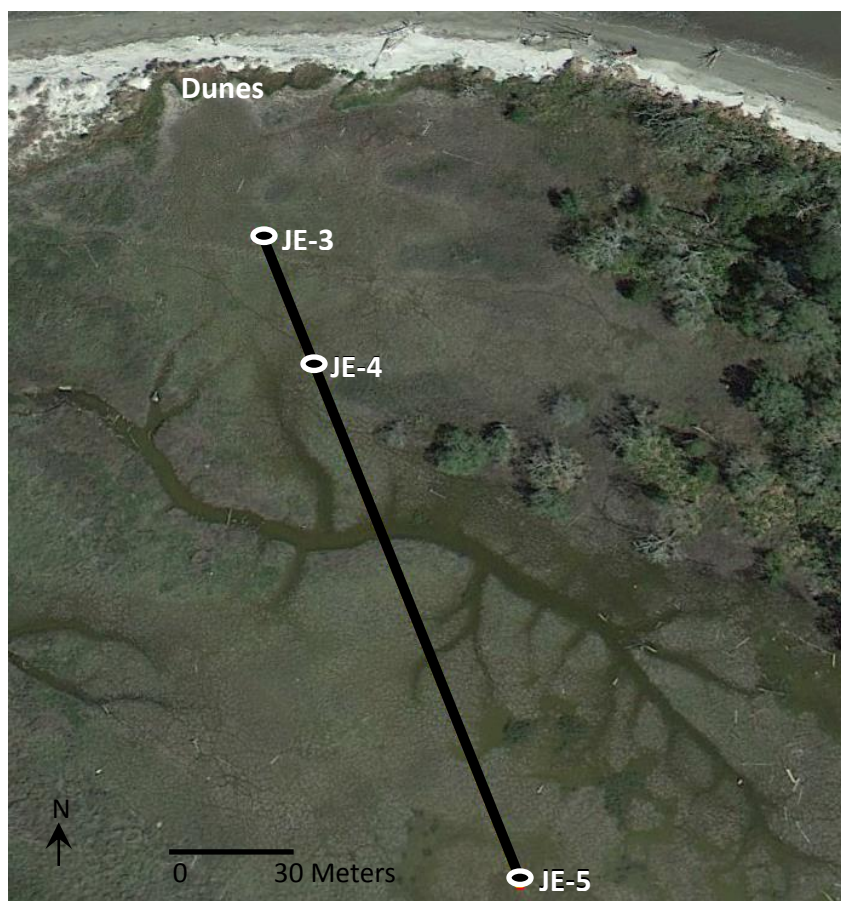


Figure 6. Transect showing the locations of cores JE-3, JE-4, and JE-5 within the study area.
Image taken from Google Earth, November, 05 2013, and manipulated.

In total, seven cores were taken within the study area; more cores would have been taken if time had permitted. The coring methods used in this study were Livingstone coring, Bolivia coring, and Russian Peat coring. Two Livingstone, one Bolivia core, and four Russian Peat cores were taken. The Russian peat cores were collected in two locations within the study area, with two cores being collected at each location, at sequential depths. The Livingstone and the Bolivia corers are both types of piston corers. Both the Livingstone and Bolivia corers collect 1.5 meter long cores within a transparent polycarbonate tube attached to a stainless steel cutting shoe (Kiage, et al., 2011). Use of the Livingstone corer in the field can be seen in figure 7. The Russian Peat corer is a semi-cylindrical side chambered “shuttle type sampler” that collects 50-

cm hemispherical cores (Franzen and Ljung 2009). A photograph of a Russian Peat core taken in the field can be seen in figure 7. Once the cores were taken, each was labeled, photographed, and measured in the field. Afterwards, the cores were sealed and transported to the Geoscience laboratories at Georgia State University for analyses.

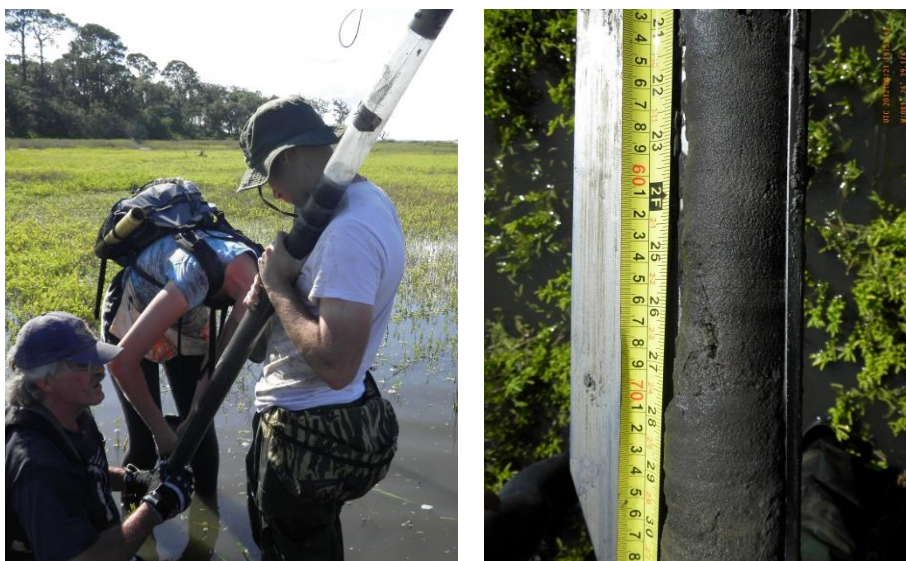


Figure 7. Image of a Livingstone corer being used in the field (Left), and a Russian Peat core taken in the field (Right).

2.2 Sample Preparation

At Georgia State University, Department of Geosciences, the laboratory analyses included Loss on Ignition (LOI), XRF, and foraminifera identification. Samples for AMS radiocarbon dating were sent to Beta Analytic in Miami, Florida, and Direct AMS in Seattle, Washington.

2.2.1 Loss on Ignition Analyses

To perform LOI, the polycarbonate core tubes were first split open using a table saw in order to view the sediment (figure 8). The cores were then sampled at 1-cm intervals. Each sample was weighed immediately after being taken from the core using a digital scale. After each sample was weighed, the samples were placed in a drying oven for twenty-four hours at a

temperature of 105°C to remove moisture from the samples. The samples were then heated at temperatures of 550°C and at 1000°C, for one hour at each temperature to remove organic and carbonate material, respectively (Boyle, 2004; Heiri et al., 2001; Dean, 1974; and Liu and Fearn, 2000). The samples were weighed before and after heating the samples at 105°C, 550°C, and at 1000°C to determine the water, organic, and carbonate weight percentages respectively (Kiage et al., 2011). However; structural water may be lost from clay minerals, such as smectite, illite, and kaolinite, inducing error in the LOI procedure at temperatures ranging from 450°C to 550°C (Sun, *et al.*, 2009). Illite, smectite, and kaolinite clay minerals are typical of marsh environments, in a study by Freile *et al.*, (2004) it was observed that a marsh on Skidaway Island Georgia contained these clay minerals. This suggests that the study area may also contain illite, smectite, and kaolinite, and that the structural water loss should be taken into consideration when determining the weight percentage of water when performing the LOI analysis. However; Sun, et al., (2009) observed that structural water represents a small portion of the soil mass, ranging from 0.56% to 2.45% weight percent, indicating that the error margin associated with structural water loss is small.



Figure 8. Splitting cores using a table saw.

2.2.2 X-Ray Fluorescence (XRF) analysis

Samples were analyzed in situ within the cores at 5cm intervals using a portable Innov-X alpha-4000 energy-dispersive X-ray fluorescence spectrometer. Each sample was analyzed for chlorine, sulfur, titanium, and iron concentrations.

2.2.3 Foraminifera Identification

To further determine whether noticeable sand layers were overwash layers from a hurricane, marine microfossils were analyzed. A small sample was taken at 5cm intervals to be analyzed for foraminifera abundance and diversity. Each sample that was taken contained approximately 1cm³ of sediment (Dalman and Park, 2011, Forester, 1990, Hippenstell, 2011). After the samples were obtained, they were wet sieved through a 500- μ m sieve in order to remove coarse grained organic matter. The samples were then wet sieved through a 63- μ m sieve to capture the microfossils (Scott *et al.*, 2003). Following the sieving process, the fraction between

63- μm and 500- μm was left to dry at room temperature (Saffert and Thomas, 1998, Grand Pre, *etal.*, 2011). Following the drying process, the sediment was viewed under a dissecting microscope with 20-40X to determine the abundance and diversity of microfossils (Scott, *etal.* 2003). Foraminifera were then picked up with a fine tipped brush, and placed on microfossil slides. When it was possible, at least 100 foraminifera were picked up and identified. In previous studies it has been observed that this is a large enough sample size to provide meaningful results (Culver and Horton, 2005, Saffert and Thomas, 1998, Grand Pre, *etal.*, 2011, Cronin, *etal.*, 2000, Karlsen, *etal.*, 2000). The foraminifera that were placed on the microfossils slides were later identified, counted, and, photographed.

