ABSTRACT

Title of Thesis:	WINDS OF CHANGE: HURRICANE PATTERNS AND IMPACTS ON EARLY NATIVE COASTAL COMMUNITIES
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Thesis Directed By:	Dr. Matthew Palus, Anthropology Department

Over time society has learned to adapt during hurricane season with various methods of preparations, some including evacuating. But how did early Native settlements prepare and withstand such adversity? Hurricanes would have tested the resiliency and adaptability of early Native settlements. Utilizing common theories and methods of paleotempestology and marine historical ecology, this research analyzes the relationship between early Native settlement patterns and hurricane patterns in the Panhandle and Northwest Region of Florida. Early storm data is extracted from cores processed through sedimentary particle size analysis. The storms identified are compared to the historical hurricane data published by the National Oceanic and Atmospheric Administration (NOAA). Archaeological sites with pertinent existing collections within the vicinity of the research areas are identified and with permissions of the Florida Bureau of Archaeological Research (BAR), new data on shell height was recorded to support this research project. The shell height data had a noticeable relationship with the periods of stormy impact. The period of stormy occurrence is compared to archaeological site location data provided by the Florida Master Site Files (FMSF) identifying an apparent relationship between the storm occurrences and the archaeological site density along the coastline.

WINDS OF CHANGE: HURRICANE PATTERNS AND IMPACTS ON EARLY NATIVE COASTAL COMMUNITIES

by

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Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Master of Professional Studies
2024

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Foreword

"Everyone then who hears these words of mine and does them will be like a wise man who built his house on the rock. And the rain fell, and the floods came, and the winds blew and beat on that house, but it did not fall, because it had been founded on the rock. And everyone who hears these words of mine and does not do them will be like a foolish man who built his house on the sand. And the rain fell, and the floods came, and the winds blew and beat against that house, and it fell, and great was the fall of it."

- *Matthew 7:24-27*

Acknowledgements

I would like to express my gratitude to all the individuals who encouraged me throughout the process of my thesis. I am extremely grateful to Dr. Matthew Palus for the guidance he provided me during the journey of completing my thesis. I am very appreciative of the University of Maryland and the staff of the Cultural and Heritage Resource Management program, who taught me so much information during my time in the program.

I also want to thank my colleague Sierra DeVanie for introducing me to the University of Maryland's Cultural and Heritage Resource Management program. She has continuously opened amazing opportunities for me in my career in cultural resource management. She is not only my colleague but my dear and loving friend who I am blessed to have a part of my life.

I must give thanks to my partner Kyle Kozlowski for believing in me and supporting me through tough times. He never complained when I would ask him to read over my chapters and would listen when I needed to talk out the subject. He helped me structure my thesis better for individuals who have limited knowledge in the subject matter.

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Chapter 1: Introduction

For decades the state of Florida has been battered and bruised by vicious storms. Hurricane season falls between the months of June to November. Every year residents make preparations for protection against these violent storms. But these wicked storms bring various degrees of devastation across the state of Florida forcing communities to rebuild. As a native Floridian I have witnessed the history of hurricanes and the threats they pose on communities. Every year when hurricane season rolls around other locals to the Tampa Bay Area, where I live, discuss the folktale that Tampa Bay is protected from these major storms because the Tocobaga Tribe blessed the land. There is a lot of belief to the folktale since it had been 103 years since the last major hurricane made landfall in the area. Unfortunately, in the process of writing this thesis hurricane Milton made landfall this year as a category 3 hurricane, upsetting the record. The folktale about the Tampa Bay Area inspired this thesis to explore the significance of early Native settlement locations and their relation to hurricane patterns. This thesis will focus on answering the following research questions: What hurricane patterns existed prior to the historic record? How do these patterns compare to hurricane patterns today? What is the relationship between the hurricane patterns and early Native settlement patterns?

This research will be focusing on the Panhandle and Northwest region of Florida. In this thesis the data collected in the previous thesis and dissertation completed by Bret Parbus (2018), *Weathering the Storm: Effects of Storm Periods on Ancient Populations of Coastal Florida*, will be reassessed for identification of early storm occurrence. The identification of historical hurricanes will contribute to this thesis and be compared with the data identifying early storm occurrence. Once early storm occurrence has been identified it will be compared with Florida's current archaeological site records to identify relationships between early Native settlement patterns and early storm patterns.

Chapter 2 discusses what a hurricane is, how a hurricane forms, and what range of effects a hurricane can cause. Hurricanes are categorized by windspeed to determine the intensity of effects the storm will have on an area. The effects of a hurricane can vary to include high winds, storm surge, flash flooding, tornados, and heavy rainfall. The understanding of hurricanes and the identification of their effects in Chapter 2 will help provide explanation how these effects can provide measurable data that will be utilized in this research.

In Chapter 3 the theories that are used to guide the research are presented and explained. Some of the theories utilized in this thesis are common theories to paleotempestology and marine historical ecology. The theories listed will assist in explaining the selection of methods of data collection used in this research. Chapter 4 will list and explain the methods of data collection that will be used throughout this research, and Chapter 5 will present the results of the four data sets noted in chapter 4. Chapter 6 will present an analysis of the results, explaining what they mean and how they address the proposed research.

The thesis will be concluded in Chapter 7 with an assessment of the success of the methods utilized for this research. Based off the assessment of the success of the methods and data provided in this research, recommendations for further research success are identified.

Chapter 2: Historical Hurricane Patterns and Terminology

The focus of this research is to answer the following questions: What hurricane patterns existed prior to the historic record? How do these patterns compare to hurricane patterns today? What is the relationship between the hurricane patterns and early Native settlement patterns? In order to understand the research better, this chapter provides information on the regions of Florida, hurricanes, hurricane formation, and hurricane effects.

2.1 Regions of Florida

The state of Florida is divided into seven different regions: Panhandle, Northeast, Northwest (Big Bend), East Central, West Central, Southeast, and Southwest. These regions were determined by local Floridian culture and communities along with environmental and geographical features. The layout of the regions of Florida are displayed in **Figure 1**. This research will be focusing on two regions of Florida that run along the Gulf Coast, the Panhandle and Big Bend region **(Figure 2)**.

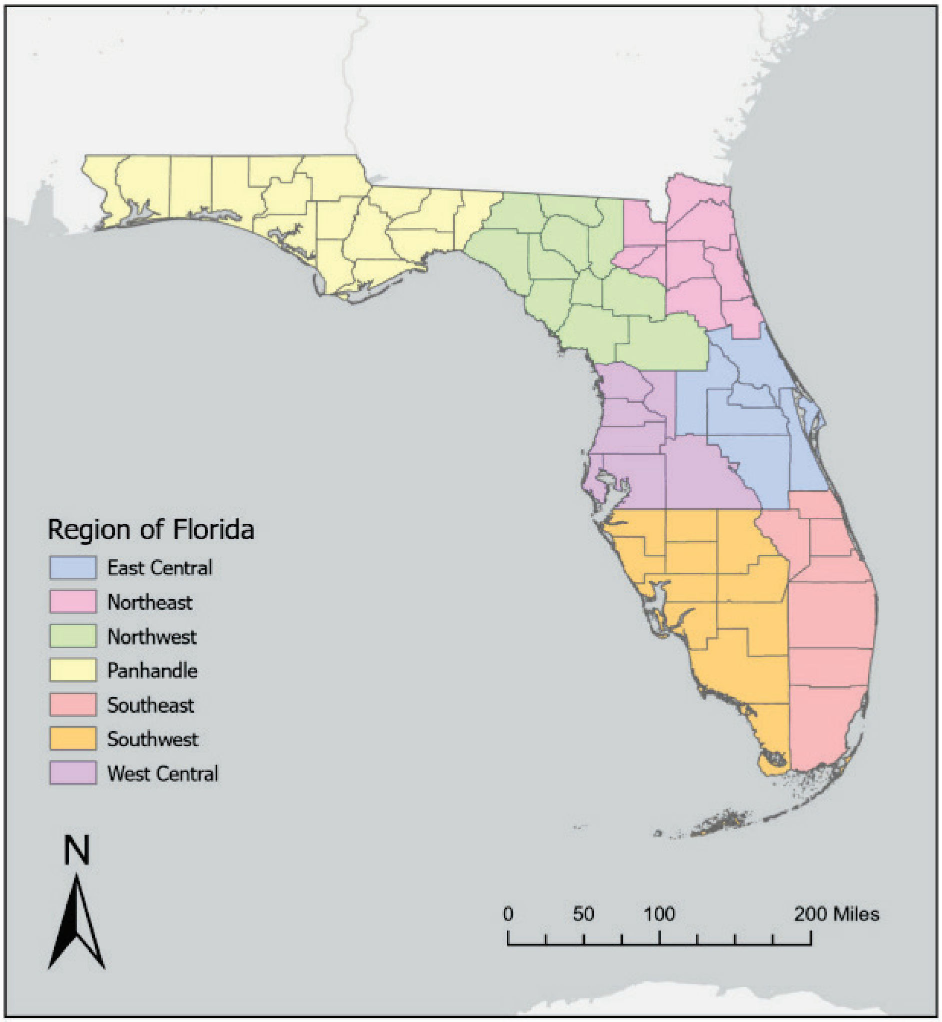

Figure 1. Regions of Florida. (Original work of the author)

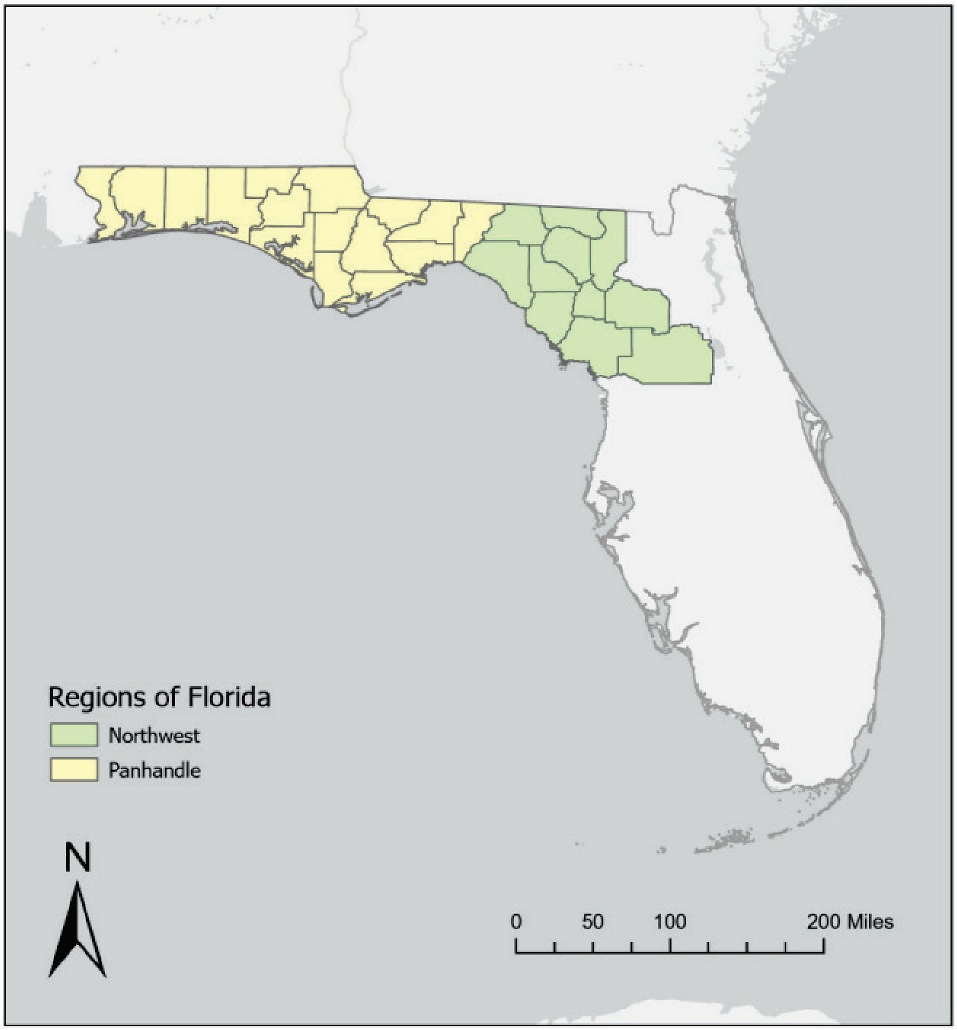

Figure 2. Regions of Study (Original work of the author)

2.2 Historical Hurricanes

Florida is notorious for its hurricane season, which falls between the months June and November. According to the National Oceanic and Atmospheric Administration (NOAA), "A hurricane is a type of storm called a tropical cyclone, which forms over tropical or subtropical waters" (2013). Tropical cyclones are called hurricanes when they sustain winds of at least 74 miles per hour (mph) (NOAA 2013). Once tropical cyclones become hurricanes, they are categorized on a scale of 1 to 5 "based on a hurricane's maximum sustained winds" (NOAA 2013). Each hurricane category is defined as follows: Category 1 wind speeds are from 74 to 95 mph, Category 2 is 96 to 110 mph, Category 3 is 111 to 129 mph, Category 4 is 130 to 156 mph and Category 5 is anything with winds greater than 156 mph winds (Florida Climate Center 2023). The higher the category, the greater potential there is for destruction.

According to NOAA, hurricanes or tropical cyclones develop an average of twelve times yearly in the Atlantic Basin (2024). Let it be noted that out of the average twelve hurricanes, very few make landfall or come close enough to affect the coastline of Florida. In fact, as of 2023, Florida has been impacted by 155 hurricanes since 1851 (NOAA 2024c). Within the time span of 172 years, 113 hurricanes have made landfall in Florida and the other 42 either were not a category 1 hurricane or higher when landfall occurred, but were categorized as a category 1 hurricane or higher within 60 nautical miles (nmi) of the coastline, or the storm never made landfall but were a category 1 hurricane or higher within 60 nmi of the coastline of Florida (NOAA 2024c). That would average to be less than one hurricane a year, but make no mistake, hurricanes are not predictable. The number of hurricanes that make landfall varies each season.

With 155 hurricanes impacting the state of Florida, it is fair to say all of Florida's coastlines have been impacted by at least one of these major storms that could be categorized as either a tropical storm or a hurricane since 1851, the furthest record back that the National Oceanic and Atmospheric Administration (NOAA) has on record (NOAA 2024c). A hurricane is classified as major when it reaches a category 3 or higher (sustained winds greater than 110 mph) (Florida Climate Center 2023). Out of the 155 hurricanes which have impacted Florida, 60 have been categorized as major hurricanes upon landfall in Florida or within 60 nmi of the Florida coastline.

2.2.1 Panhandle

From 1851 to 2024 a total of 170 major storms that are categorized as either a tropical storm or a hurricane have impacted the Panhandle region of Florida. Only 63 were categorized as a 1 or higher upon landfall or within 60 nmi of the coastline (NOAA 2024c). Out of the 63 to impact the Panhandle region, 40 of the hurricanes made landfall the other 23 either were not a category 1 hurricane or higher when landfall occurred but were categorized as a category 1 hurricane or higher within 60 nautical miles (nmi) of the coastline, or the storm never made landfall but were a category 1 hurricane or higher within 60 nmi of the coastline of Florida (NOAA 2024c). The Panhandle has been impacted by 18 major hurricanes (hurricanes sustaining winds greater than 110 mph) with 10 making landfall within the region from 1851 to 2024 (NOAA 2024c). A list of all major hurricanes making landfall in the Panhandle region of Florida can be found in Appendix D. The region averages less than one hurricane a year and a major hurricane every 10 years.

2.2.2 Northwest

From 1851 to 2024 a total of 148 major storms that are categorized as either a tropical storm or a hurricane have impacted the Northwest region of Florida. Only 62 were categorized as a 1 or higher upon landfall or within 60 nmi of the coastline (NOAA 2024c). Out of the 62 to impact the Northwest region, 23 of the hurricanes made landfall the other 39 either were not a category 1 hurricane or higher when landfall occurred but it was categorized as a category 1 hurricane or higher within 60 nautical miles (nmi) of the coastline, or the storm never made landfall but were a category 1 hurricane or higher within 60 nmi of the coastline of Florida (NOAA 2024c). The Northwest has been impacted by 9 major hurricanes (hurricanes sustaining winds greater than 110 mph) with 3 making landfall within the region from 1851 to 2024

(NOAA 2024c). A list of all major hurricanes making landfall in the Northwest region of Florida can be found in Appendix D. The region averages less than one hurricane a year and a major hurricane every 14 years.

The Panhandle region is more susceptible to storms than the Northwest region. The Panhandle is also more susceptible to major hurricanes historically. Since the region is more likely to struck by a major hurricane, it means that it is more likely to experience long term destruction of the region from the hurricanes, as discussed below in Section 2.4. In **Table 1** the number of major storms (tropical storm or hurricane) per category is listed for both regions. All storms were counted as the highest category storm they were with 60 nmi of the regions.

Table 1. Number of major storms that are categorized as either a tropical storm or a hurricane within 60 nmi of each region of study broken down by storm category (NOAA 2024c).

Region/ Category	**Panhandle**	**Northwest**
Tropical Storm (39 to 73 mph)	106	89
Category 1 (74 to 95 mph)	29	31
Category 2 (96 to 110 mph)	17	19
Category 3 (111 to 129 mph)	13	6
Category 4 (130 to 156 mph)	4	3
Category 5 (>156 mph)	1	0

2.3 Hurricane Formation

Hurricanes call for several factors in order to form. These factors include pre-existing weather disturbances, warm water, thunderstorm activity, and low wind shear (NOAA 2013). Florida is connected to the Gulf of Mexico, which averages 81.65°F within the months of hurricane season (June to November) (SeaTemperature.info 2024). The warm water of the Gulf fuels the fury of these catastrophic storms. Florida is frequently impacted by hurricanes due to its geographical location. Florida is in the Atlantic Basin, which included the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico. Hurricanes tend to originate in the Atlantic Basin (NOAA 2024d).

2.4 Effects of Hurricanes

Hurricanes can have various effects on regions of impact. Hurricanes can produce high wind, deadly storm surge, flash flooding and tornados. The higher the intensity of the storm, the stronger the impacts will be.

2.4.1 High Winds

Hurricanes produce strong winds that have catastrophic impacts on the environment. As mentioned above hurricanes are categorized based on their highest sustained winds. Hurricanes with sustaining winds of 39 to 110 mph (Tropical storm to Category 2) can cause some minor damages to roofs and siding of structures, powerline and pole damage resulting in power outages for a couple days, breakage of large tree branches and toppling of shallow rooted trees (NHC 2024). Hurricane with sustaining winds of 111 or higher (Category 3 or higher) can cause catastrophic damages such as severe damages to roofs and exterior walls of structures, power line and pole damages resulting in power outages for weeks or months, and snapping or uprooting of most trees that will isolate residential areas (NHC 2024).

2.4.2 Storm Surge

Storm surge is the deadliest effect of hurricanes. It is the rise of sea level produced during tropical storms or hurricanes. Storm surge is measured as "the height of the water above normal predicted astronomical tide" (NOAA 2016). Surge is caused by strong winds from a storm pushing the waters onshore (NOAA 2016). The intensity of storm surge depends on "orientation of the coastline with storm track; the intensity, size, and speed of the storm; and the local bathymetry [depths and shape of underwater terrain]" (NOAA 2016). Storm surge can cause flooding, erosion of beaches, roadways, and houses, destruction of marinas and boats, washover, displacement of wildlife, and alteration to the ecosystem and geomorphology of the area of impact (NOAA 2015a).

2.4.3 Flash Flooding

Flash flooding occurs when there is extremely heavy rainfall from storms and stormwater management systems fail to remove adequate surface water. There are several factors that contribute to the intensity of flash flooding such as the intensity of rainfall, topography, vegetation, soil type, and soil water-content (NOAA 2024a). Flash flooding is possible everywhere unlike storm surge which only impacts the coasts. Flash flooding can cause erosion of roadways and houses, tear out trees, displace wildlife and sediment, and isolate communities (NOAA 2024b).

2.4.4 Tornados

Hurricanes can produce tornadoes. Tornadoes are "violently rotating columns of air touching the ground" (NOAA 2023). Tornadoes produced by hurricanes often occur in the rainbands further way from the center of the hurricane (NOAA 2015b). Tornadoes can cause damages such as shredding structures, tearing down trees, and turning objects into airborne projectiles.

Hurricanes are catastrophic storms. It is important to understand how they form, why Florida is susceptible to hurricane impacts, and the effects of hurricanes. This information will provide some clarity to the information and data that will be presented in future chapters. The next chapter will discuss the major theories that will be applied to the thesis.

Chapter 3: Theoretical Background

The purpose of this thesis is to answer the following research questions: What hurricane patterns existed prior to the historic record? How do these patterns compare to hurricane patterns today? What is the relationship between the hurricane patterns and early Native settlement patterns? This research is based on a combination of theories. One of the theories guiding this research is the theory of resilience. This research also expands upon the previous model of pre-contact Native American site abandonment in relation to stormy periods. The concept that overwash deposits (or washovers) can produce legible data in the sediment profile will be referred to frequently in the research. Additionally, this research will be guided by the theory that hurricanes have long-term and short-term impacts on the development of oysters and utilizing the concept of seriation dating.

3.1 Resilience Theory

The resilience theory seeks to understand the role of change and how it causes adaptation. In this research, hurricanes are the destabilizing forces that bring change to the environment, which would impact the Native American settlements that fall within the line of destruction. The resiliency theory may address the continuation or discontinuation of occupation within a region when comparing site abandonment timeframes with hurricane occurrence. Charles L. Redman (2005) studied various environmental changes, including urbanization, climate change, and land-use changes which reflected the resiliency theory. In the context of this research, the resiliency theory is used to explain settlement changes due to extreme weather patterns.

According to Charles L. Redman (2005), the resilience theory is an adaptive cycle that flows into a figure-eight pattern. The figure-eight flows between three to four functions: exploration, release, reorganization, and conservation. The exploration function is the first function where colonization is rapidly increasing. Then the release function occurs which is where external forces create an imbalance. After that, the reorganization function occurs, and resources and behaviors are reorganized. Lastly, the conservation function occurs when resources and practices are stabilized again (Redman 2005:72-73). When the model is applied to this research it would follow as such:

1. **Exploration**: Before a hurricane occurs, a society is in a phase of rapid growth and development. This is where a settlement is in a state of stability.
2. **Release**: When a hurricane occurs, it becomes a disturbance to the settlement and the surrounding environment by causing massive destruction to the natural and man-made environment.
3. **Reorganization**: After the hurricane passes the adaptation and recovery process begins. This is where society is likely to create methods of prevention of devastation from hurricanes, such as site abandonment and relocation.
4. **Conservation**: After the previous location is abandoned, a new location is settled into. In this phase, society is building itself back to a state of stability and will eventually cycle back to the exploration phase.

Figure 3. A representation of the four functions in the adaptive cycle located (Original work of the author).

3.2 Site Abandonment in Stormy Periods

This research is an expansion on previous theories tested concerning stormy periods and their impact on early Native settlements along the coastal areas of Florida. In 2018 Brett Parbus conducted research on the correlation between stormy periods and site abandonment over the course of several archaeological time periods. His theory was that "environmental stressors caused by periods of increased storminess are in some part responsible for the adoption of new cultural behaviors and broad geographic change in subsistence strategy" (Parbus 2018:83).

To test his theory, Parbus used sedimentological data and compared it against the archaeological record to assess any correlation between ancient coastal settlements and increased storminess (2018). His sedimentological data came from five sediment cores from various lake beds along the coast. With the cores, Parbus analyzed the particle size of the soil and the volume (2018: 29-30). After completing the particle analysis, the cores were profiled to permit further analysis of any anomalies or characteristics that allowed for the creation of the chronology of stormy periods. The methods utilized in his research were based on previous research showing that during “major storm events, storm surge overwash deposits layers of coarse sediments into beds of coastal lakes” (Parbus 2018: 33) Once the chronology of stormy periods was established Parbus compared his data with the occupation chronology of archaeological sites recorded. The comparison in the timeline of site occupation and stormy periods helped Parbus identify which sites in the surrounding area were impacted by the hurricane that also impacted the lake from which the core was extracted (Parbus 2018: 29-30).

The data from Parbus (2018) research showed “several noticeable patterns… when comparing the chronology of the storm period against the occupational period generated from the archaeological record” (44). The most significant finding was a potential correlation between storm period occurrence and settlement abandonment (Parbus 2018:110). However, it was concluded that his research was flawed and required more statistical data to verify the results. Parbus’s conclusion on his research is what directed the current thesis research to have oyster shell measurements as a comparative data set to sediment analysis. Both datasets will be compared in relation to identify stormy periods and impacts on the environment.

3.3 Washover Deposit Recording

Overwash deposits or washovers will be frequently referred to in this research. Washover deposit recording is a common theory and method utilized in the paleotempestology (the study of past tropical cyclone activity using historical documents and geological proxies) field. Washovers are the result of when a combination of waves and storm surge transports sediment and deposits the sediment more inland (USGS 2015). Washovers are visible in the sediment profile and stratigraphy. Washovers are identified by coarse sediment such as sand which is typically found along shorelines. Jeffery Donnelly et al. (2004) conducted a study to reconstruct the overwash history at Brigantine Marsh in New Jersey. Donnelly et al. (2004) extracted a series of sediment cores in three transects. Several samples from the cores were dated through accelerator mass spectrometry (AMS) radiocarbon analysis. The study revealed a series of sand overwash fans within the sediment. When the series of overwash fans were dated it expressed an agreement with the historical record of intense storm occurrence (Donnelly et al 2004).

3.4 Impacts on Oyster Growth

This research will utilize oyster shell height data based on the theory that hurricanes have long-term and short-term impacts on the development of oysters. In 2003-2004 a study was conducted to measure the impacts of hurricanes and boat wakes on oyster reefs in Indian River Lagoon on the east coast of Florida. During the period of research, the oyster reefs that were studied were impacted by three hurricanes that made landfall in 2004. These hurricanes brought significant rainfall and storm surge and resulted in significant local property damage and Atlantic coast beach erosion (Walters et al. 2007). Three variables were measured, shell height, prevalence of dermo (deadly disease in oysters), and infection intensity. The results showed that out of the three variables measured, shell height was the only variable to significantly decrease in all the oyster reef sites after the hurricanes (Walters et al. 2007).

Another piece of information that researchers noted is that peak oyster settlement recruiting occurs April to June, during the same time as the 2004 hurricanes. Oyster recruiting refers to the populating of oysters and their development. Michelle Boudreaux (2005) published a study on the influence of dead margins on the recruitment of sessile organisms on oyster reefs in Mosquito Lagoon. Sessile organisms are organisms that cannot move by themselves such as barnacles, muscles, and algae. The study showed that "settlement of oyster larvae decreased with increasing sediment loads" (Boudreaux 2005:46). Increased sediment loads are caused by wave action, which increase the flow rate of sediment (Boudreaux 2005:47). Wave action with enough strength and consistency such as boat wakes or hurricane waves of surge can over wash sediment loads more inland, otherwise known as washover. The study also showed that the decrease in oyster recruitment also decreased the development of other sessile organisms (Boudreaux 2005: 47-48).

Both these studies show that hurricanes have a significant impact of the growth and development of oysters. Hurricanes can impact the size and quantity of oysters when sustaining high winds and heavy storm surge.

3.5 Seriation

Seriation is the technique of dating sites or object by cultural traits (Brauer 2006). In the world of archaeology, timeframes are identified as “cultural periods”, which we use to associate artifacts and sites with similar cultural dates as a method of dating. Seriation dating by cultural periods will be utilized in this research for all archaeological sites, especially the six specific archaeological sites along the Gulf Coast of Florida that contribute data to this thesis: 8FR0014, 8WL2267, 8WL2269, 8LV0126, 8LV0032, 8LV0537. **Table 2** is a list of applicable cultural periods that will be referenced in the results chapter.

Table 2: List of Cultural Periods

Cultural Period	**Start**	**End**
Paleoindian	10000 BCE	7500 BCE
Dalton	8000 BCE	6000 BCE
Archaic Northwest Region	7500 BCE	4500 BCE
Archaic Panhandle Region	7500 BCE	2000 BCE
Orange	2000 BCE	1000 BCE
Norwood	2000 BCE	500 BCE
Woodland	1000 BCE	1500 CE
St. Johns (Unspecified)	500 BCE	1700 CE
Deptford	500 BCE	200 CE
Swift Creek	100 CE	800 CE
Santa Rosa	200 CE	500 CE
Cades Pond	200 CE	600 CE
Weeden Island	400 CE	1100 CE
Hickory Pond	600 CE	1250 CE
Safety Harbor	900 CE	1600 CE
Mississippian	1000 CE	1500 CE
Pensacola	1100 CE	1700 CE
Fort Walton	1200 CE	1500 CE
Alachua	1250 CE	1500 CE
Leon-Jefferson	1500 CE	1704 CE
Seminole	1715 CE	1842 CE

3.5.1 8FR0014

Site 8FR0014 is contributing to the following cultural periods: Deptford (800 BCE- 700 CE) or Santa Rosa-Swift Creek (100-800 CE), Weeden Island (450-1000 CE), and Fort Walton (1200-1500CE). The site consists of five (5) shell middens and three (3) mounds (a-c), with several burials identified. When the site was first recorded in 1974, it was classified based on diagnostic pottery fragments discovered and the style or construction of the three mounds identified on the site (FMSF 1974a). In 2014 the site was resurveyed where it appears more mounds were identified and additional diagnostic materials were collected such as check-stamp pottery sherds, Weeden Island I incised pottery sherds, projectile points, etc. (FMSF 2014). During the 2014 survey, 14 carbon samples were collected dating Mound F to 930+30 Cal BP or 1025-1165 CE and Mound D dating 900+30 Cal BP or 1039-1210 CE (FMSF 2014). Both mounds fit nicely into the Fort Walton timeline. Site 8FR0014 is the only site in this sample with associated radiocarbon dates.

3.5.2 8WL2267

Site 8WL2267 is contributing to the following cultural periods: Deptford (800 BCE- 700 CE) and Weeden Island (450-1000 CE). The prehistoric content of the site consisted of three (3) lithics, thirty-five (35) ceramics, and small sample of shell (Mathews and Campbell 2009). The prehistoric ceramic collection consisted of three (3) Deptford Check Stamped, four (4) Deptford Linear Check Stamped, one (1) Deptford Simple Stamped, one (1) Carrabelle Punctuated, two (2) Ruskin Dentated Stamped, one (1) Wakulla Check Stamped, and three (3) Norwood fiber-tempered wares (Mathews and Campbell 2009).

3.5.3 8WL2269

Site 8WL2269 was recorded in the same survey as 8WL2267. The site is contributing to the following cultural periods: Deptford (800 BCE- 700 CE), Weeden Island (450-1000 CE), Pensacola (1100-1700 CE), and Fort Walton (1200-1500 CE). The site was recorded in 2007 with 460 artifacts with 43 prehistoric remains and 26.5 g of shell (Mathews and Campbell 2009). The prehistoric ceramic collection consisted of three (3) Pensacola Plain, one (1) Cool Branch Incised, seven (7) Wakulla Check Stamped of the Weeden Island period, and one (1) Deptford Check Stamped (Mathews and Campbell 2009). The site artifact collection also included lithics which consisted of two (2) tools and sixteen (16) pieces of debitage (Mathews and Campbell 2009).