2.2.4 Radiocarbon Dating

After foraminifera identification had taken place, the next step was to establish the chronology of paleohurricane events in order to create a paleohurricane record. To create a paleohurricane record, organic material was taken from the marsh layers directly above sand layers that were presumed to be overwash layers (Kiage, *et al.*, 2011). Organic material was collected from cores JE-3 and JE-4 for radio-carbon dating. Radiocarbon dating analysis was performed by Beta Analytic and Direct AMS. Before radiocarbon dating could be performed, Beta Analytic and Direct AMS both first acid washed the organic material, and afterwards an Accelerator Mass Spectrometer (AMS) was used to perform radiocarbon dating. Beta Analytic reported the radiocarbon dates in conventional years and Direct AMS reported the dates in uncalibrated years. To calibrate the radiocarbon dates produced by Direct AMS, the program CALIB 7.0 was used. For radiocarbon dates that were younger than 350 BP, the UW single year98 setting was used. This setting was chosen because it provides the highest time resolution comparisons when the un-

calibrated date is younger than 350 BP (Stuiver, Reimer, Reimer, 2005). The mixed marine setting was used for radiocarbon dates that were older than 350 BP. This setting was chosen because the sediment was obtained from a marsh, which is neither completely terrestrial nor marine. The calibrated dates were then chosen based on the two sigma ranges generated by CALIB 7.0. The two sigma range that had the highest accuracy was chosen as the radiocarbon date.

3 RESULTS

3.1 Stratigraphy, Loss on Ignition, and X-Ray Fluorescence

After the cores were split open, the stratigraphy and sedimentary structures of each core was documented. The type and thickness of each lithology was documented for cores JE-3, JE-4, and JE-5. It was noticed that five lithologies existed within these cores. The five lithologies are clay, sandy clay, clayey sand, sand, and a sandy shell layer. To make a correlation between the stratigraphies of cores JE-3, JE-4, and JE-5, a stratigraphic correlation was created (figure 9). It was also observed that sedimentary structures were not present within any of the cores.

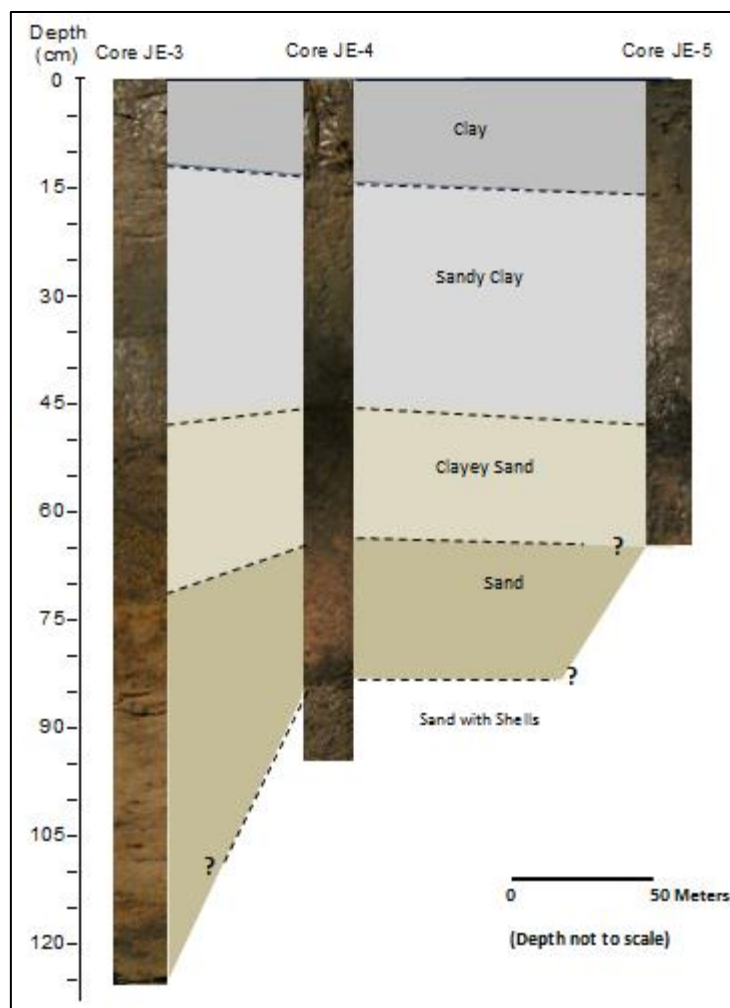


Figure 9. Stratigraphic correlation of cores JE-3, JE-4, and JE-5.

Scale bar shows the distance between cores, the depth is not to scale.

After the stratigraphy was documented, LOI and XRF analyses were performed on cores JE-3, JE-4, and JE-5. Following the LOI and XRF analyses graphs were created to show the results of each. The LOI results show the weight percent of water, organics, and carbonates present within the cores. From the XRF analysis, the chemostratigraphy was determined for the cores. The chemostratigraphy shows the concentrations of chloride, sulfur, titanium, and iron in parts per million (ppm). The concentrations for each of the elements were scaled down by a thou-

sand to make the trends within the data more apparent. Photo logs were also added to the graphs to show the change in stratigraphy with depth.

3.1.1 *Loss on Ignition and X-Ray Fluorescence of Core JE-3*

Core JE-3 was collected 46 m away from the sand dunes using a modified Livingstone corer. The core measures 125 cm in length, and is composed of four lithologies. The four lithologies within the core are clay, sandy clay, clayey sand, and sand. From a depth of 0 to 14 cm, the sediment is predominantly clay, the sediment then transitions to sandy clay. The sandy clay layer is located from 14 to 46cm. The sandy clay layer is followed by a layer of clayey sand; the clayey sand layer is from 46 to 63 cm. At the bottom of the core, from 63 to 125 cm, the sediment transitions to sand (figure 9).

The stratigraphy recorded in the photo log of core JE-3helped to reinforce what was observed in the loss on ignition results. It was noticed that the weight percent of water in core JE-3 was 50% from 0 to 50 centimeters, where clay sediments dominate. However, from 50 to 125 centimeters, where sand is the dominant sediment, the weight percent of water decreases to 20%. Organic material and carbonates are also more prevalent in areas of the core where clay is the primary sediment. Organic material had weight percentages of 7% from 0 to 50 cm, and 2% from 50 to 125 cm. Carbonate material had weight percentages of 4% from 0 to 50 cm, and 1% from 50 to 125 cm. Along with the noticed trends, there were also peaks within the water, organic, and carbonate curves. It was observed that there were peaks at 60 cm and 120 cm in the water curve, where weight percent of water increased to 35%. A peak at 120 cm in the organic curve was observed, in which the weight percent of organic material increased to 5%.

Peaks were also observed in the carbonate curve from 85 to 95 cm, the weight percent ranged from 2.5 to 5%. The LOI of core JE-3 can be seen in figure 10.

The chemostratigraphic graph of core JE-3 revealed trends within the chlorine, sulfur, titanium, and iron curves. It was identified that the concentrations of chlorine, titanium, and iron decreased with increasing depth, and sulfur increased with increasing depth. It was observed that the highest concentrations of chlorine were from 20 to 55 cm, with concentrations of approximately 23,000 parts per million (ppm), and the lowest chlorine concentrations present were from 85 to 105 cm, with an average concentration of 11,000 ppm. Overall, it appeared that the chlorine concentration had decreased with depth. Also of interest are the spikes in concentration at 110 cm and 120 cm within the chlorine curve, where concentrations reached 15,000 ppm. While a trend could be determined for the chloride curve, the sulfur curve did not appear to follow a trend. Upon investigating the sulfur curve, it was identified that sulfur concentrations were very high from 40 to 50 cm and from 70 to 80 cm. The concentrations were approximately 45,000 ppm at both 40 and 50 cm, and concentrations were approximately 35,000 ppm at 70 and 80 cm. While a trend could not be determined from the chlorine or the sulfur curve, it was noticed that both titanium and iron follow a trend. Titanium and iron both had the highest concentrations from 0 to 50 cm, the areas of the core that contain mostly clay. Titanium had concentrations of 2,500 ppm, and iron had concentrations of 18,000 ppm within the clay layer. Also of note are the increased iron concentrations at 75 and 115 cm, here the concentrations of iron reached 11,000 ppm (figure 10).

Two AMS radiocarbon dates were obtained from core JE-3 at depths of 53 and 121 cm. A radiocarbon date of 510 ± 30 calibrated years BP was obtained at 53 cm, and a radiocarbon

date of 2743 ± 30 calibrated years BP was obtained at 121 cm. Both dates are in conventional radiocarbon years before present (BP). The radiocarbon dating results for core JE-3 can be viewed in Table 1. Radiocarbon dates were also added to the photo log, LOI, and chemostratigraphic graphs of core JE-3, figure 10.