3.5.4 8LV0126

Site 8LV0126 is classified contributing to the Weeden Island cultural period. The site consists of shell middens, one (1) basal portion of a stemmed projectile point, and a ceramic collection consisting of: two (2) buff-colored "muck" ware, one (1) grit-tempered incised, fifty-four (54) plain sand to grit-tempered (FMSF 1974b).

3.5.5 8LV0032

Site 8LV0032 is contributing to the following cultural periods: Deptford (800 BCE-700CE), Swift Creek (100-800 CE), Weeden Island (450-1000 CE), Fort Walton (1200-1500 CE), and Seminole (1715-1842 CE). The site was originally recorded in 1950 but has been resurveyed several times with the most recent being in 2005. The site consists of midden materials, ten (10) Check Stamped Gritty sherds, four (4) Pinellas Plain sherds, one (1) Fort Walton or Pinellas Incised sherd, one (1) Jefferson Comp Stamped (San Marcos) sherd, two (2) Simple Stamped Gritty sherd, one (1) Alachua cob-marked sherd, one (1) core impressed sherd, one (1) fabric impressed sherd, one (1) St. Johns Plain sherd, two (2) Prairie Cord Marked sherds, and several other unclassified sherds (FMSF 2005).

3.5.6 8LV0537

Site 8LV0537 is contributing to the following cultural periods: Archaic (7500-4500 BCE), Deptford (800 BCE- 700 CE), St. Johns (500 BCE-1565 CE), and Alachua (1250-1500 CE). The site was originally recorded in 1999 but has been resurveyed several times with the most recent in 2011. Diagnostic material found within the site includes a Levy projectile point, Marion projectile point, a reworked Marion projectile point, Lochloosa Punctuated ceramic sherds, and Prairie Cord Marked ceramic sherds (FMSF 2003).

All the theories listed in this chapter are guiding resources to the research of this paper. These theories give an understanding of reasoning for methods utilized in the research. In the next chapter the methods that are used to collect data will be listed and explained

Chapter 4: Methods and Data Collection

Since hurricanes have short-term and long-term impacts on the environment that are measurable, this research will use environmental data to determine periods of hurricane impact and the severity of their effects. This research will use sedimentary particle size analysis and oyster height to compare to documented historical hurricane data. The particle size analysis, historical hurricanes, and oyster height measurements will assist in answering the initial two research questions: What hurricane patterns existed prior to the historic record? How do these patterns compare to hurricane patterns today? The data that will represent the archaeological record is a shapefile of site locations obtained from the Florida Master Site File (FMSF). The data represents all recorded sites in Florida up to August of 2024. This dataset will help assist in answering the third research question: What is the relationship between the hurricane patterns and early Native settlement patterns?

4.1 Sedimentary Particle Size Analysis

The collection of sediment cores is a key component for this data set. This research will be utilizing data collected by other researchers and analyzing their data with a different perspective. This research specifically needs cores which have had sedimentary analysis completed. Sedimentary analysis is "a specialized scientific approach utilized to investigate and explore the attributes of sediment particles present in diverse geological formations, soil, or aquatic environments" (Cheng 2023). For the purposes of this research, sedimentary analysis will be used to give "precise measurements and quantifications of the size distribution" of sediment particles (Cheng 2023). The particle analysis data will come from Brett Parbus's (2018) research on stormy periods and archaeological site abandonment. In his research sedimentary analysis was completed by running the core samples through a machine that conducts laser diffractions to acquire a “diverse range of both particle size and shape” (Fisher et al 2017). The sediment core analysis dataset from Parbus (2018) that will be utilized was processed with the following methods:

> “…the core is sampled at approximately 3-mm intervals for particle size analysis…The top and bottom depth of each sample layer is recorded, as well as the total wet weight for each sample. The samples are then placed in an oven at 50 degrees C to dry. From there, the samples are cooled and reweighed in order to determine the percent moisture content of the core. The samples typically weigh between 2 and 10 grams depending on the types of sediment and the percentage of moisture. The dried samples are then disaggregated and suspended in a dispersant solution (5% sodium hexametaphosphate) before being run through a Cilas 1190L laser particle-size analyzer (PSA). Each sample is run through the analyzer a minimum of two times to ensure that the measurements are repeatable. The output of the PSA is stored in a template file that calculates a multitude of statistics, including the percentages of sand, silt, and clay, the mean, the standard deviation (sorting), the skewness, and the average particle diameter at distinct cumulative percentages of the sample particle size distribution” (Parbus, 2018: 32-33).

The particle analysis provided an output based on the measured statistics shown in **Table 3**. The measured statistics utilized may vary depending on the different soil complexities specific to each area. each sediment sample (Parbus 2018). Any further detail or clarification needed about the methods used for the particle size analysis or the collection of the cores should refer to the thesis and dissertation completed by Bret Parbus (2018), *Weathering the Storm: Effects of Storm Periods on Ancient Populations of Coastal Florida.*

Table 3. Statistic plotted for each sediment sample created by Parbus (2018).

Measured Statistic	Observation	Units
Percentage of total sample volume containing particles greater than or equal to very fine sand	Percentage of Coarse Sample	µm
Percentage of total sample volume containing particles less than or equal to clay	Percentage of Coarse Sample	µm
Percentage of total sample volume containing particles within the range of silt grain size	Percentage of Coarse Sample	µm
Percentage of total sample volume containing particles greater than or equal to silt	Percentage of Coarse Sample	µm
Graphic mean grain size recorded in phi units	Coarseness of total sample volume	ϕ
Graphic standard deviation for mean grain size recorded in phi units	Width of Distribution	ϕ
Graphic Skewness	Width of Distribution	
Moment mean grain size recorded in phi units	Width of Distribution	ϕ
Moment standard deviation for mean grain size recorded in phi units	Width of Distribution	ϕ
Moment skewness	Width of Distribution	
Cumulative percentage of total sample volume less than or equal to 3.9 microns	Distribution of sample by maximum particle size	%
Cumulative percentage of total sample volume less than or equal to 63.0 microns	Distribution of sample by maximum particle size	%
Cumulative percentage of total sample volume less than or equal to 125.0 microns	Distribution of sample by maximum particle size	%
Cumulative percentage of total sample volume less than or equal to 250.0 microns	Distribution of sample by maximum particle size	%
Particle size diameter at 5 percent of the total sample volume in microns	Mean particle size by cumulative sample volume	µm
Particle size diameter at 10 percent of the total sample volume in microns	Mean particle size by cumulative sample volume	µm
Particle size diameter at 16 percent of the total sample volume in microns	Mean particle size by cumulative sample volume	µm
Particle size diameter at 50 percent of the total sample volume in microns	Mean particle size by cumulative sample volume	µm
Particle size diameter at 84 percent of the total sample volume in microns	Mean particle size by cumulative sample volume	µm
Particle size diameter at 90 percent of the total sample volume in microns	Mean particle size by cumulative sample volume	µm
Particle size diameter at 95 percent of the total sample volume in microns	Mean particle size by cumulative sample volume	µm
Particle size diameter at 98 percent of the total sample volume in microns	Mean particle size by cumulative sample volume	µm
Particle size diameter at 5 percent of the total sample volume in phi units	Mean particle size by cumulative sample volume	ϕ
Particle size diameter at 16 percent of the total sample volume in phi units	Mean particle size by cumulative sample volume	ϕ

Table 3 Continued

Particle size diameter at 50 percent of the total sample volume in phi units	Mean particle size by cumulative sample volume	ϕ
Particle size diameter at 84 percent of the total sample volume in phi units	Mean particle size by cumulative sample volume	ϕ
Particle size diameter at 95 percent of the total sample volume in phi units	Mean particle size by cumulative sample volume	ϕ

4.1.1 Chronological Dating

To estimate the time of stormy impact, all the cores from Parbus (2018) research went through two types of analysis. One of the analyses that was employed was to have organic sediment samples at various depths of the cores sent to the National Ocean Sciences Accelerator Mass Spectrometry (NOSAMS) lab for Accelerator Mass Spectrometry (AMS) radiocarbon dating (Parbus 2018: 35). Additional dating assays were run on other organic materials, such as shell or wood, found within the core samples when they were available (Parbus 2018: 35).

The second dating analysis performed on the cores from Parbus's (2018:35) research was gamma ray spectrometry. Parbus (2018) utilized spectrometry to date samples on the top 30 centimeters of each core. Gamma ray spectrometry is a radiological absolute dating method based on the decay of uranium and thorium into a series of isotopes (USGS 2024). According to Parbus (2018:35) "the results of the gamma spectrometry were used in developing [isotopes] lead-210 and cesium-137 chronologies, which covers the past 100-plus years".

To chronologically date the identified stormy periods, Parbus uses the radiocarbon samples to create best fit linear models to calculate the age of the stormy periods (Parbus 2018: 45). The linear model creates a relationship between the depth (cm) and the age (Cal yr BP); stormy periods are then chronologically dated based on the depth recorded using the linear model. In Parbus's (2018) paper the data set is originally rounded to the nearest 10 years. For this research, I will be utilizing the linear models created to recalculate the age of the storms in Cal yr

BP. Results will be rounded to the nearest year to provide a more specific chronology of the stormy periods identified. During the recalculation process, I identified a discrepancy in the Parbus's data for one of the cores. I reached out to confer with Brett Parbus via email and he confirmed there was a miscalculation for the Mullet Pond core that he was previously unaware of.

4.2 Historical Hurricanes

The historical hurricanes data will be used for comparison with the storms calculated from the sedimentary particle size analysis. The historic hurricane data derives from the National Oceanic and Atmospheric Administration (NOAA*) Historical Hurricane Tracks* database. The location of reference will be the coordinates of the location where the cores were collected. A 60 nautical mile (nmi) buffer is placed around each location to filter for historical hurricanes that fall within the set distance. A 60nmi buffer is utilized since it is the recommended search distance on the database. Data will be filtered to reflect the total number of hurricanes that impacted the search area and the number of major hurricanes, a hurricane categorized as 3 or higher, that impact the search area.

4.3 Oyster Height Data

The oyster measurement data is another key component to answer some of the research questions. Archaeological sites within 40 miles of the core collection sites were identified. The sites were identified through the Florida Master Site File database and correspondence with the Florida Master Site File office. The Florida Master Site File office helped sort the sites to identify which had oyster shells in their artifact collections. They provided me a list which I then had to sort through measuring the site distance from the sediment core location. Once I figured out what sites fell within or close to the 40-mile buffer and contained oyster shells in their collections, I coordinated with the Florida Bureau of Archaeological Research to see if they housed any of the site's collections.

After the sites were selected, the collected oyster artifacts from the sites could then be measured. The site collections were accessed through The Florida Bureau of Archaeological Research located in Tallahassee, Florida, which houses collections of only state and federal projects. Florida lacks a repository for private surveys, therefore limiting the readily available data to use for the project. The collection bags had limited provenience, most of the bags were only labeled with the site number. The six sites that were utilized—detailed in Chapter 3 of this thesis—were surveyed in the 1970's to early 2000's, when guidelines for collections were not as refined as they are today. The measurements consist of the oyster shells height. The height of an oyster shell is measured from the "umbo (the high point near the hinge of the two shells) to the farthest away point" (Venolia 2018) (**Figure 4**). The height is measured with a caliper in millimeters (mm). The oysters are assumed to be dated to the cultural period(s) the site is associated with, as reported in the state inventory and based on diagnostic artifacts or other dating methods. A description of each site utilized in this data set is described in the theoretical background chapter. The spatial data for each site is provided by the FMSF with precise locations.

Figure 4. Sketch of oyster shell demonstrating measurement of shell height (Commonwealth of Massachusetts 2024).

The limitation of collection guidelines and lack of provenance of the oysters leaves outlying variability in the results. There is the potential that some shells are not dated to the site. Another limitation of the data is that there are other factors that can decrease the shell size of oysters such as overharvesting and disease.

4.4 Archaeological Site Density and Distribution

After collecting data to identify when and where early hurricanes impacted the Gulf Coast of Florida, it is necessary to identify sites in the location of impact and compare whether that site thrives after the time of impact or is abandoned. This task is accomplished by utilizing a shapefile of obscured site location data points provided by the Florida Master Site Files (FMSF 2024). The site locations within the shapefile have been obscured by 3,000 m (2-3 mi) due to the sensitivity of the information. The 3,000 m obscurement is less than 60 nmi, which is the buffer used in the historical hurricane data, therefore the obscurement does not affect the outcome of the study in a negative way. The Florida Master Site File would prefer to keep the data obscured to protect the sites from looting and vandalism. The tabular data within the shapefile is like that of the 'Santa Claus' data file, which is a large tabular data set with all sites documented statewide in a single Microsoft Access Database. The data is not user friendly, so a lot of sorting is needed to get the data necessary for this research. For instance, the sites are organized by what county they are in, so all the counties need to be sorted into what region of Florida they fall into. The tabular data also allows for each site to be classified in up to eight cultural periods. This means that some sites will be counted for more than one cultural period when identifying the quantity of sites per cultural period within in each region of study. An important note is that the regions of Florida focused on for the research of this project experience different cultural periods at various times. Cultural periods can overlap in different regions and some last longer than others.

For this dataset a buffer of 60 nautical miles (nmi) will be placed around the core locations for site density and distribution changes. The buffer will be 60 (nmi) for consistency since 60 nmi was the recommended distance from National Oceanic and Atmospheric Administration (NOAA) when utilizing the historic hurricane tracker. The results will reflect the number of sites per regionally applicable cultural period. The cultural periods will also be grouped into broader categories: early, middle, and late. Early cultural periods will be defined as cultural periods beginning before common era (BCE). Middle cultural periods will be defined as cultural periods beginning from the beginning of common era (CE) to 1200 CE. Late cultural periods will be defined as beginning from 1200CE to 1900CE. The results will reflect the distribution of sites per grouping.

There are limitations to the data and what it shows. The data can show us the number of sites in one area at a time. However, the timeframes cause a lot of limitation since there are some cultural periods that have a longer timeframe than others and there is no definitive time in which these sites were inhabited. Additionally, the data reflects many biases including survey bias, where some areas have been extensively surveyed and other are not, and cultural bias, where the individual who identified the site has a bias towards a particular cultural period. It is important to note that there are many other factors which can influence settlement patterns such as political changes, environmental changes, technological changes, etc. This thesis will focus on strong stormy periods as environmental change affecting settlement patterns.

In the next chapter results created utilizing the methods listed in this chapter will be displayed for discussed. The methods provided in this chapter will be pieced together to support an answer for the research questions guiding this paper.

Chapter 5: Results

The methodology described in the previous chapter provides four data sets, which will be reported in this chapter. The first data set listed will help answer the initial two research questions: What hurricane patterns existed prior to the historic record? How do these patterns compare to hurricane patterns today? The first data set results from three cores that were processed through sedimentary particle size analysis and radiocarbon dated at various depths (Parbus 2018). The second data set supports the first data set in answering the initial two questions. The second data set includes the count of historical hurricanes that have impacted each core collection location. The third data set consists of measurements of archaeologically recovered oyster shells from sites located within the general area where the cores were collected for data comparison. The measurements of the oyster shells are included to provide confirmation of storm occurrence and potential effects of storm intensity. The fourth data set helps answer the third research question: What is the relationship between hurricane patterns and early Native settlement patterns? The fourth data set reflects the site density and distribution along the Gulf Coast of Florida in the regions of study for each cultural period.

5.1 Sedimentary Particle Size Analysis

The sedimentary particle size analysis data comes from three cores that are presented by Parbus (2018), and two of the cores are located within the Panhandle region of Florida. The two cores located in the Panhandle are from Mullet Pond and Western Lakes sites. The third core from Brett Parbus's research is in the Northwest region of Florida, also known as the Big Bend. The core located in the Northwest region is from Cedar Key site. The particle size analysis is utilized to identify stormy periods, which refers to a strong storm occurrence such as a tropical storm or hurricane. This broad term, stormy periods, is utilized since the data set does not specify the intensity of the storm being recorded. Stormy periods are identified with particle analysis by examining a percent of the grain size. Larger grain size is an indication of coarser sand, a high volume of coarse sand is considered to indicate a stormy period of high energy. Each core's particle size analysis takes into consideration the different soil complexities specific to each area.

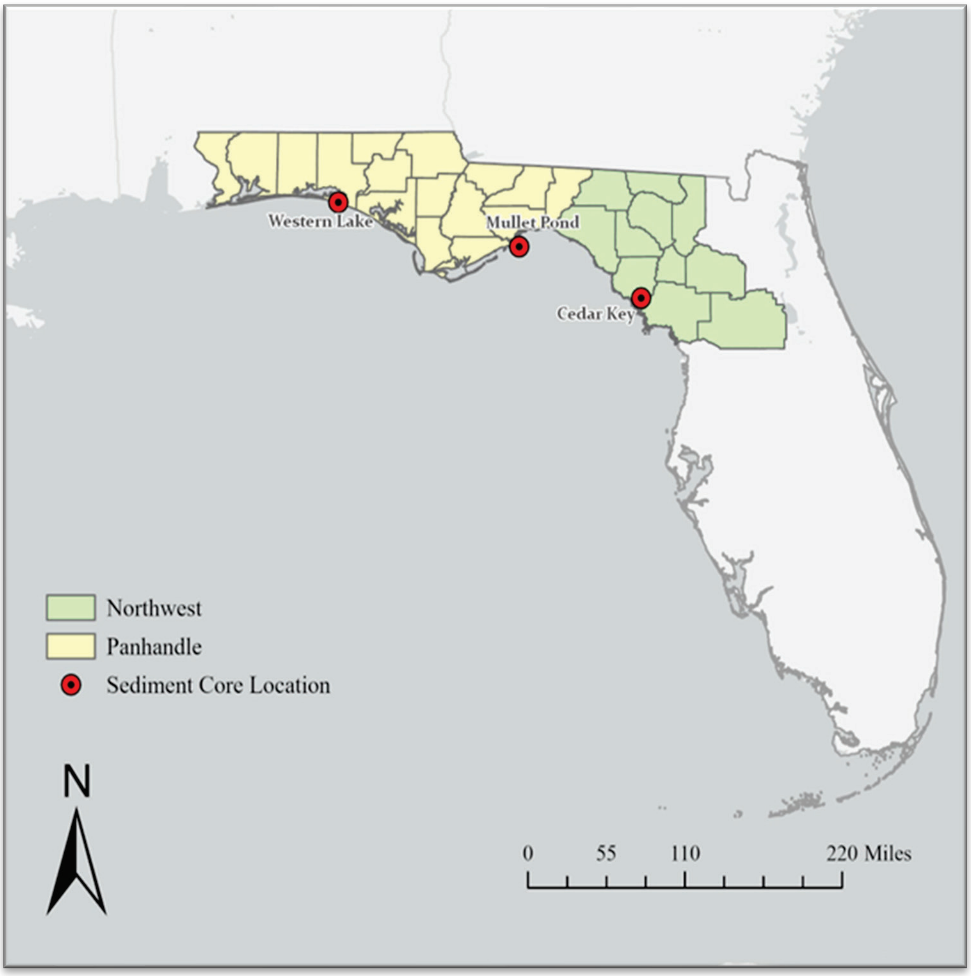

Figure 5. Map displaying the locations of the cores and what region of Florida they are located (Original work of the author).

5.1.1 Mullet Pond

The first core in the Panhandle came from Mullet Pond in Bald Point State Park, Florida. Based on Parbus's (2018) results fourteen (14) radiocarbon samples were collected, six were taken from organic sediment, and four were taken from grass/ twigs found within the core (Parbus 2018:55). The age and depth of the fourteen (14) radiocarbon samples are recorded in **Table 4**. Parbus (2018) created a linear model averaging the age to depth ratio of the radiocarbon samples recorded. The best fit linear model was created with a y-intercept of -80.324 and a slope formula of $y=0.105x-80.324$. This best fit linear model was utilized to calculate the age of stormy periods based on the depth recorded (Parbus 2018:55). The results from this linear model are recorded in **Table 5** along with a plot of the linear regression shown in **Figure 6**, originally created by Brett Parbus (2018). Parbus (2018) reported that a total of twenty-two (22) stormy periods were recognized by analyzing increases in particle size primarily focusing on the percentage of total sample volume consisting of very fine sand grains size and larger (shown in **Figure 7**). Further documentation of the stormy periods identified can be found in appendix A. Out of the twenty-two (22) stormy periods identified, twelve (12) of them go over 1 standard deviation (SD) of the mean percentile, which is an indication of heavy storm surge produced by a more intense storm. Further documentation of the stronger stormy periods identified can be found in appendix B. Parbus (2018) also analyzed the particle size diameter at fifty (50) percent of the total sample volume in microns, which refers to the median particle size of the total sample (shown in Error! Reference source not found.)(2018:55).

Table 4. Raw radiocarbon dates for samples taken from core from Mullet Pond (Parbus 2018:56).

Radiocarbon Samples Mullet Pond Core	
Depth (mm)	**Age (yr BP)**
15	645
54	905
60	870
188	860
188	1100
274	1230
308	1075
440	1085
524	1320
638	1330
784	1520
833	1440
945	1565
945	1665

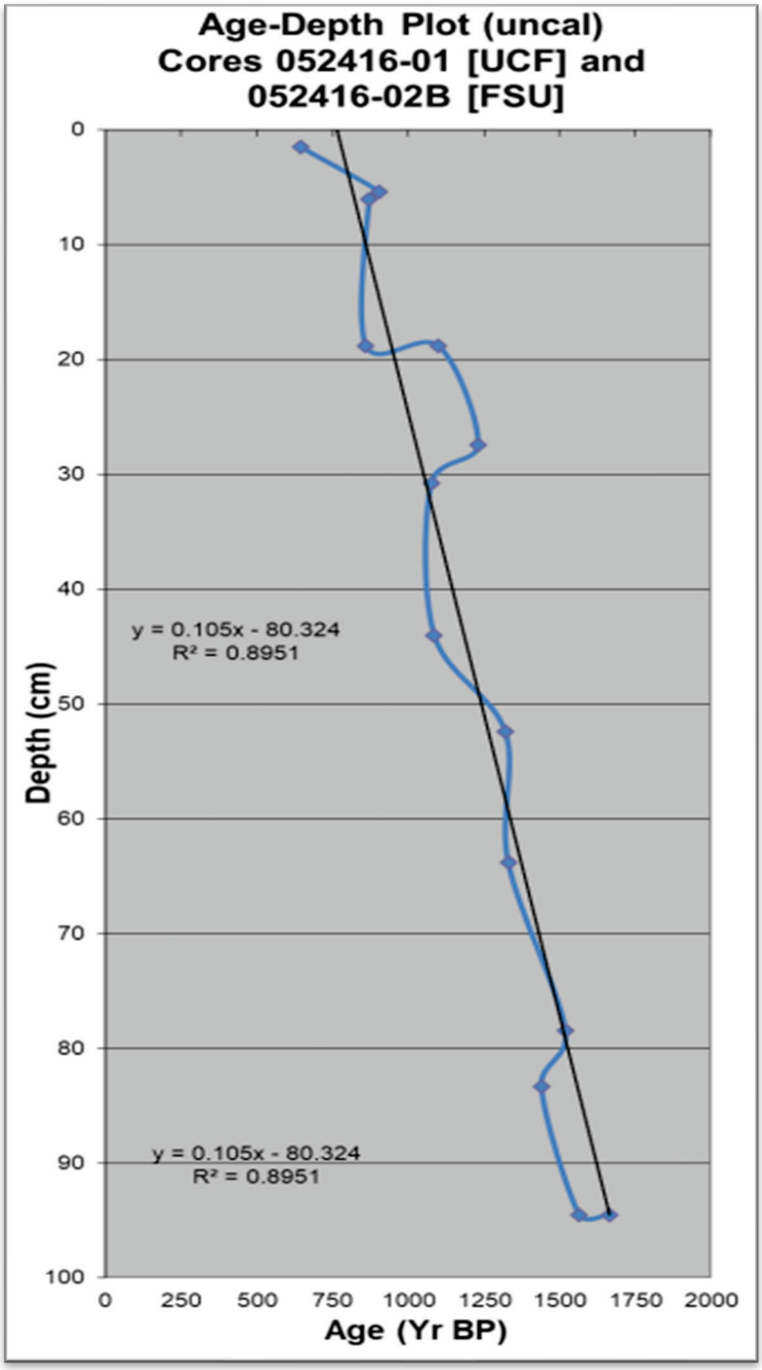

Figure 6. Linear regression of the core from Mullet Pond (Parbus 2018:57; Used with permission of Brett Parbus).

Table 5. Ages of storm periods recorded from the core from Mullet Pond. Calculation results are rounded to the nearest whole year to generate the age estimate in yr BP (Parbus 2018: 58).

Mullet Pond Core	
Core Depth (mm)	**Age (Cal yr BP)**
144	902
153	911
162	919
208	963
237	991
314	1064
320	1070
338	1087
357	1105
494	1235
502	1243
511	1252
520	1260
587	1324
677	1410
697	1429
718	1449
733	1463
739	1469
745	1474
786	1514
798	1525

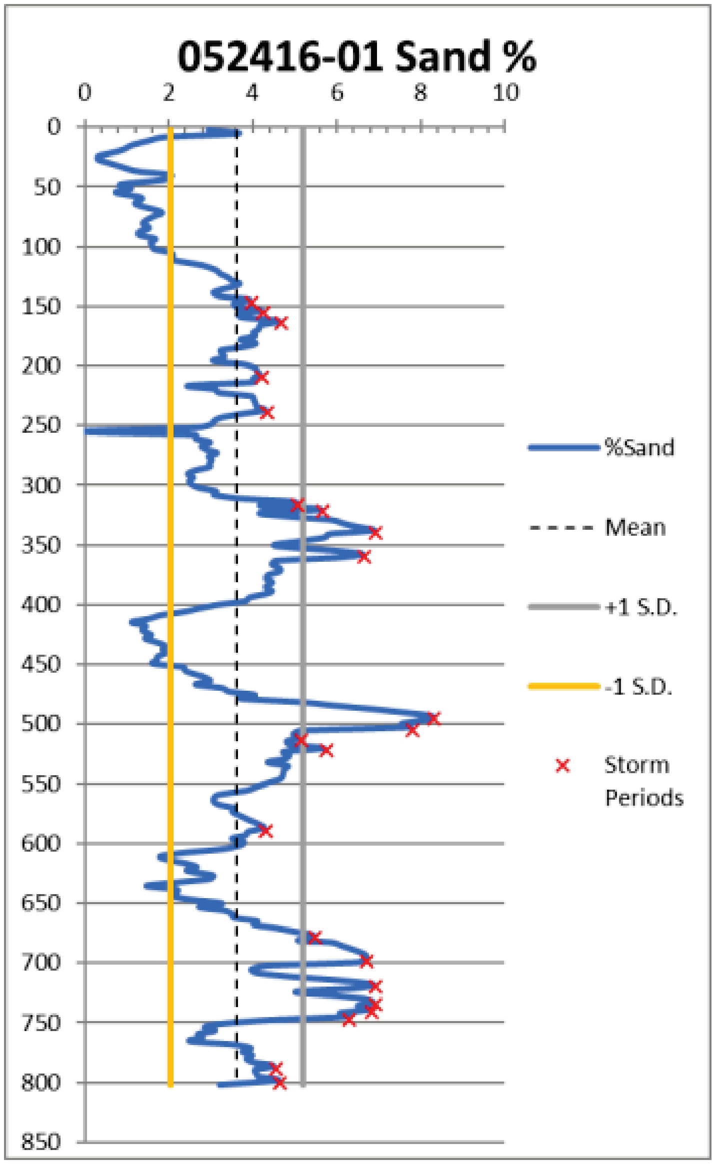

Figure 7. Sediment profile for Mullet Pond core displaying the percentage (x-axis) of total sample volume containing particles of grain size greater than or equal to very fine sand (62.5 microns). (Parbus 2018:59; Used with permission of Brett Parbus).

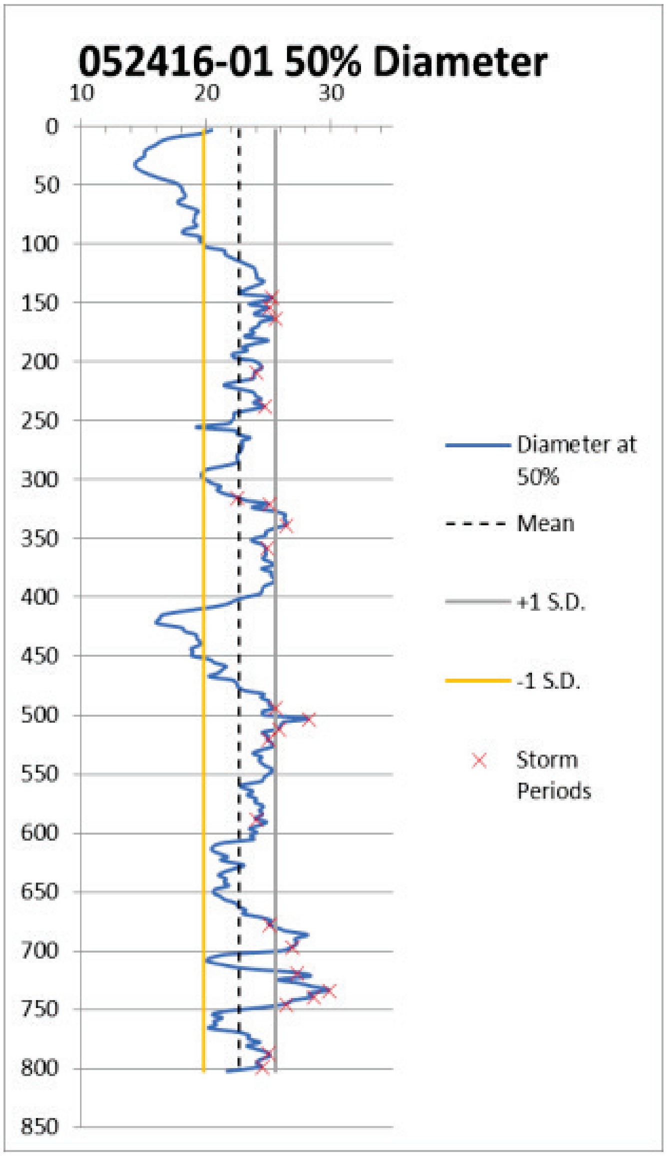

Figure 8. Sediment profile for the Mullet Pond core displaying the particle size diameter (x-axis) at 50% of the total sample volume in microns, with stormy periods indicated (Parbus 2018:60; Used with permission of Brett Parbus).

5.1.2 Western Lake

The second core in the Panhandle region of Florida is the core from Western Lake collected by Parbus (2018). There were a total of three (3) radiocarbon dates taken from organic sediment which were taken from three depths in the core (Parbus 2018:61). The depth and ages of the three (3) radiocarbon samples are recorded in **Table 6**. Parbus (2018) created a linear model averaging the age to depth ratio of the radiocarbon samples recorded. The best fit linear model was created with a y-intercept of 0 and a slope formula of y=0.0266x. This best fit linear model was utilized to calculate the age of stormy periods based on the depth recorded (Parbus 2018:61). The results from this linear model are recorded in **Table 7** along with a plot of the linear regression shown in **Figure 9** originally created by Brett Parbus (2018). The data identifies twenty-nine (29) stormy periods within the core from Western Lake, by analyzing increases in particle size focusing on the percent of total sample volume consisting of very fine sand grain size and larger and "comparisons of that plot with increases in particle size diameter at multiple cumulative percentiles as well as decreases in total percent clay and silt" (shown in **Figure 10**) (Parbus 2018: 61). Further documentation of the stormy periods identified can be found in appendix A. Out of the twenty-nine (29) stormy periods identified, twenty (20) are greater than 1 standard deviation (SD) of the mean percentile, which is an indication of heavy storm surge produced by a more intense storm. Further documentation of the stronger stormy periods identified can be found in appendix B.