Table 1. Radiocarbon dates of core JE-3.

Laboratory number	Core	Sample depth (cm)	Conventional ^{14}C age (a BP)
Beta-344925	JE-3	53	510 ± 30
DAMS-003590	JE-3	121	2743 ± 30

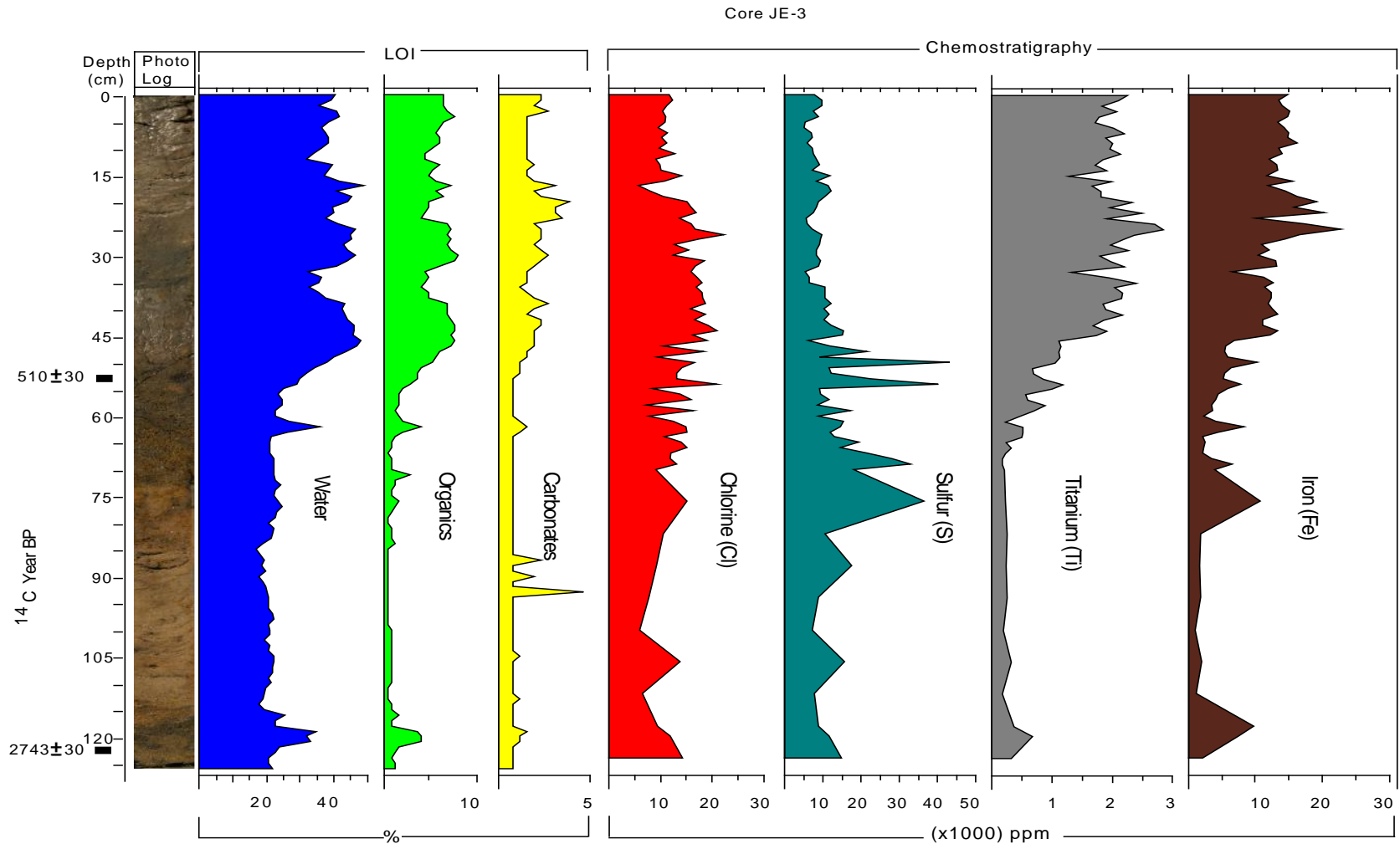


Figure 10. Photographic log, loss on ignition (LOI), chemostratigraphy, and radiocarbon dates of core JE-3.

The photographic log shows the changes in stratigraphy, the LOI curves show weight percent water, organics, and carbonates. The chemostratigraphy shows concentrations of chloride, sulfur, titanium, and iron in parts per million (ppm). Concentrations of each element were scaled down by a thousand. The photographic log, LOI, chemostratigraphy, and radiocarbon dates are plotted against corresponding depth in centimeters (cm).

3.1.2 Loss on Ignition, X-Ray Fluorescence, and Radio Carbon Dates of Core JE-4

Core JE-4 was collected using a modified Livingstone corer. This core was collected 75 m away from the sand dunes. The overall length of the core was 96 cm, and it contained five main lithologies. The five lithologies in the core are clay, sandy clay, clayey sand, sand, and sand with fossils. Clay is present from 0 to 14 cm, sandy clay is found from 14 to 44 cm, from 44 to 65 cm the sediment is comprised of clayey sand, from 65 to 86 cm the sediment is sand, and from 86 to 96 cm the sediment is sand with marine fossils (shells) (figure 9).

The photographic log of core JE-4 proved to be useful when analyzing the LOI graphs (figure 4). The LOI in figure 4 indicates that the highest weight percentage of water within the core is from 0 to 44 cm, with weight percentages that range from 30 to 50%. Where the highest weight percentage of water is located corresponds with sediment layers that were composed of clay. However, where sandy layers are located the weight percentage of water decreases to 20%, occurring from 44 to 96 cm. Organic material was also more prevalent in regions of the core that contained clay sediments. From 0 to 44 cm the weight percentage of organic material is the highest, ranging from 3 to 7%. As the depth increases, the weight percent of organic material decreases to below 2%. The carbonate curve also follows a similar trend as the water and organic curves of core JE-4. It was observed that from 0 to 44 cm the weight percent of carbonates ranged from 1 to 2.5%. The highest weight percent of carbonates; however, was noticed from 82 to 96 cm. From 82 to 96 cm, the weight percent of carbonates ranged from 1 to 3%. The smallest weight percent of carbonates was identified from 44 to 82 cm, where the weight percent was less than 1% (figure 11).

As with the LOI, trends were also observed in the chemostratigraphy. It was observed that the concentration of chlorine, sulfur, titanium, and iron were the highest from 0 to 30 cm, corresponding to the noticed clay layer within the core. Below a depth of 30 cm, the concentration of each of the elements decreases dramatically. From 0 to 30 cm, chlorine had concentrations ranging from 20,000 to 70,000 ppm, below 30 cm the concentration dropped to 100 ppm. Sulfur had concentrations that ranged from 15,000 to 45,000 ppm at depths from 0 to 30 cm; however, sulfur had an observed decrease in concentration from 30 to 95 cm. The concentration of sulfur decreased to 5,000 ppm below 30 cm. Titanium also had high concentrations from 0 to 30 cm. From 0 to 30 cm, the concentration of titanium ranged from 1,000 to 1,500 ppm. However, from 30 to 95 cm, the concentration of titanium decreased to 500 ppm. The concentrations of iron ranged from 5,000 to 12,000 ppm within the top 30 cm of the core. There was a decrease in concentration of iron below 30 cm. the concentration of iron from 30 to 95 cm had an average concentration of 100 ppm (figure 11).

Two AMS radiocarbon dates were obtained from core JE-4 at depths of 34 and 90 cm. The radiocarbon date that was obtained from a depth of 34 cm was 107 ± 0.4 calibrated years BP, and at 90 cm, the age of the organic material was 406 ± 30 calibrated years BP. Both of the dates are in conventional radiocarbon years before present. The radiocarbon dating results for core JE-4 can be seen in Table 1, in the appendices. Radiocarbon dates were added to the photo log, LOI, and chemostratigraphic graphs of core JE-4, figure 11.

Table 2. Radiocarbon dates of core JE-4.

number	Core	Sample depth (cm)	Conventional ^{14}C age (a BP)
Beta-344927	JE-4	34	107 ± 0.4
DAMS-003587	JE-4	89	406 ± 30

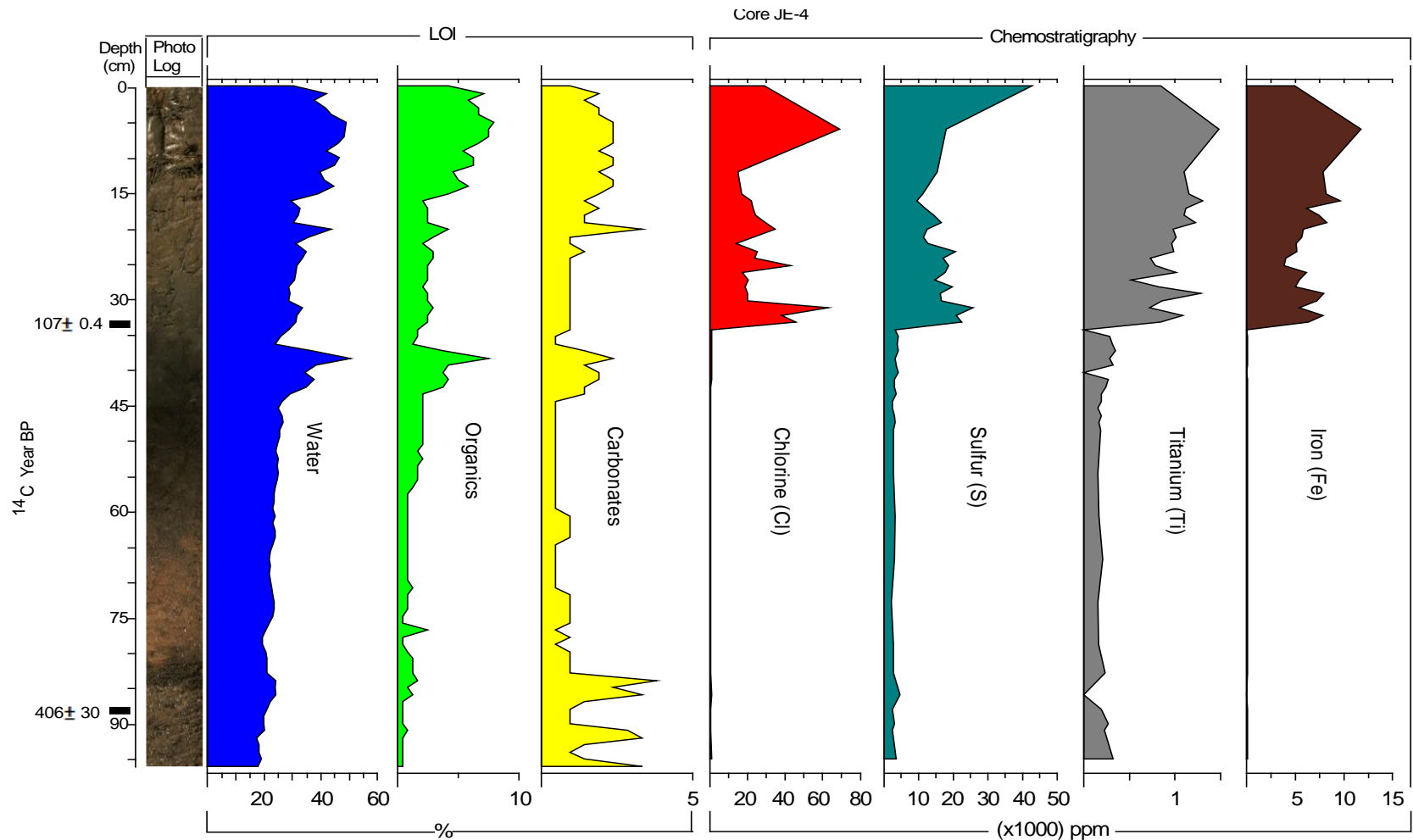


Figure 11. Photographic log, loss on ignition (LOI), chemostratigraphy, and radiocarbon dates of core JE-4.

The photographic log shows the changes in stratigraphy, the LOI curves show weight percent water, organics, and carbonates. The chemostratigraphy shows concentrations of chloride, sulfur, titanium, and iron in parts per million (ppm). Concentrations of each element were scaled down by a thousand. Radiocarbon dates are shown in calibrated years before present (BP). The photographic log, LOI, chemostratigraphy, and radiocarbon dates are plotted against corresponding depth in centimeters (cm).

3.1.3 Loss on Ignition and X-Ray Fluorescence of Core JE-5

Core JE-5 was obtained 195 m away from the sand dunes using a Bolivia corer. The length of the core measures 63 cm in length. Stratigraphy of core JE-5 has three lithologies, clay, sandy clay, and clayey sand. From 0 to 16 cm the sediment is composed primarily of clay, from 16 to 48 cm the sediment is sandy clay; clayey sand is present from 48 to 63 cm (figure 9).

Comparing the photo log to the LOI of core JE-5 is useful for identifying trends. From the LOI curves of core JE-5, it was noticed that the weight percent of water was highest from 0 to 25 cm, where clay is the dominant sediment. The weight percent of water within the top 25 cm of the core ranged from 50 to 61%. Within the water curve, it was also observed that the weight percent of water had peaks at 40 cm, and from 47 to 58 cm. At these peaks, the weight percent of water increased from 25 to 40%. The organic curve resembled the water curve. It was observed that the highest weight percent of organic material was from 0 to 25 cm, with weight percentages that ranged from 10 to 15%. There were also noticed spikes within the organic curve at 12 cm, 40 cm, and from 47 to 58 cm. The carbonate curve also revealed that the highest weight percent was from 0 to 25 cm, with a peak at 16 cm, and multiple small peaks between 30 and 62 cm (figure 12).

Unlike the LOI, trends were not as noticeable within the chemostratigraphy of core JE-5. The chlorine curve does not appear to indicate a trend, however, spikes in concentration were observed. An increase in chlorine concentrations were observed within the chlorine curve at 12 cm, 42 cm, and 58 cm. These peaks ranged in concentration from 12,500 to 15,000 ppm. The sulfur curve also does not appear to have a trend; however, areas of increased concentration were observed. Spikes in sulfur concentration were identified at 2 cm, a 25 to 40 cm, 50 cm,

and 60 cm. These peaks had a range of concentrations from 12,000 to 16,000 ppm. The most notable of these spikes was from 25 to 40 cm, as it was the most extensive. Unlike the chlorine and sulfur curves, a trend was identified with the titanium curve. The titanium curve revealed that the highest concentration was located from 0 to 30 cm; with concentrations ranging from 1,750 to 2,600 ppm. Observed titanium concentration below 30 cm. Below 30 cm, the average concentration was 800ppm. A trend was also observed within the iron curve. It was observed that the highest iron concentrations were from 0 to 30 cm, with concentrations ranging from 12,500 to 17,500 ppm. It was also observed that iron concentration decreased after 30 cm as well. Below 30 cm, the average concentration of iron was 5,500 ppm (figure 12).