Table 6. Radiocarbon dates for samples collected from the Western Lake Core (Parbus 2018:61).

Western Lake Core	
Depth (mm)	**Age (yr BP)**
280	1690
550	2230
950	3120

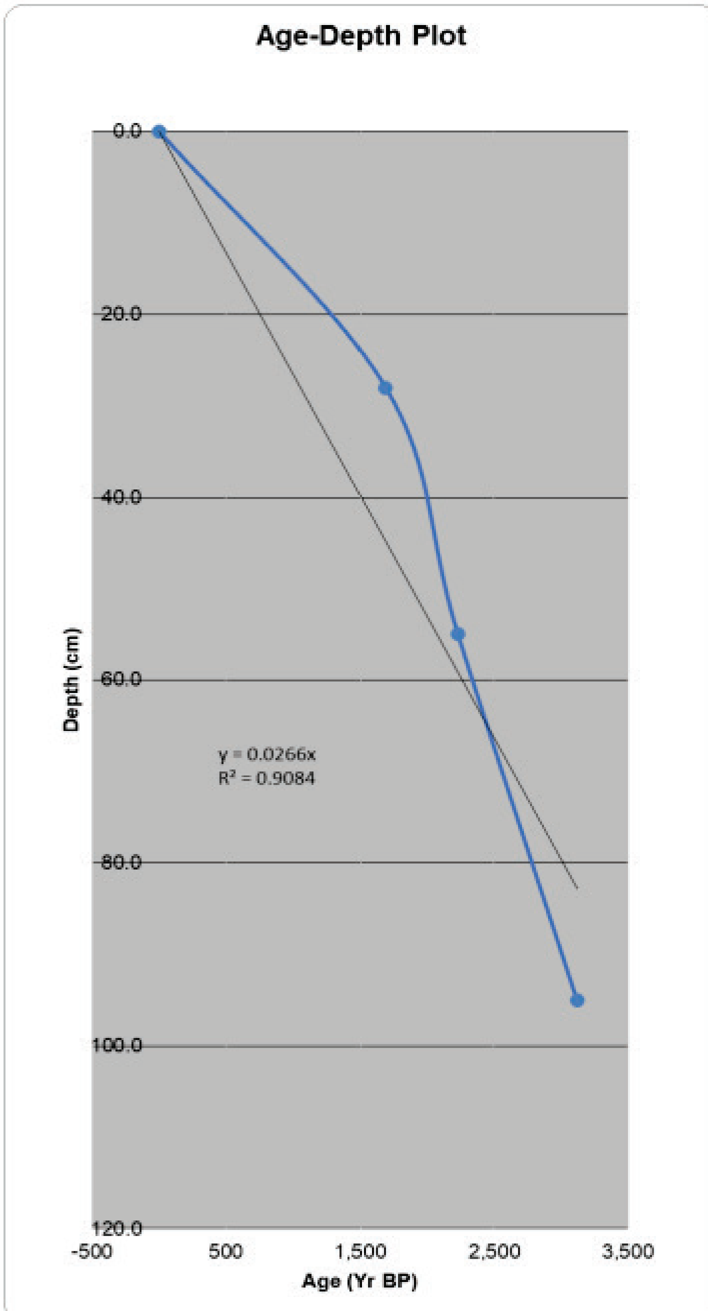

Figure 9. Linear regression of the Western Lake core (Parbus 2018:64; Used with permission of Brett Parbus).

Table 7. Ages of storm periods recorded from the core from Mullet Pond. Calculation results are rounded to the nearest whole year to generate the age estimate in yr BP (Parbus 2018: 62-63).

Western Lake Core	
Core Depth (mm)	**Age (Cal yr BP)**
12	45
31	117
46	173
63	237
79	297
88	331
97	365
118	444
128	481
136	511
148	556
191	718
225	846
235	883
269	1011
306	1150
318	1195
355	1335
454	1707
547	2056
795	2989
809	3041
830	3120
930	3496
977	3673
1026	3857
1048	3940
1076	4045
1088	4090

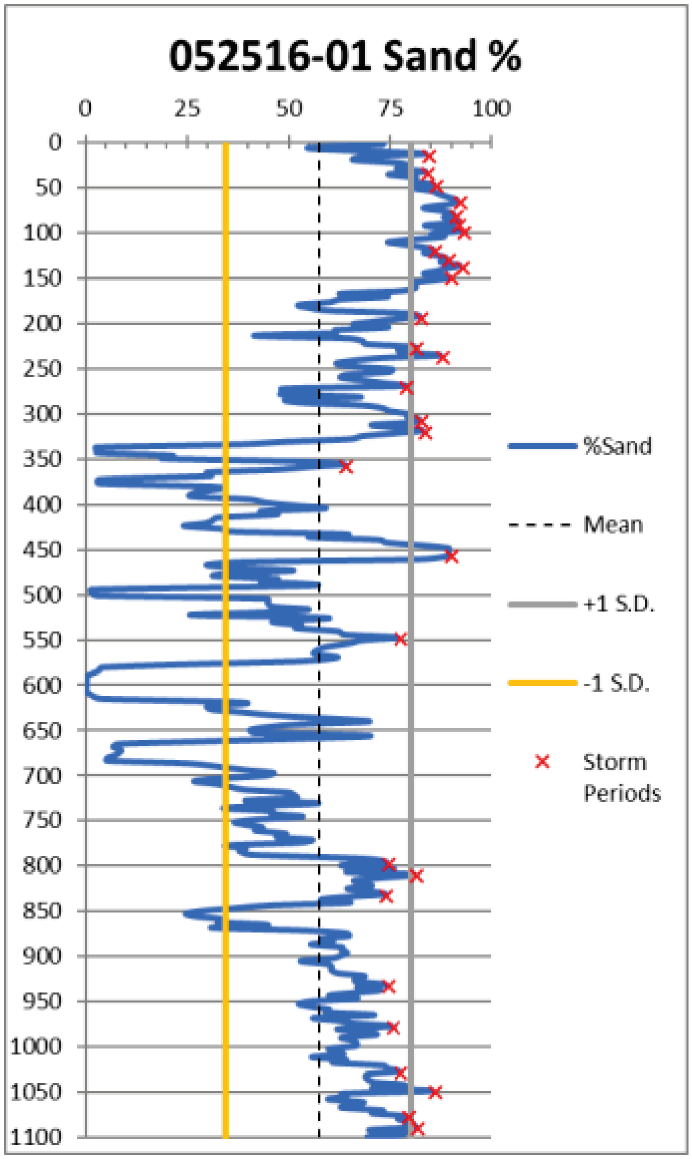

Figure 10. Sediment profile created by Parbus (2018) for the Western Lake core "displaying the percent (x-axis) of total sample volume containing particles of grain size greater or equal to very fine sand (62.5 microns)" (Parbus 2018: 65; Used with permission of Brett Parbus).

5.1.3 Cedar Key

The core collected in the Northwest region of Florida, otherwise referred to as the Big Bend region, came from the Cedar Key site. Parbus (2018) reported a total of seven (7) radiocarbon samples that were dated from various samples of "plant fragments, shell and plant matter, and sediment organic carbon." The depth and ages of the seven (7) radiocarbon samples are presented in **Table 8**. Parbus (2018) created a linear model averaging the age to depth ratio of the radiocarbon samples. The best fit linear model was created with a y-intercept of 0 and a slope formula of y=0.019x. This best fit linear model was utilized to calculate the age of stormy periods based on the depth recorded (Parbus 2018:66). The results from this linear model are recorded in **Table 9** along with a plot of the linear regression shown in **Figure 11**. There was a total of nineteen (19) stormy periods identified from the core from Cedar Key (shown in **Figure 12**). Further documentation of the stormy periods identified can be found in appendix A. These stormy periods were identified by analyzing increases in particle size focusing on the percentage of total sample volume consisting of very fine sand grain size and larger and "the comparison of that plot with increases in particle size diameter at multiple cumulative percentiles as well as decreases in total percent clay and silt" (Parbus 2018: 66). All of the stormy periods identified are greater than 1 standard deviation (SD) of the mean percentile, which is an indication of heavy storm surge produced by a more intense storm.

Table 8. Depth and radiocarbon dates for samples taken from the Cedar Key core (Parbus 2018:66).

Cedar Key Core	
Depth (mm)	**Age (yr BP)**
30	0
50	0
125	200
275	840
300	990
398	1920
505	2285
505	3350

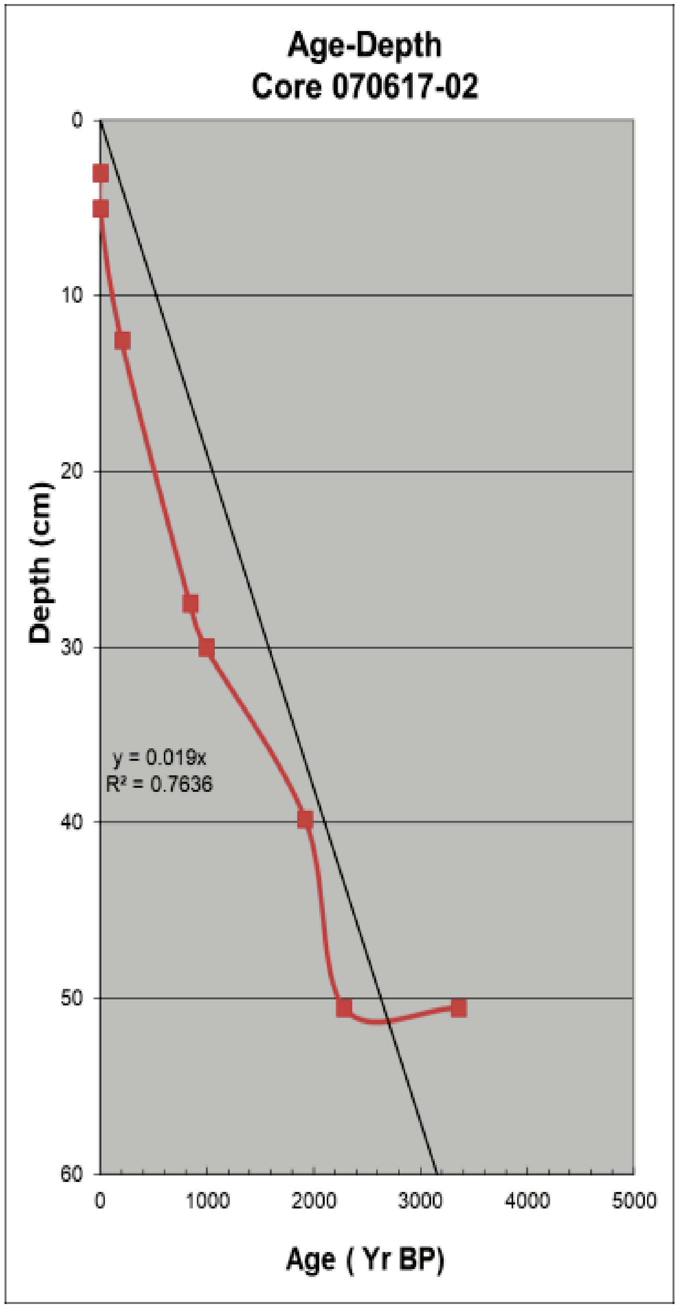

Figure 11. Linear regression plotted for the Cedar Key core (Parbus 2018: 67; Used with permission of Brett Parbus).

Table 9. Ages of storm periods recorded from the core from Mullet Pond. Calculation results are rounded to the nearest whole year to generate the age estimate in yr BP (Parbus 2018: 68).

Cedar Key Core	
Core Depth (mm)	**Age (yr BP)**
302	1589
308	1621
320	1684
329	1732
335	1763
350	1842
365	1921
374	1968
386	2032
392	2063
404	2126
443	2332
455	2395
464	2442
473	2489
479	2521
524	2758
533	2805
539	2837

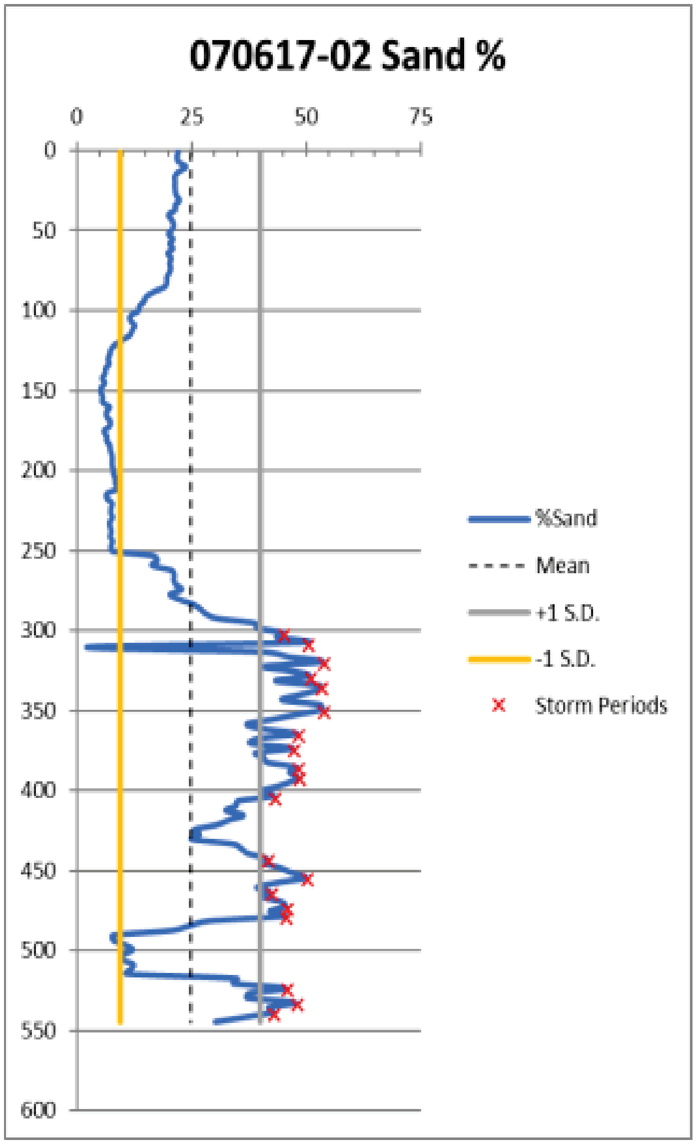

Figure 12. Sediment profile of the Cedar Key core displaying the percentage (x-axis) of total sample volume containing particles of grain size greater than or equal to very fine sand (62.5 microns) (Parbus 2018: 68; Used with permission of Brett Parbus).

5.2 Historical Hurricanes

Historical hurricanes that were tracked within 60 nautical miles (nmi) of each core collection location was recorded. Historical hurricanes were identified utilizing the *Historical Hurricane Tracks* database created by the National Oceanic and Atmospheric Administration

(NOAA) (2024c). A radius of 60 nmi is utilized since it is the recommended search distance on the database. The data below identifies all hurricanes that fall within the research area. The data below also identifies all major hurricanes that fall within the research area. A major hurricane is defined as a hurricane categorized as a 3 or higher (sustained winds greater than 110 mph) (Florida Climate Center 2023). It is noted by NOAA that "the number and intensities of U.S. hurricanes is underestimated before 1901 due to the sparsely populated U.S. coastlines" (Landsea et al. 2024).