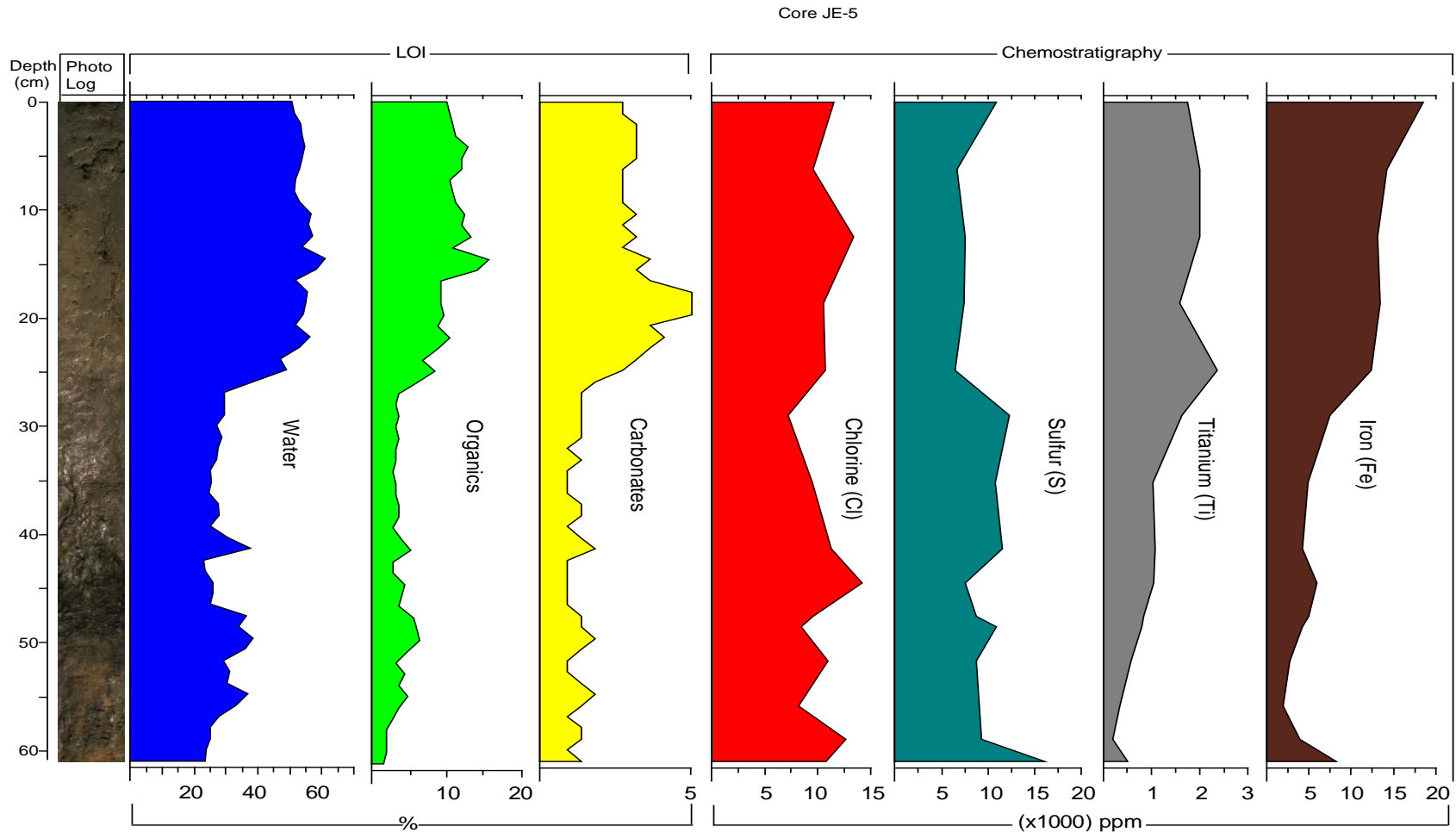


Figure 12. Photographic log, loss on ignition, and chemostratigraphy of core JE-5.

The photographic log shows the changes in stratigraphy, the LOI curves show weight percent water, organics, and carbonates. The chemostratigraphy shows concentrations of chloride, sulfur, titanium, and iron in parts per million (ppm). The concentrations of each element were scaled down by a thousand. The photographic log, LOI, and chemostratigraphy are plotted against corresponding depth in centimeters (cm).

3.2 Foraminifera Analysis

The two longest cores, JE-3 and JE-4, were both analyzed for abundance and diversity of foraminifera. In total seven species of foraminifera were identified in cores JE-3 and JE-4. It was found that the cores contained *Trochammina inflata*, *Trochammina macrescens*, *Miliammina fusca*, *Haplophragmoides* species (sp.), *Arenoparrella Mexicana*, *Elphidium* sp., and *Ammonia* species. *Trochammina inflata*, *Trochammina macrescens*, *Miliammina fusca*, *Haplophragmoides* sp., and *Arenoparrella Mexicana* are foraminifera typical of low salt marshes (Goldstein and Alve, 2011, and Hawkes *et al.*, 2009; Goldstein, Watkins, and Kuhn, 1995; Goldstein, Watkins, 1999). *Elphidium* and *Ammonia* species, however, live in near shore or marsh environments (Schweizer, *et al.*, 2011, Phleger, 1970, Javaux and Scott, 2003, Hippensteel, Martin, and Harris, 2005). Images of near shore species collected from core JE-4 can be seen in figure 13, and images of marsh species collected from cores JE-3 and JE-4 can be seen in figure 14.

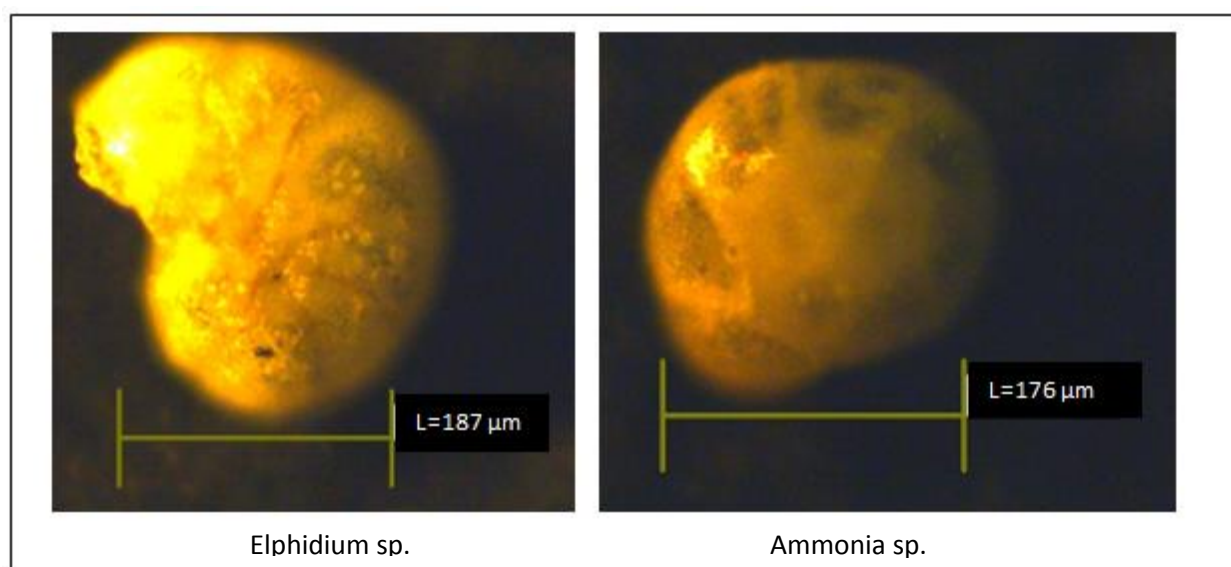


Figure 13. Images of near shore foraminifera found within Core JE-4.

The length (L) of the foraminifera are given in microns (μm).

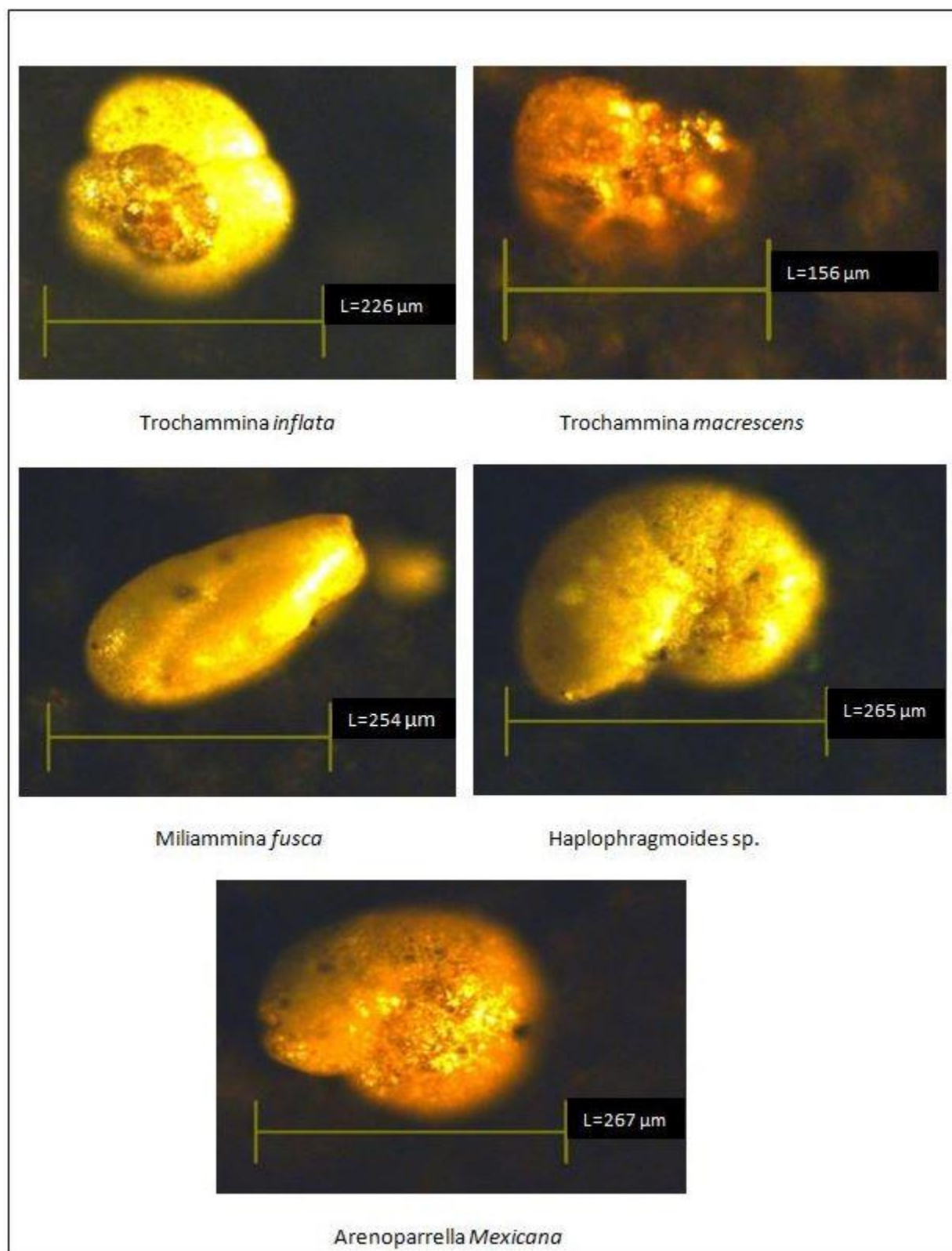


Figure 14. Images of lagoonal foraminifera found within cores JE-3 and JE-4.
The length (L) of the foraminifera are given in microns (μm).

3.2.1 Foraminifera Analysis of Core JE-3

After core JE-3 was analyzed, it was found that the core contained only species that are typical of low marsh environments. The species that were found in core JE-3 were *Trochammina inflata*, *Trochammina macrescens*, *Miliammina fusca*, *Haplophragmoides* species (sp.), and *Arenoparrella Mexicana*. When creating the foraminifera graphs, *Trochammina inflata* and *Trochammina macrescens* were lumped together to create the *Trochammina* species (spp.) column. The two *Trochammina* species were added together because it was difficult to discern between the two species. By adding the two species together it alleviated some of the uncertainties associated with identifying between the two species.

Where foraminifera are present within core JE-3, the genus *Trochammina* is the dominant foraminifera with the exception of two areas. In areas of the core where *Trochammina* is the dominant foraminifera, it is observed that it makes up 50 to 100% of the foraminifera assemblage. From five to twenty centimeters, *Miliammina fusca* is the most abundant species, making up 45 to 50% of the foraminifera assemblage. *Haplophragmoides* sp. is the most abundant species from 60 to 68 cm, making up 40 to 100% of the foraminifera assemblage. The percentages of foraminifera not only changes throughout the core, but also the abundance changes. The abundance of foraminifera has been observed to decrease with depth, with the majority of foraminifera being found from 0 to 50 cm, and none being found from 80 to 125 cm. Abundance and diversity of foraminifera found within core JE-3 can be seen in figure 15.

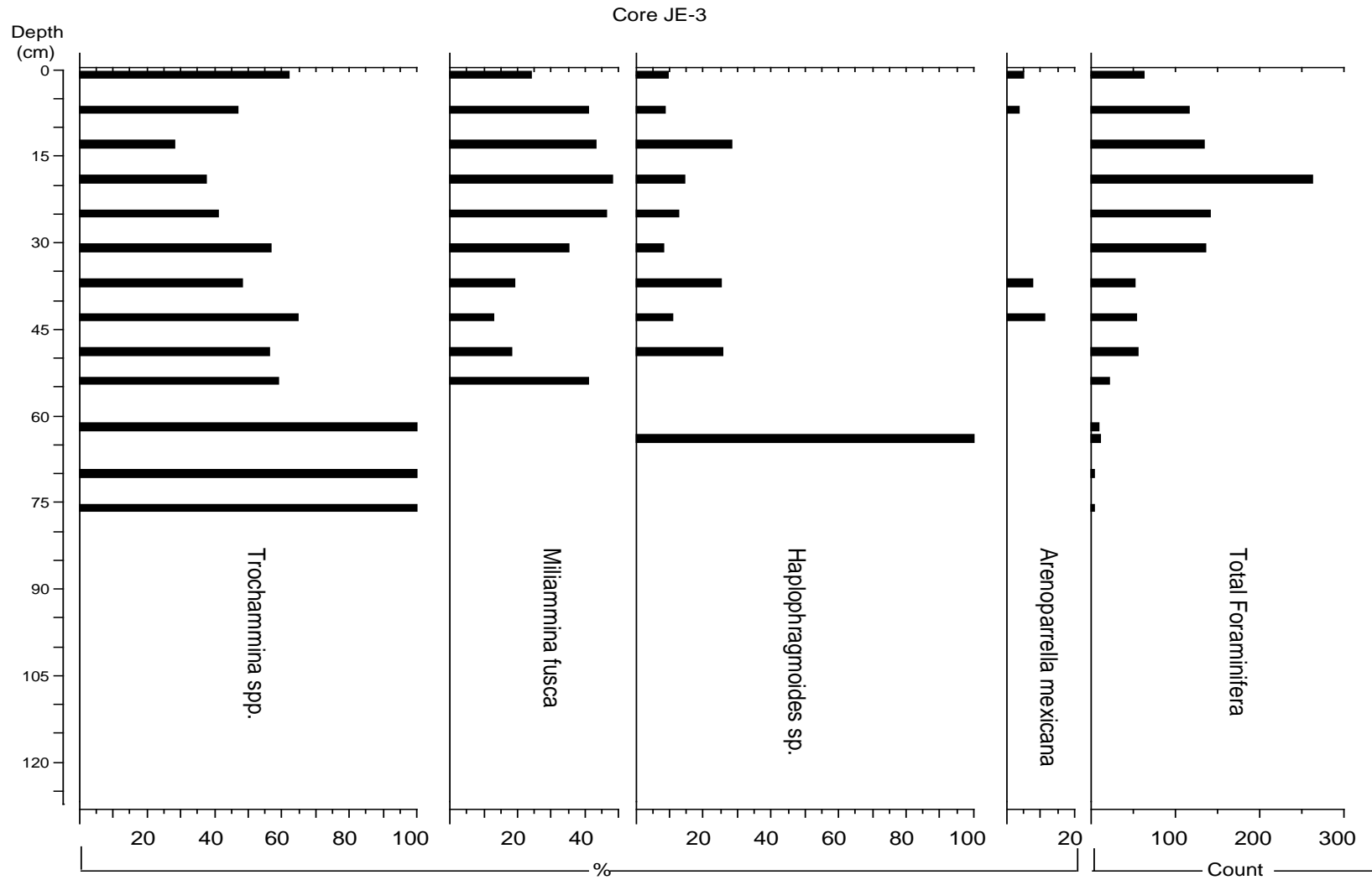


Figure 15. Foraminifera assemblage of core JE-3.

This figure illustrates the percentages of foraminifera, and total foraminifera found within the core. The percentage, and the total number of foraminifera are plotted with corresponding depth in centimeters (cm). Core JE-3 is dominated by marsh foraminifera species from zero to 80 centimeters, from 85 to 125 cm the core did not contain any foraminifera.

3.2.2 Foraminifera Analysis of Core JE-4

Figure 13 presents the abundance and diversity of foraminifera in core JE-4. It was found that core JE-4 contained low marsh and near shore species. The low marsh species in core JE-4 were *Trochammina inflata*, *Trochammina macrescens*, *Miliammina fusca*, *Haplophragmoides* sp., and *Arenoparrella Mexicana*. Within the last fifteen centimeters of core JE-4, both *Elphidium* sp. and *Ammonia* sp. were observed. As with core JE-3, both *Trochammina* species were grouped together to create a *Trochammina* species (spp.) column.

Miliammina fusca is the dominant species in core JE-4 from zero to thirty centimeters, making up 35 to 80% of the foraminifera assemblage. The predominant genus then becomes *Haplophragmoides* from thirty to forty centimeters, making up 30 to 40% of the assemblage, and also from eighty to ninety cm making up 45 to 55% of the foraminifera assemblage. *Trochammina* is the most abundant foraminifera from forty to eighty centimeters, making up 40 to 80% of the assemblage. The last five centimeters of the core becomes dominated by both *Elphidium* and *Ammonia* species. *Elphidium* makes up 35 to 55% of the assemblage, and *Ammonia* makes up 25 to 45% of the assemblage from 90 to 95 cm. It should also be noted that the total number of foraminifera decreases with depth, with the majority of foraminifera being found from 0 to 45 cm. Both the abundance and diversity of foraminifera within core JE-4 can be observed figure 16.