5.2.1 Mullet Pond

Within 60 nmi of the Mullet Pond core a total of seventy-seven (77) hurricanes and tropical storms can be tracked from 1852 to 2024 (NOAA 2024c). A list of all hurricanes and tropical storms that can be tracked within 60 nmi of the Mullet Pond core can be found in Appendix C. The time between the hurricanes averaged to approximately 2 years. The total number of storms per category within the buffer is expressed in **Table 10**. Out of all the hurricanes tracked only five (5) were categorized as major hurricanes with four (4) of them making landfall within 60 nmi. A list of all major hurricanes that made landfall within 60 nmi of the Mullet Pond core can be found in Appendix E. Two (2) of the major hurricanes were category 3 hurricanes in 1877 and 1894. Another two of the major hurricanes were category 4 hurricanes in 2023 (Idalia) and 2024(Helene). The fifth major hurricane was hurricane Michael from 2018 which was a category 5 hurricane (NOAA 2024c). The time between the major hurricanes averaged to approximately 29 years.

Table 10. Total number of historical hurricanes impacting within 60 nmi of the Mullet Pond core collection location (NOAA 2024c).

Storm Category	**Total**
Tropical Storm (39 to 73 mph)	51
Category 1 (74 to 95 mph)	14
Category 2 (96 to 110 mph)	7
Category 3 (111 to 129 mph)	2
Category 4 (130 to 156 mph)	2
Category 5 (>156 mph)	1

5.2.2 Western Lake

Within 60 nmi of the Western Lake core a total of sixty-six (66) hurricanes and tropical storms can be tracked from 1851 to 2021 (NOAA 2024c). A list of all hurricanes and tropical storms that can be tracked within 60 nmi of the Western Lakes core can be found in Appendix C. The time between the hurricanes averaged to approximately 3 years. The total number of storms per category within the buffer is expressed in **Table 11**. Out of all the hurricanes tracked only eleven (11) were categorized as a major hurricane with nine (9) making landfall within 60 nmi. A list of all major hurricanes that made landfall within 60 nmi of the Western Lakes core can be found in Appendix E. There are a total of nine (9) category 3 hurricanes, and those hurricanes occurred in 1851, 1877, 1882, 1894, 1917, 1926, 1975 (Eloise), 1985 (Elena), and 1995 (Opal). One of the other major hurricanes was hurricane Denis in 2005 which was a category 4, and then hurricane Michael in 2018 which was a category 5 hurricane (NOAA 2024c). The time between the major hurricanes averaged to approximately 15 years.

Table 11. Total number of historical hurricanes impacting within 60 nmi of the Western Lake core collection location (NOAA 2024c).

Storm Category	Total
Tropical Storm (39 to 73 mph)	34
Category 1 (74 to 95 mph)	14
Category 2 (96 to 110 mph)	7
Category 3 (111 to 129 mph)	9
Category 4 (130 to 156 mph)	1
Category 5 (>156 mph)	1

5.2.3 Cedar Key

Within 60 nmi of the Cedar Key core a total of seventy-three (73) hurricanes and tropical storms can be tracked between 1867 to 2024 (NOAA 2024c). A list of all hurricanes and tropical storms that can be tracked within 60 nmi of the Cedar Key core can be found in Appendix C. The time between the hurricanes averaged to approximately 2 years. The total number of storms per category within the buffer is expressed in **Table 12**. Out of all the hurricanes tracked only four (4) were categorized as a major hurricane with all four making landfall within 60 nmi. Two of the major hurricanes were category 3 in 1896 and 1950 (Easy). The other two major hurricanes were category 4 hurricanes in 2023 (Idalia) and 2024 (Helene) (NOAA 2024c). A list of all major hurricanes that made landfall within 60 nmi of the Cedar Key core can be found in Appendix E. The time between the major hurricanes averaged to approximately 32 years.

Table 12. Total number of historical hurricanes impacting within 60 nmi of the Western Lake core collection location (NOAA 2024c).

Storm Category	**Total**
Tropical Storm (39 to 73 mph)	46
Category 1 (74 to 95 mph)	17
Category 2 (96 to 110 mph)	6
Category 3 (111 to 129 mph)	2
Category 4 (130 to 156 mph)	2
Category 5 (>156 mph)	0

The historical hurricane data shows us the current hurricane pattern for each study area. In Chapter 6 the data will be compared with the storm patterns identified with the sedimentary particle size analysis data.

5.3 Oyster Height Data

Oyster measurements were collected from sites within a 40-mile radius of the core collection locations, except Mullet Pond which was within 40.92 miles. The sites were selected by sorting through the Florida Master Site File database to identify sites within the desired radius that contained oysters in their collections. Coordination with the Florida Bureau of Archaeological Research occurred to decipher what collections were available. On May 23rd, 2024, I visited the Florida Bureau of Archaeological Research to collect measurements of oyster heights. The oyster height measurements were collected from a total of seven different sites. The shells heights were measured following a standardized methodology measuring from the "umbo (the high point near the hinge of the two shells) to the farthest away point" (Venolia 2018). The six sites utilized were originally collected in between 1970 to 2006 when collections guidelines in Florida were limited. Due to this many of the bags in the collections to lack labels of provenience besides the site number.

5.3.1 Mullet Pond

For the Mullet Pond core, only one archaeological site was referenced for oyster height data. The site referred to for oyster data collection is site 8FR00014, approximately 40.92 miles from the core's location. The spatial location of the site in reference to the Mullet Pond core is displayed in **Figure 13**. A total of nineteen (19) oysters were measured from the site's collection. The shell heights ranged from 46.27 to 128.07 mm with an average height of 80.92 mm. The height measurements collected for site 8FR00014 are shown in **Table 13**.

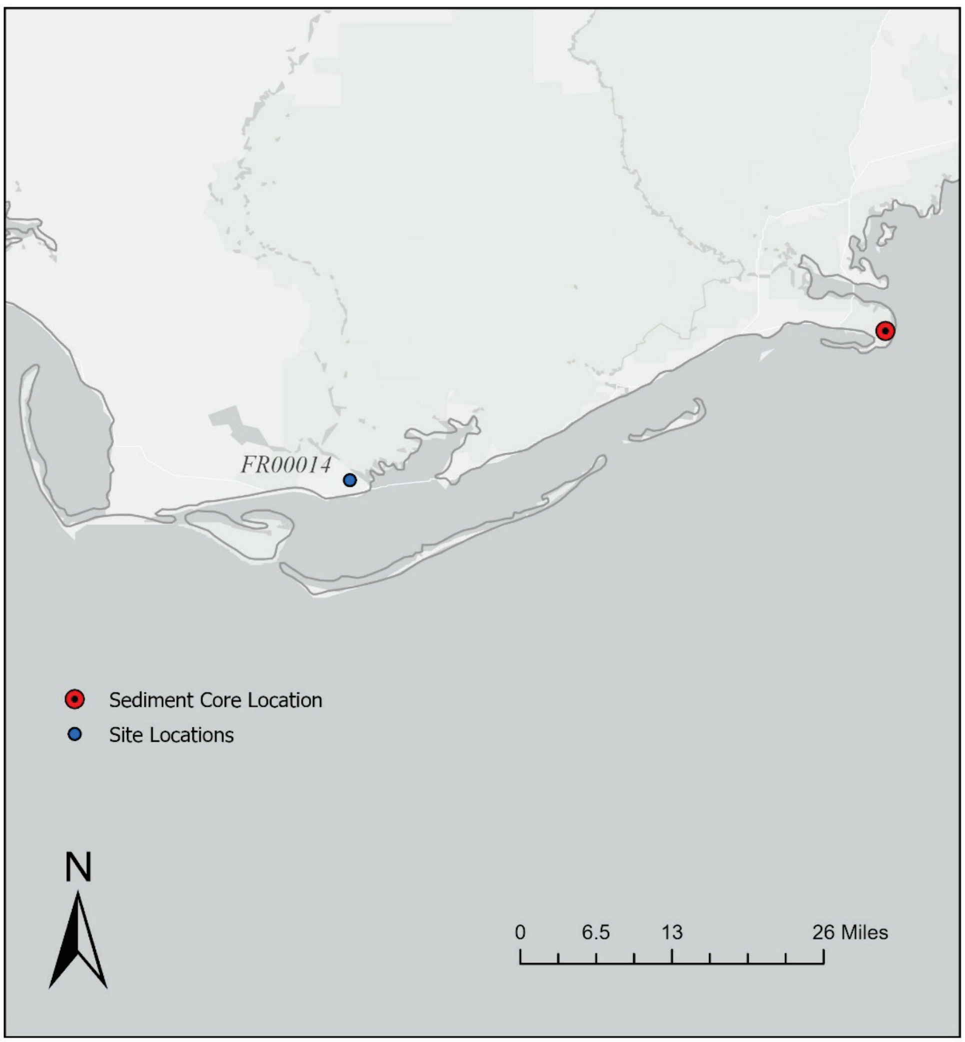

Figure 13. Map displaying the spatial location between the Mullet Pond core and the precise location of site FR00014. (Original work of the author)

Table 13. Oyster shell height measurements in millimeters (mm) for site located within a 40-mile radius of the Mullet Pond core.

Mullet Pond	
Oyster Height (mm) for the following sites:	
8FR00014	
75.52	76.91
66.76	57.38
89.86	89.99
47.88	71.24
46.27	90.77
84.81	128.07
93.19	71.86
81.50	128.07
79.35	
86.36	
71.86	

5.3.2 Western Lake

The oyster data collected for the Western Lake core location referenced two different sites, 8WL2267 and 8WL2269. Site 8WL2267 is approximately 3.12 miles from the core's location and site 8WL2269 is 4.37 miles from the core's location. The spatial location of the site in reference to the core is shown in **Figure 14**. Between the two sites referenced a total of thirteen (13) oysters were measured, two (2) from 8WL2267 and eleven (11) from 8WL2269. The heights ranged from 20.75 to 110.25 mm with a height average of 47.74 mm. The height measurements collected for sites 8WL2267 and 8WL2269 are shown in **Table 14**.

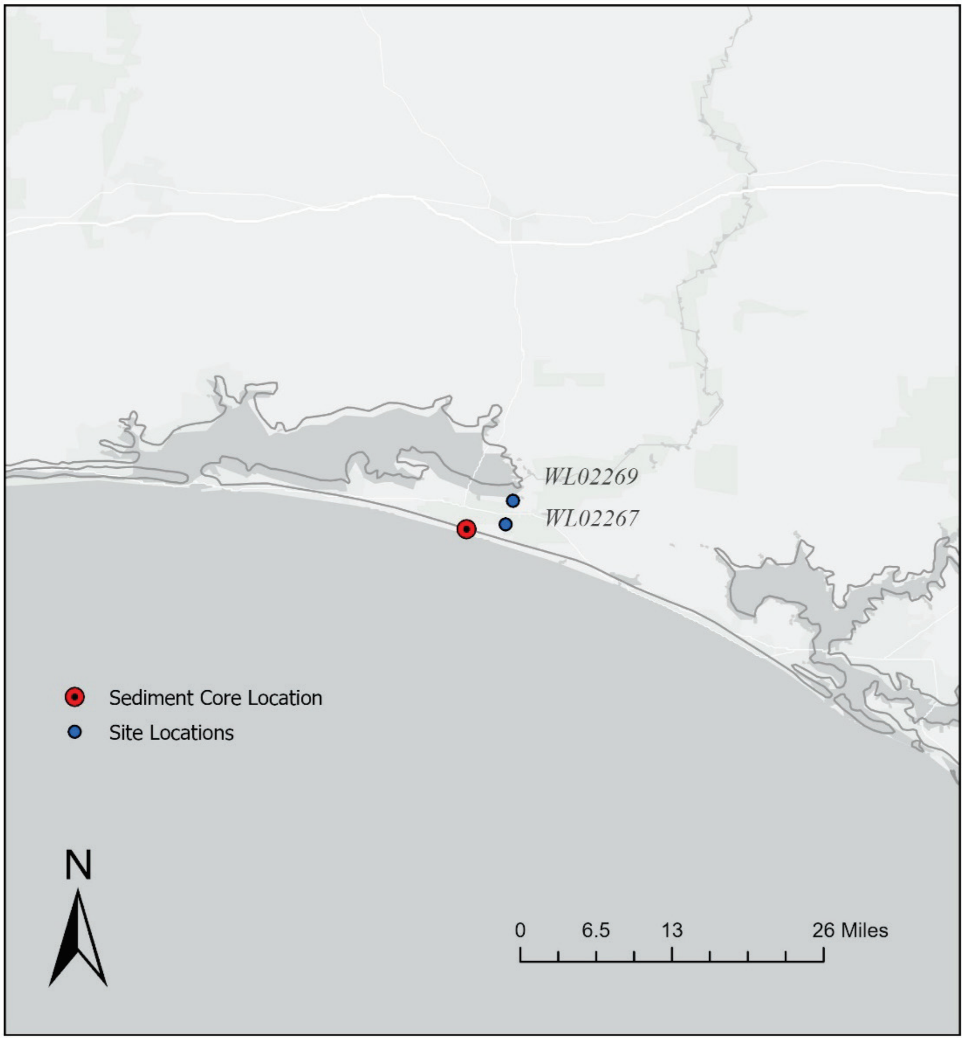

Figure 14. Map displaying the spatial location between the Western Lake Pond core and the precise locations of sites WL02269 and WL02267. (Original work of the author)

Table 14. Oyster shell height measurements in millimeters (mm) for sites located within a 40-mile radius of the Western Lake Pond core.

Western Lake	
Oyster Height (mm) for the following sites:	
8WL2267	**8WL2269**
20.75	33.58
110.25	23.17
	35.24
	63.54
	60.09
	62.49
	48.51
	48.63
	33.54
	36.73
	44.17

5.3.3 Cedar Key

The oyster data that was collected for the Cedar Key core location referenced three different archaeological sites 8LV00126, 8LV00032, and 8LV0537. Site 8LV00126 is 16.85 miles from the core location, 8LV00032 is 8.84 miles from the core location, and 8LV00537 is 14.83 miles from the core location. The spatial location of the sites in reference to the core is displayed in **Figure 15**. Between the three sites a total of fifty-one (51) oysters were measured. Five of the oysters measured came from site 8LV00126, from site 8LV00032 twenty-six (26) oysters were measured, and from site 8LV00537 twenty (20) oysters were measured. The heights ranged from 21.53 to 92.79 mm with an average height of 54.93 mm. The height measurements collected are shown in **Table 15**.

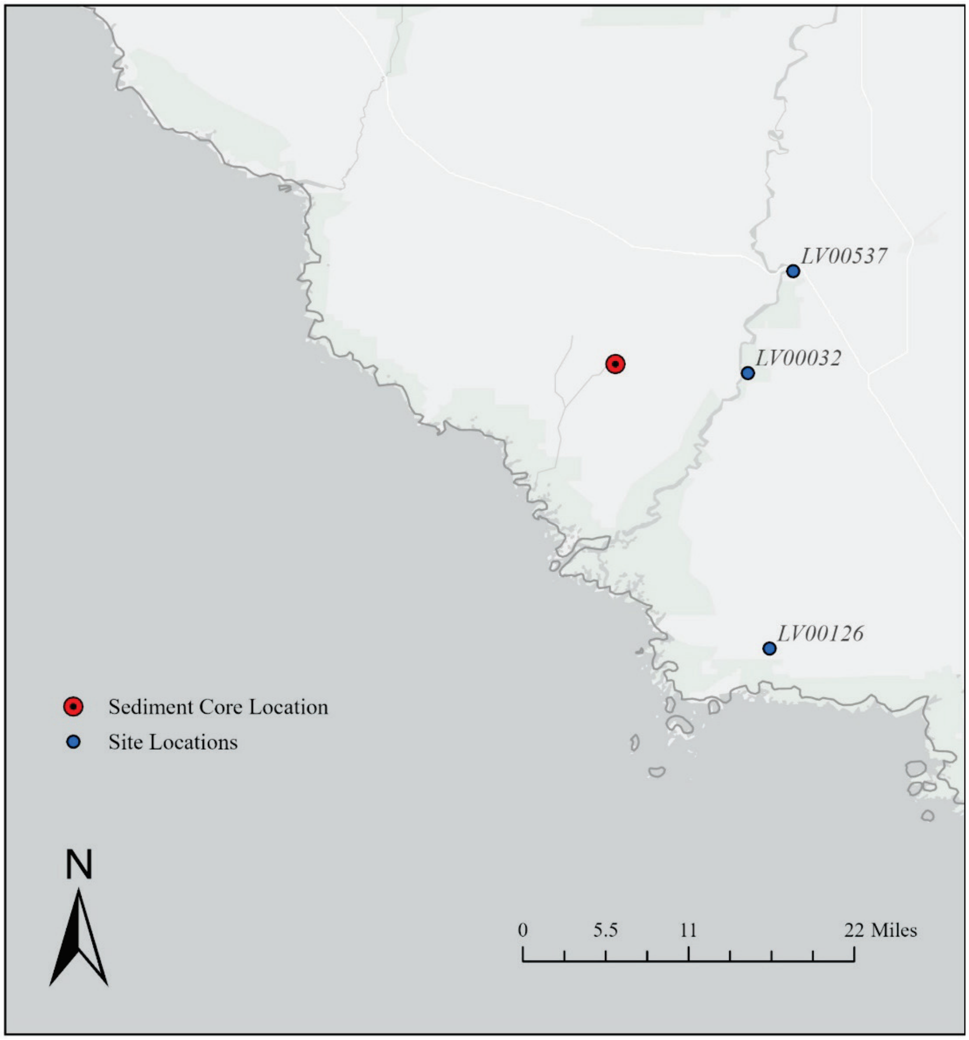

Figure 15. Map displaying the spatial location between the Cedar Key core and the precis locations of sites LV00537, LV00032, and LV00126. (Original work of the author)

Table 15. Oyster shell height measurements in millimeters (mm) for sites located within a 40-mile radius of the Cedar Key core.