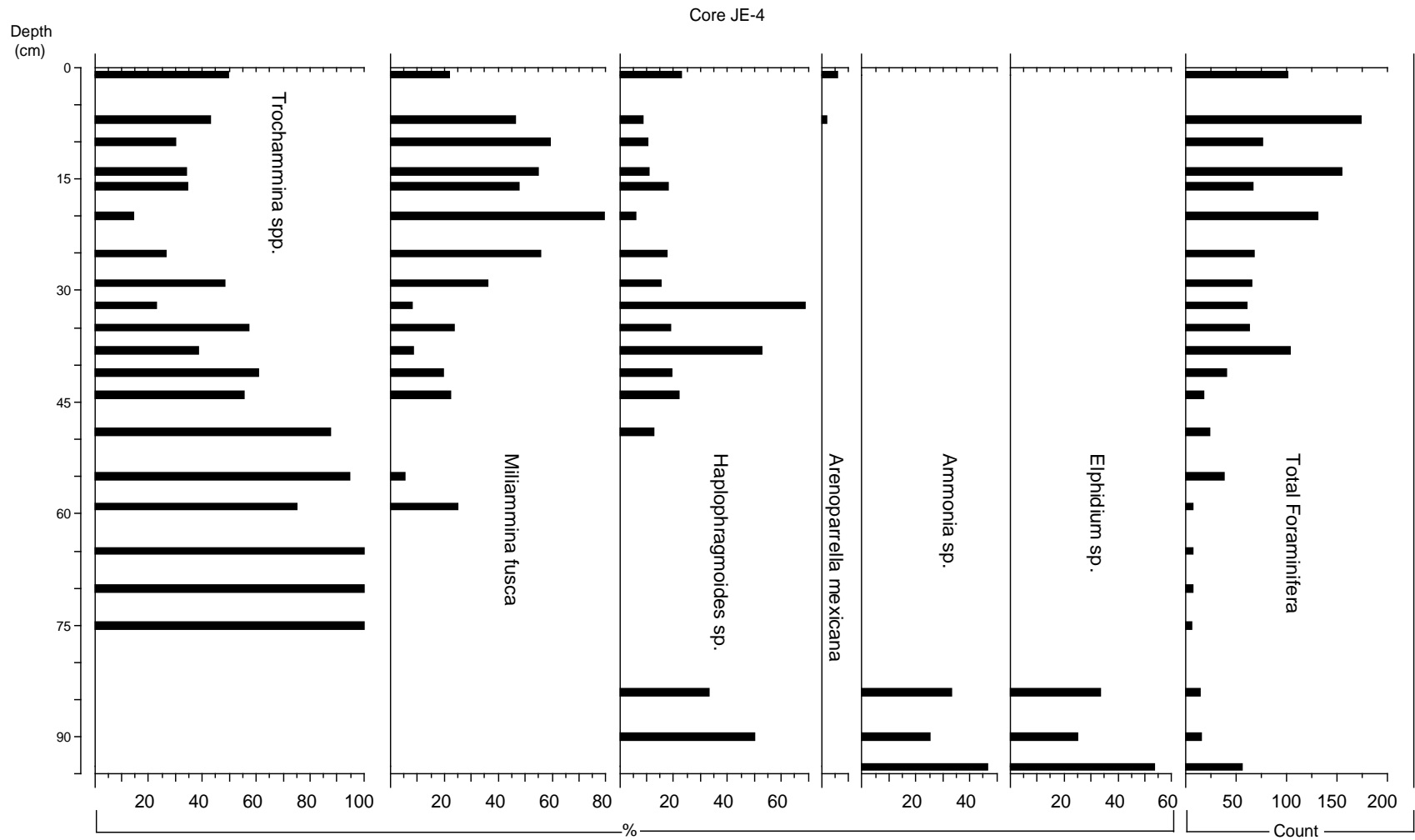


Figure 16. Foraminifera assemblage of core JE-4.

This figure illustrates the percentages of foraminifera, and total foraminifera found within the core. Percentages and total foraminifera are plotted with corresponding depth in centimeters (cm). Marsh foraminifera species dominate the core from zero to 90 centimeters, from 90 to 95 centimeters the core is dominated by near shore species.

4 DISCUSSION

Marshes are typically composed of fine grained material, such as clay. Whenever sand is observed within a marsh, it may be indicative of an over wash layer. It was possible to discern between clay and sand layers by the weight percent of water, organics and carbonate material. From the LOI results of cores JE-3, JE-4, and JE-5, it was determined that the top of each core was composed primarily of clay material, while the bottom of the core was mostly sand. The dominance of clay sediments at the top section of all three cores recovered from Jekyll is not a surprise considering that the island has not experienced major hurricane landfall in the recent past. Typically, where clay is present, the weight percent of water, organic, and carbonate material are the highest. In the sections of the cores that are dominated by sand; however, the weight percent of water, organic material, and carbonate material decreases. The weight percent of water, organic material, and carbonate material do not always decrease in areas dominated by sand. Peaks were observed in areas dominated by sand; these peaks indicate the presence of clay sediments within the sand. However, these peaks indicate that the weight percent of each of the constituents of the LOI is still far less than where clay is the primary sediment. Because the weight percent of water, organics, and carbonates is much higher where clay is the primary sediment, these peaks do not provide any useful information for indicating overwash layers, except in core JE-4. The LOI graph of JE-4; indicates a slight decrease in water and organics, and a significant increase in carbonate material from 85 to 95 cm. The large increase in carbonate material correlated with the presence of shell material, which may have been deposited by a hurricane around 406 ± 30 a BP. Longer cores from the site are needed to show the sediment layers below the sand. Ideally when sand is deposited in a marsh by a hurri-

cane, the sand layer is sandwiched in between two clay layers, making the overwash layer discernible. However, because only sand was present at the bottom of the cores, it was not possible to positively identify the sand layer as an overwash layer by the use of LOI alone. Also, as with core JE4, both cores JE-3 and JE-5 also only contained sand at the bottom of the cores suggesting that the overwash deposit was extensive. Because only sand was present at the bottom of cores JE-3 and JE-5, these cores did not provide further evidence to determine whether the observed layer of sand and shells in core JE-4 was deposited by a hurricane.

To be able to discern whether the observed sand layer within the cores is an overwash layer, XRF analysis was performed. By performing an XRF analysis, it was possible to identify the concentrations of chlorine, sulfur, titanium, and iron. The concentrations of these elements can help to identify whether the sediments within the cores are marine or terrestrial. High concentrations of chlorine and sulfur indicate marine environments, while high titanium and iron concentrations indicate sediment from terrestrial environments. Moser *et al.* (2011) observed that chlorine concentrations within Georgia marshes have an average concentration of 17,000 ppm, approximately half that of sea water, which has a chlorine concentration of 35,000 ppm. When an overwash layer is created from a hurricane, sea water is pushed onto the shore, and into the marsh. This means that if the sand layer is an overwash layer, then the concentrations of chlorine should be greater than 35,000 ppm, the average concentration of sea water. Also, if a sand layer is an over wash layer, then the concentrations of chlorine, sulfur, titanium, and iron should follow a few trends. Sediment that makes up an overwash layer should have increased concentrations of chlorine sulfur, and titanium, and decreased concentrations of iron.

It was observed that the concentration of chlorine within cores JE-3, JE-4, and JE-5 were typical of marsh environments, with the exception of the first 30 cm of core JE-4. Within the first 30 cm of core JE-4, it was observed that chlorine concentrations ranged from 20,000 to 70,000 ppm. Also, within the top five cm of core JE-4, high concentrations of sulfur were observed. Within the top five cm of core JE-4, sulfur concentrations reached 40,000 ppm. These very high concentrations of chlorine and sulfur observed in the top portion of core JE-4 may be due to storm events pushing sea water into the marsh, creating high levels of chlorine and sulfur. However, the area of the core where these high concentrations were observed corresponds to a clay layer, suggesting this is not an overwash layer. It was also noticed that within the top 30 cm of core JE-4 that the concentrations of sulfur, titanium, and iron were higher than the lower section of the core from 30 to 96 cm. Within the top 30 cm of core JE-4, the average sulfur concentration was 12,000 ppm, an average titanium concentration of 1,200 ppm, and an average iron concentration of 11,000 ppm. Meyer (2013), reported that low marsh environments on St. Catherines Island, GA, have an average sulfur concentration of 5,000 ppm titanium concentration of approximately 1,000 ppm, and an average iron concentration of 13,000 ppm. The average concentration of each of these elements correlates fairly well with what was observed in the top 30 cm of core JE-4, with the exception of sulfur. However, it was noted by Meyer (2013) that sulfur in low marsh environments ranged from 2,000 to 32,000 ppm. This means that the observed average sulfur concentration of 12,000 ppm falls within the sulfur concentration range observed on St. Catherines Island. The observed concentrations of sulfur, titanium, and iron within the top 30 cm of core JE-4 suggests that the sediments are of a low marsh environment. It was also observed in cores JE-3 and JE-5, that the top of the cores fol-

lowed a similar trend to that of the top 30 cm of core JE-4, suggesting that the top of these cores are also composed of low marsh sediments.

The chlorine, sulfur, and titanium concentrations did not increase where the sand layer was present in core JE-4, however, iron decreased within the sand layer. It was observed that the average concentration of sulfur was 4,000 ppm, the average titanium concentration was 400 ppm, and that the average iron concentration was 500 ppm within the sand layer in core JE-4. In a study by Meyer, 2013, it was also observed that eolian deposits, such as sand dunes, on St. Catherines Island, GA, had low concentrations of sulfur, titanium, and iron. The concentrations of sulfur, titanium, and iron observed by Meyer, 2013, within eolian deposits were similar to what was observed in core JE-4 from 65 to 96 cm. This suggests that the sand dunes are the probable source of the observed sand layer in core JE-4. Also, similar concentrations of sulfur, titanium, and iron that were observed from 65 to 96 cm in core JE-4 were also observed in core JE-3 from 60 to 126 cm, and in core JE-5 from 55 to 63 cm. The concentrations of sulfur, titanium, and iron suggest that the sand dunes were the source of the observed sand layers in cores JE-3, JE-4, and JE-5. Chowns, *et al.* (2008) noted that Waterfall Marsh is composed of a sandy fill, attributed to beach ridges and sand dunes being pushed back due to sea level rise. The movement of the beach ridges and sand dunes has created a coarsening-upward fill of estuarine clays and washovers within Waterfall Marsh (Chowns, *et al.*, 2008). This also suggests that the sand observed in cores JE-3, JE-4, and JE-5 are most likely sourced from dune sand.

Also of interest is the sulfur and iron peaks observed in core JE-3. In core JE-3 it was observed that there were peaks within the sulfur and iron curves at the same depth. The increase in both sulfur and iron at the same depths in core JE-3 may indicate the presence of pyrite. Roy-

choudhurya, Kostkab, and Cappellenc (2003) observed that pyrite is commonly found in marshes due to pyritization. It is believed that the presence high concentrations of sulfur and iron in core JE-3 at 75 cm and 115 cm may be due to pyritization.

Foraminifera analysis was performed on both cores JE-3 and JE-4 to provide further clues as to whether the observed sand layer within the cores was deposited by a hurricane. In marsh environments, typically species of foraminifera associated with marshes are present. In an overwash fan; however, marine foraminifera should be present, along with marsh species, due to foraminifera within sea water being pushed inland by hurricane events.

Core JE-4 contained both foraminifera associated with low marsh environments, and nearshore species. The top 80 cm of core JE-4 only contained species typically found within marshes, suggesting that only marsh sediments were present. In core JE-3, low marsh foraminifera were also detected within the top 80 cm of the core. The foraminifera analysis of core JE-3 correlates with the foraminifera analysis of core JE-4, providing more confidence to the analysis.

An observed change in foraminifera species occurred in core JE-4 from 80 to 96 cm. From 80 to 96, both marsh and nearshore species were detected within the core. The combination of both marsh and nearshore species suggests that there was a change in the environment. The nearshore species that were detected below 80 cm were *Elphidium spp.* and *Ammonia spp.* *Ammonia* and *Elphidium* have been used to identify overwash layers in previous studies. In a study by Scott, *et al.*, 2003, species of *Ammonia* and *Elphidium* were used as indicators of large storm events. Large storm events were identified when there was a notable change from marsh foraminifera, to nearshore or offshore foraminifera. Also, in a study by Hippensteel, (2011) it

was observed that *Ammonia* and *Elphidium* species were present in overwash layers along with offshore species of foraminifera. While offshore species were not observed within the last 16 cm of core JE-4, the presence of *Ammonia* and *Elphidium* clearly indicates that a change in the environment occurred. The change in the environment was most likely caused by a large storm, such as a hurricane, which pushed nearshore foraminifera inland. The foraminifera record of core JE-3 provides further evidence that the last 16 cm of core JE-4 is most likely due to a hurricane event. In core JE-3, foraminifera were not present below 80 cm; also shells were not present below 80 cm as well. This suggests that the presence of shell material and the presence of *Ammonia* and *Elphidium* species are uniquely tied together. This provides further evidence that the sandy shell layer observed in core JE-4 is most likely due to a hurricane event.

The LOI, XRF analysis, and foraminifera analysis of core JE-4 shows that at ca. 406±30 a BP, there is evidence of a possible overwash event. However, evidence from cores JE-3 and JE-5 was inconclusive. The LOI of core JE-4 indicated that there was an increase in carbonate material from 82 to 96 cm. The increase of carbonate material correlated with the presence of shells. Where the shell layer was present, it was observed that there was a change from low marsh species of foraminifera, to nearshore foraminifera, indicating a change in the environment precipitated by the paleostorm event. The transition noticed was from a marsh to a marine environment. The change from a marsh to a marine environment may indicate that a hurricane created an overwash layer. While LOI and foraminifera data helped to corroborate the existence of an overwash layer from 82 to 96 cm, the XRF data did not provide evidence of an overwash layer. The XRF analysis of core JE-4 did not provide evidence that the sandy shell layer in core JE-4 is an overwash layer. However; because of the strong evidence provided by the LOI and forami-

nifera results, it is believed that the shell layer within core JE-4 was produced by a hurricane event. The thickness of the sandy shell layer in core JE-4 also provides some clues to as to its origin as well. Typically overwash layers range in thickness from centimeters up to a meter. Donnelly *et al.*, (2011) observed overwash layers ranging from a few centimeters to twenty centimeters thick, however; it was observed by Mark and Ping, 2005, that overwash layers may be as thick as one meter. The observed sand and shell layer in core JE-4 is at least fourteen cm thick, which is typical of overwash layers. To determine when the shell layer in core JE-4 was created, a radiocarbon date was obtained. It was discovered that the shell layer had a conventional date of 406 ± 30 a BP. This indicates that if the sandy shell layer in core JE-4 is an overwash layer, then the hurricane event would have occurred before 406 ± 30 a BP.

Two radiocarbon dates were obtained from each of cores JE-3 and JE-4. It was determined that core JE-3 had a date of 510 ± 30 a BP at 53 cm, and a date of 2743 ± 30 a BP at 121 cm, and core JE-4 had a date of 107 ± 0.04 a BP at 34 cm, and a date of 406 ± 30 a BP at 89 cm. These dates were compared to radiocarbon dates obtained by Chowns, *et al.*, 2008. In a study by Chowns, *et al.*, 2008, a core was taken in Waterfall Marsh, it was observed that a depth of 4.14 meters the core had a conventional radiocarbon date of 1270 ± 40 a BP. This suggests that the radiocarbon date of 2743 ± 30 a BP at 121 cm in core JE-3 is most likely reworked material. However, the other three radiocarbon dates seem to correlate with what was observed by Chowns, *et al.*, 2008. This indicates that only a 510 ± 30 a BP hurricane record was produced from this study. Also, during this 510 year interval, only one hurricane event may have occurred. The minimum age of the hurricane event was 406 ± 30 a BP. It has been reported that a hurricane struck the lower coast of Georgia in 1566 (Sandrik and Landsea, 2003). The date of the recorded

hurricane event coincides with the observed radiocarbon date of the sand and shell layer in core JE-4, suggesting this layer may have been created by that storm event. Also, if the sand and shell layer is an overwash event, it means that only one major hurricane event has struck Jekyll Island within the last five hundred years. From the study, it was determined that Jekyll Island has a hurricane return interval of one major hurricane event per five hundred years.

5 CONCLUSION

Cores taken from the northern tip of Jekyll Island, within Waterfall Marsh was useful for identifying past hurricane events. Core JE-4 provided evidence that a hurricane event made landfall on the island before ca. 400 yr BP. However, longer cores need to be collected from the site to corroborate this evidence given that data from cores JE-3 and JE-5 were inconclusive. At the bottom of core JE-4 a sand layer with shells and nearshore foraminifera was observed. This shell laden layer may indicate an over wash event. Radiocarbon dating was performed on shell fragments within this layer, and a date of 406 ± 30 a BP was obtained. The radiocarbon date of the sand and shell layer coincided with the date of a hurricane event that occurred in 1566. This suggests that the sand and shell layer may mark the noted hurricane event that occurred in 1566. In conclusion, one hurricane event may have occurred before 406 ± 30 a BP. A return interval of one hurricane per five hundred years also was determined from this study.

6 FUTURE STUDIES

For future paleotempestology studies on Jekyll Island, GA, vibracoring methods should be used for collecting cores. By performing vibracoring within Waterfall Marsh on Jekyll Island, it will be possible to obtain longer cores. Collecting longer cores will allow for a much longer paleohurricane history to be determined. Also, having longer cores will make it possible to positively identify whether the sandy shell layer in core JE-4 from 80 to 96 cm is actually an overwash layer. A longer record will make it possible to identify what type of sediment is below the sandy shell layer. If clay is below this layer, then it will be possible to positively identify this layer as an overwash layer. However; if sand is below the sandy shell layer, then the longer core will hopefully provide more evidence as to how this layer was produced. Also, for future studies, two transects should be taken starting from the inlet and extending into the marsh (figure 17). One transect should be taken that intersects the location at which core JE-4 was taken for this study so that it will be possible to determine if the observed sand and shell layer in core JE-4 is continuous towards the shore, which would be expected. Also, by taking two transects starting from the inlet, it may be possible to collect cores in which there is evidence of hurricanes that predate the hurricane event that occurred around 406 ± 30 a BP, allowing for a longer paleohurricane record to be determined.



Figure 17. Suggested future transects within Waterfall Marsh.

This figure illustrates the paths the transects should follow for future studies. Note that one transect intersects the location at which core JE-4 was taken for this study.

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