Cedar Key		
Oyster Height (mm) for the following sites:		
8LV00126	**8LV00032**	**8LV00537**
66.58	61.83	86.14
44.76	46.92	53.87
71.88	54.17	64.55
92.79	58.58	77.25
62.91	54.97	58.60
	44.55	61.84
	61.53	60.56
	71.01	58.80
	50.93	64.16
	42.94	52.90
	56.82	55.31
	57.53	55.10
	50.25	47.20
	34.22	22.35
	42.82	26.02
	61.48	24.89
	63.74	26.94
	81.34	27.82
	55.13	21.53
	74.60	31.20
	89.13	
	67.28	
	51.04	
	40.20	
	58.09	
	46.79	

5.4 Archaeological Site Density and Distribution

The archaeological site density and distribution of each core location was evaluated with a 60 nmi buffer utilizing a shapefile of archaeological site location received from the Florida Master Site File (2024) obscured within a 3000 m (2-3 mi) radius of the actual locations. The cultural information within the dataset is derived from site forms that have been submitted to the Florida Master Site File. The information on the files is not always verified. The Florida Master Site files organize the data by cultural periods. The regions of Florida vary on what cultural periods were active within the regions and tend to have some timeframe overlap. Sites can be categorized into as many as 8 cultural periods within this dataset, therefore sites can be counted for representation of more than one cultural period. Some sites have been identified as just prehistoric with no specification of cultural era of occurrence. It is also important to note the site data can reflect survey bias, where some areas have been extensively surveyed more than others.

The results below will display the number of sites per regionally applicable cultural period. The results will also display the distribution of sites per grouping. The cultural periods are grouped into broader categories: early, middle, and late. Early cultural periods will be defined as cultural periods beginning before common era (BCE). Middle cultural periods will be defined as cultural periods beginning from the beginning of common era (CE) to 1200 CE. Late cultural periods will be defined as beginning from 1200CE to 1900CE.

5.4.1 Mullet Pond

The total number of sites recorded within 60 nmi of the Mullet Pond core collection location is 4,479. There are sixteen (16) cultural periods that apply to the region. Those sixteen (16) cultural periods are listed in **Table 16** with the corresponding site quantity within the buffer. The distribution of sites per cultural period grouping of early, middle, late is showed below. The early cultural period sites in **Figure 16** show the distribution of sites being denser inland with portions of the coast also having some densely grouped areas. The middle cultural period sites in **Figure 17** shows some dense portions along the coast and more sporadic distribution inland, but a higher quantity of sites was inland. The late cultural period sites in **Figure 18** show the distribution of sites being denser inland with sporadic sites along the coast. Throughout all cultural periods sites populate near a major water resource.

Table 16. Number of sites per applicable cultural period within 60 nmi of the Mullet Pond core collection location. Data provided by FMSF 2024.

Mullet Pond	
Cultural Period	**Number of Sites**
Paleoindian 10000-7500 BCE	88
Archaic 7500- 2000 BCE	982
Orange 2000-1000 BCE	6
Norwood 2000-500 BCE	112
Woodland 1000 BCE- 1500 CE	54
Deptford 500 BCE-200 CE	425
Swift Creek 100-800 CE	237
Santa Rosa 200-500 CE	35
Weeden Island 400- 1100 CE	755
Safety Harbor 900-1600 CE	1
Mississippian 1000-1500 CE	20
Pensacola 1100-1700 CE	3
Fort Walton 1200-1500 CE	727
Alachua 1250-1500 CE	5
Leon-Jefferson 1500-1704 CE	525
Seminole 1715-1842 CE	48

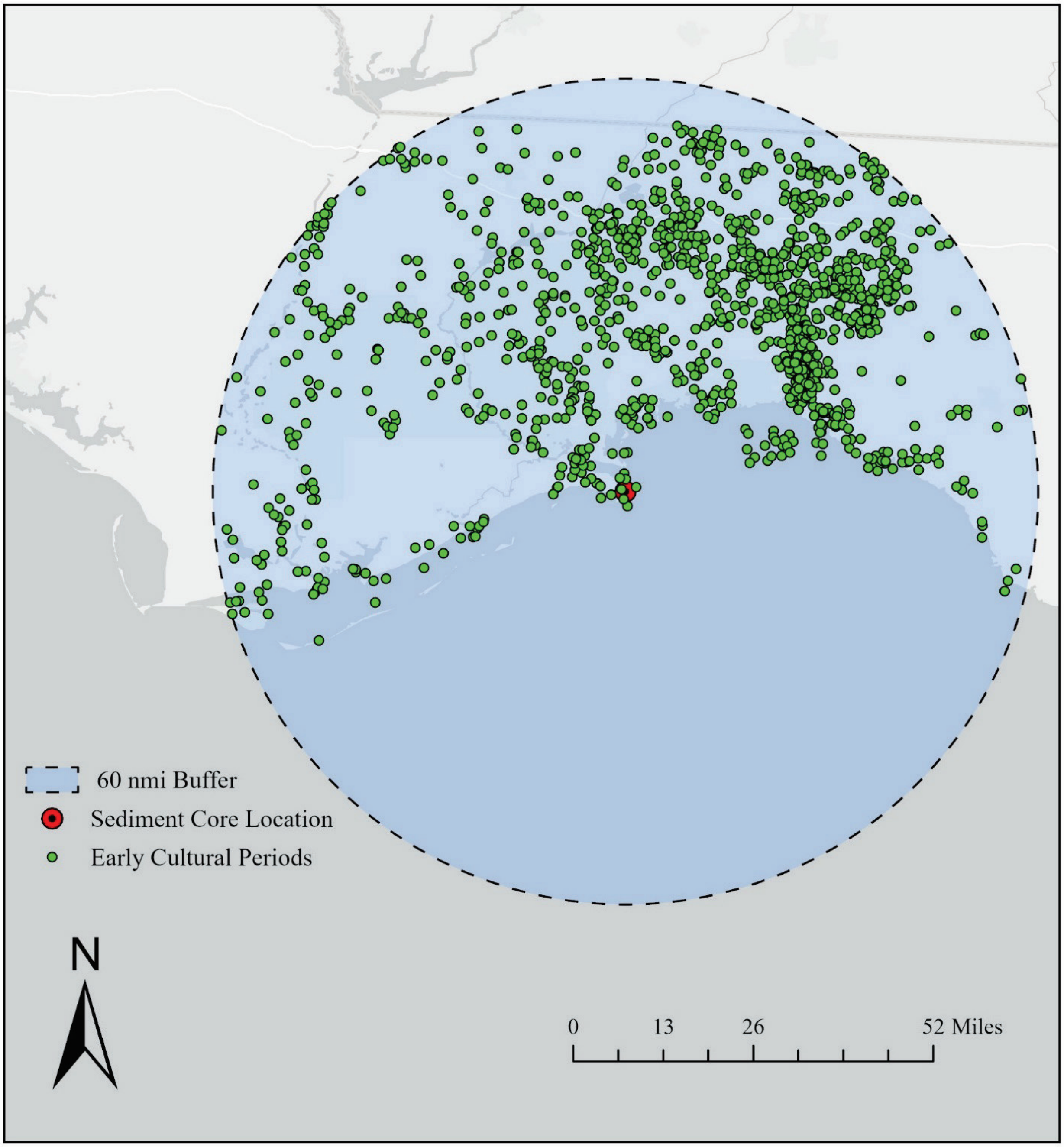

Figure 16. Distribution the obscured locations of early cultural period sites within 60 nmi of the Mullet Pond core. Data provided by FMSF 2024. (Original work of the author)

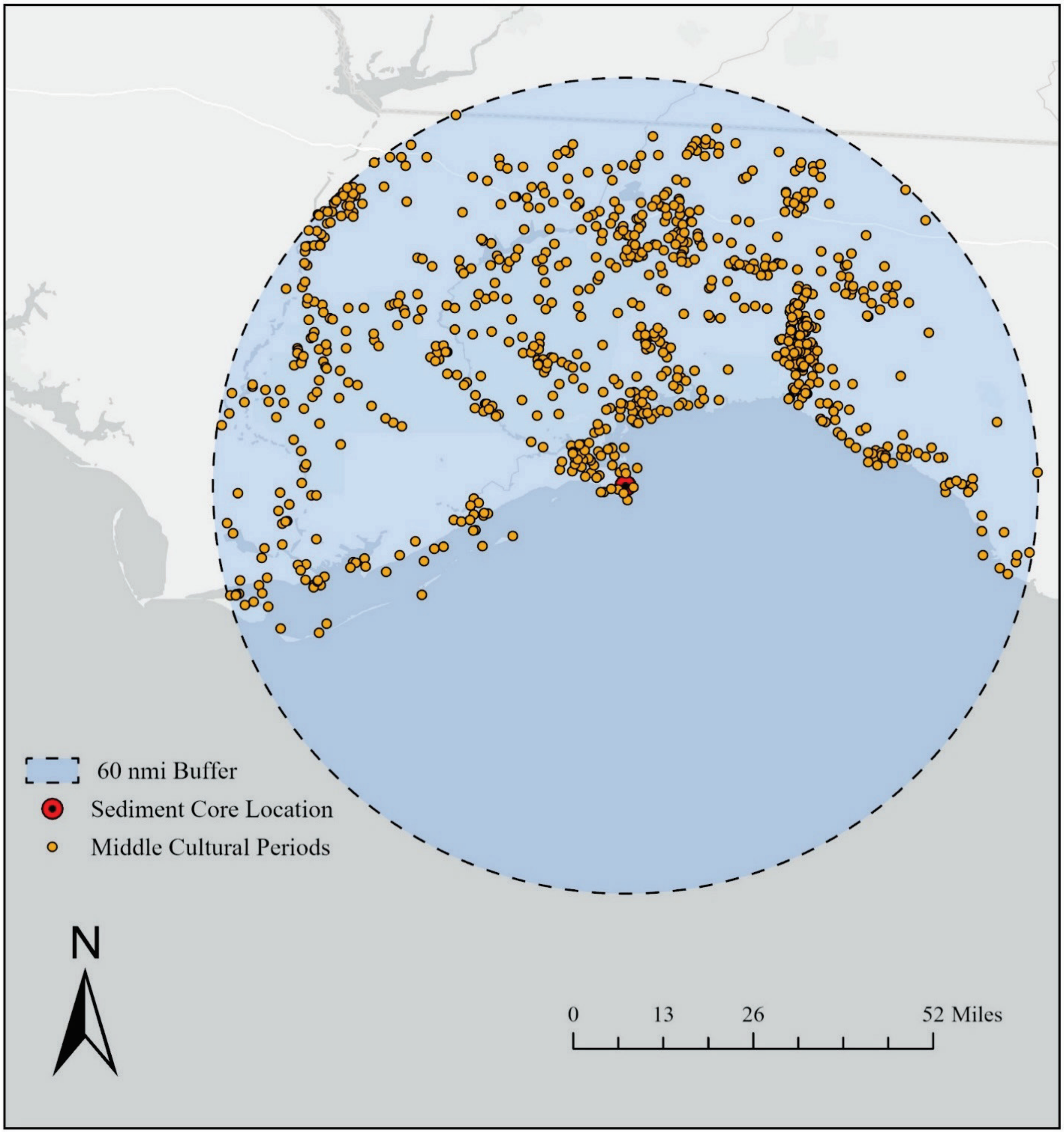

Figure 17. Distribution the obscured locations of middle cultural period sites within 60 nmi of the Mullet Pond core. Data provided by FMSF 2024. (Original work of the author)

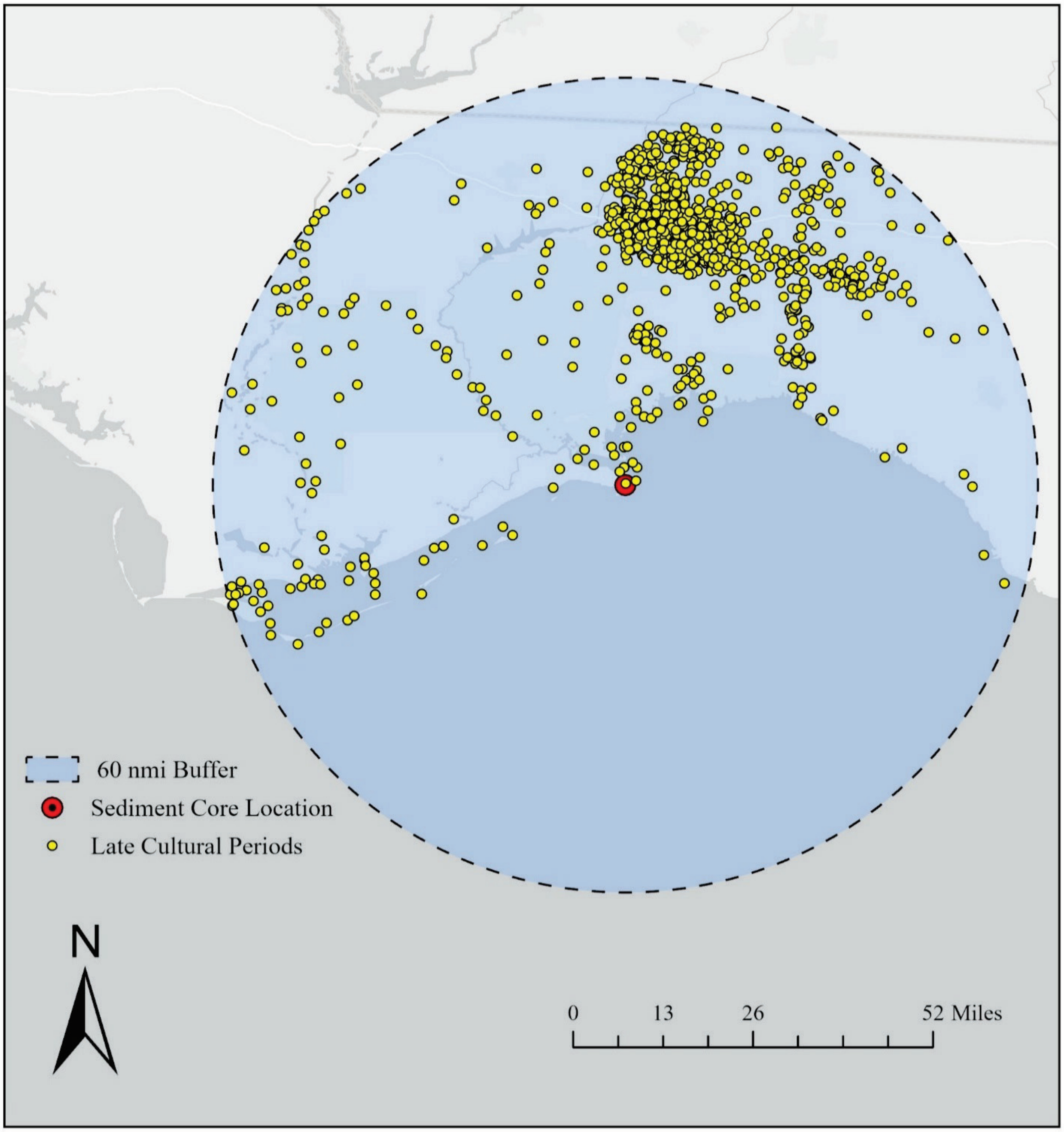

Figure 18. Distribution the obscured locations of late cultural period sites within 60 nmi of the Mullet Pond core. Data provided by FMSF 2024. (Original work of the author)

5.4.2 Western Lake

The total number of sites recorded within 60 nmi of the Western Lake core collection location is 5,665. There are seventeen (17) cultural periods that apply to the region. Those seventeen (17) cultural periods are listed in **Table 17** with the corresponding site quantity within the buffer. The distribution of sites per cultural period grouping of early, middle, late is showed below. The early cultural period sites in **Figure 19** show the distribution of sites is dense inland with some dense clusters along the coast. The middle cultural period sites in **Figure 20** show site is denser along the coast. There are some sites distributed in one dense cluster of sites more inland. Sites more inland are distributed more sporadically. The late cultural period sites in **Figure 21** show an overall significant decline in site density. Majority of the sites are distributed along the coast with some a few sporadic sites placed inland. Throughout all cultural periods sites populate near a major water resource.

Table 17. Number of sites per applicable cultural period within 60 nmi of the Western Lake core collection location. Data provided by FMSF 2024.

Western Lake	
Cultural Period	**Number of Sites**
Paleoindian 10000-7500 BCE	80
Dalton 8000-6000 BCE	3
Archaic 7500- 2000 BCE	559
Orange 2000-1000 BCE	3
Norwood 2000-500 BCE	50
Woodland 1000 BCE- 1500 CE	321
Deptford 500 BCE-200 CE	416
Swift Creek 100-800 CE	124
Santa Rosa 200-500 CE	289
Weeden Island 400- 1100 CE	1541
Safety Harbor 900-1600 CE	1
Mississippian 1000-1500 CE	68
Pensacola 1100-1700 CE	109
Fort Walton 1200-1500 CE	295
Alachua 1250-1500 CE	2
Leon-Jefferson 1500-1704 CE	10
Seminole 1715-1842 CE	6

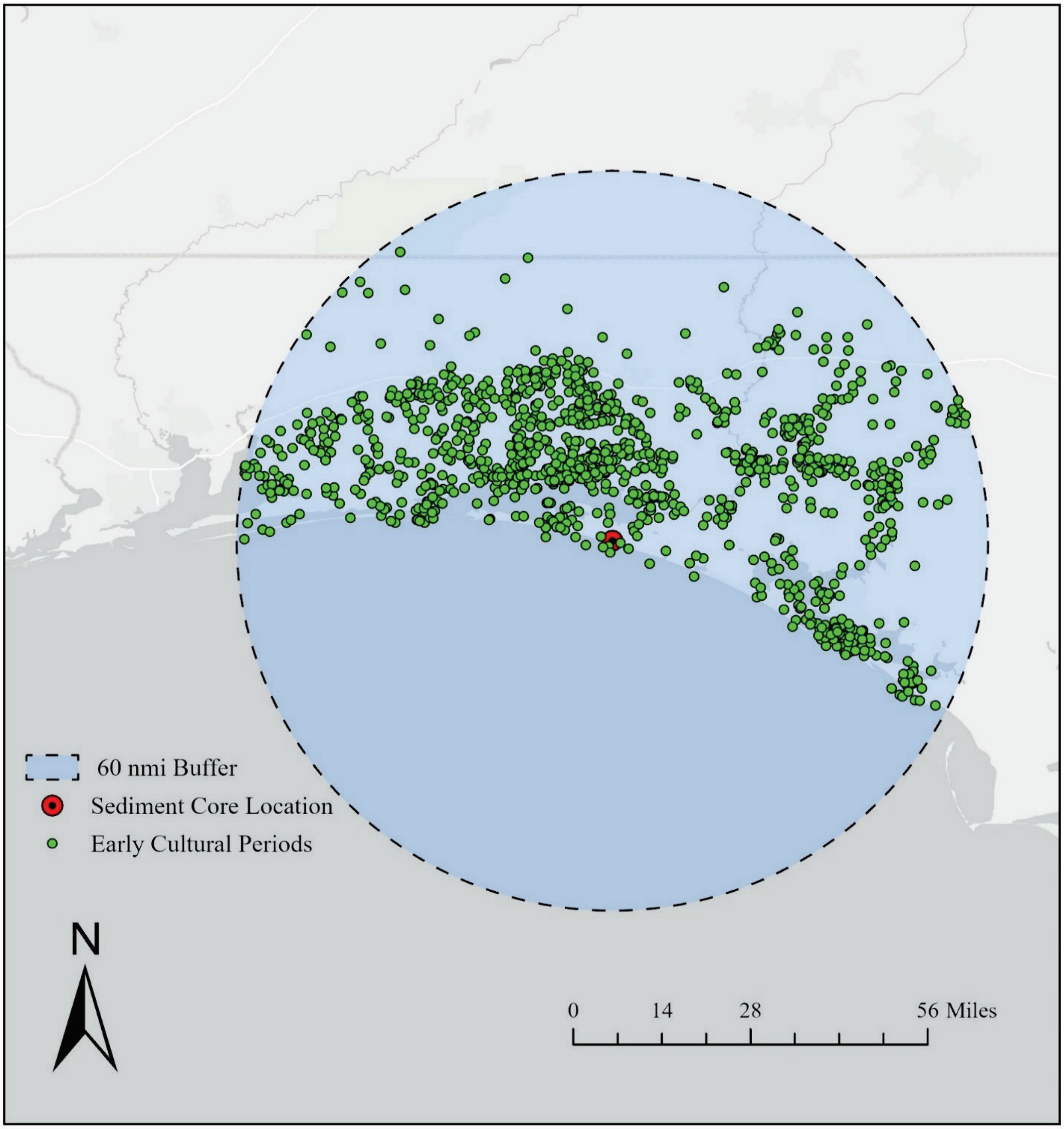

Figure 19. Distribution the obscured locations of early cultural period sites within 60 nmi of the Western Lake core. Data provided by FMSF 2024. (Original work of the author)

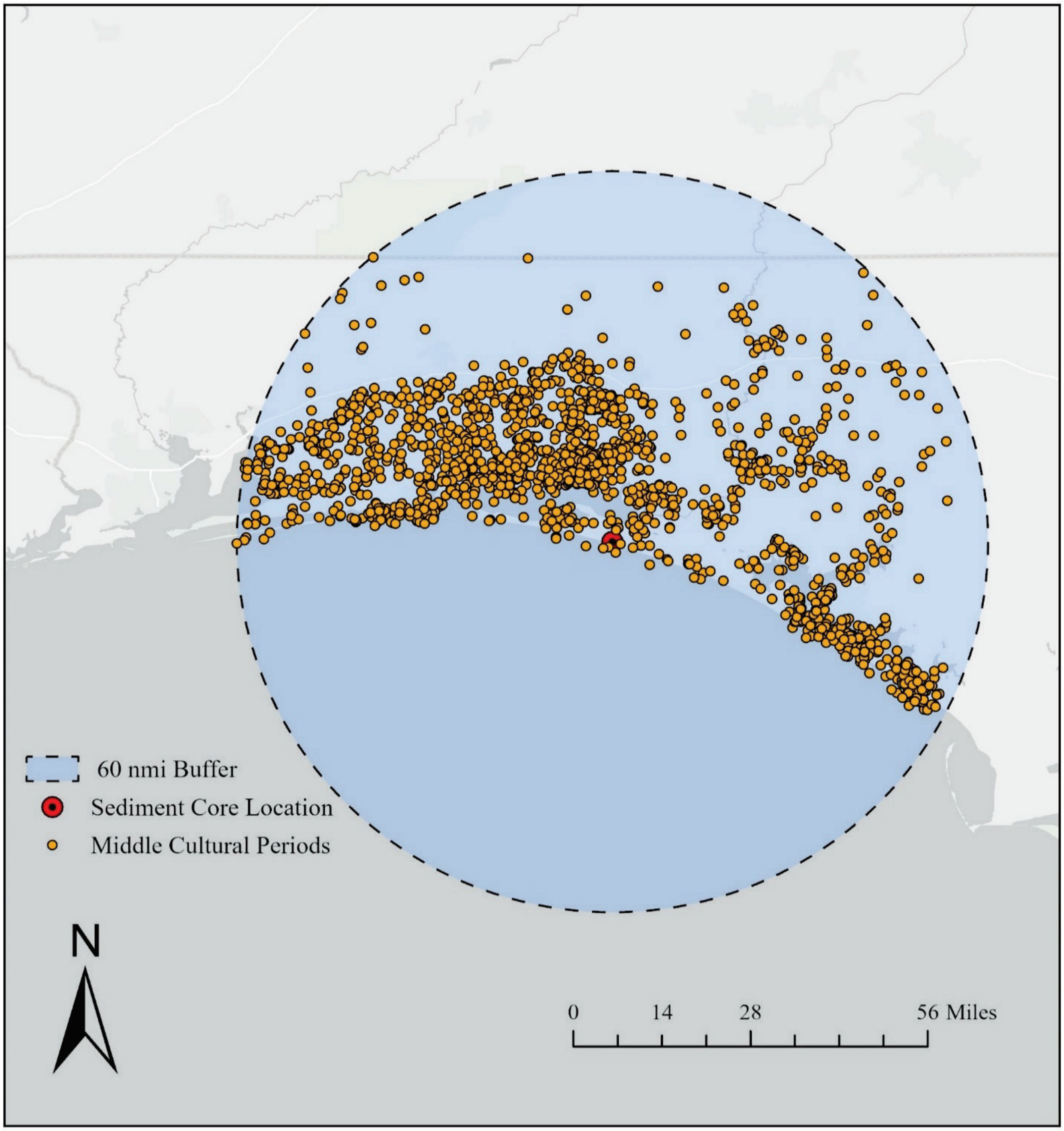

Figure 20. Distribution the obscured locations of middle cultural period sites within 60 nmi of the Western Lake core. Data provided by FMSF 2024. (Original work of the author)

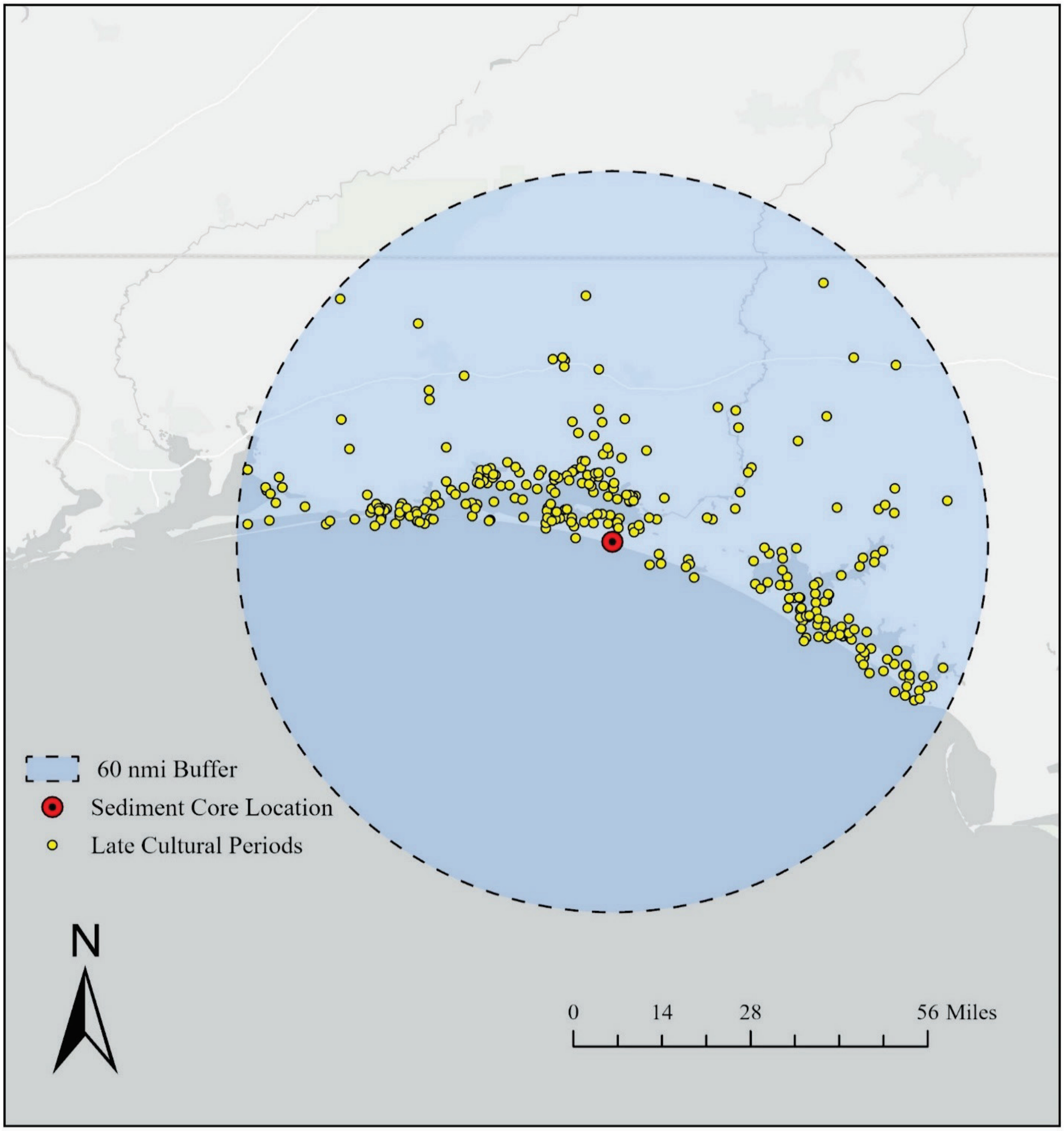

Figure 21. Distribution the obscured locations of late cultural period sites within 60 nmi of the Western Lake core. Data provided by FMSF 2024. (Original work of the author)

5.4.3 Cedar Key

The total number of sites recorded within 60 nmi of the Cedar Key core collection location is 3,407. There are twenty (20) cultural periods that apply to the region. Those twenty (20) cultural periods are listed in **Table 18** with the corresponding site quantity within the buffer. The distribution of sites per cultural period grouping of early, middle, late is showed below. The early cultural period sites in **Figure 22** show the distribution of sites favoring more inland, with few coastal sites. The middle cultural period sites in **Figure 23** show the distribution of sites are denser along the coastline with some dense clusters inland. The late cultural period sites in **Figure 24** show sites distributing more inland in large groupings but the overall density of sites significantly decreases. Throughout all cultural periods sites populate near a major water resource.

Table 18.Number of sites per applicable cultural period within 60 nmi of the Cedar Key core collection location. Data provided by FMSF 2024.

Cedar Key	
Cultural Period	**Number of Sites**
Paleoindian 10000-7500 BCE	40
Archaic 7500- 4500 BCE	581
Orange 2000-1000 BCE	34
Norwood 2000-500 BCE	10
Woodland 1000 BCE- 1500 CE	77
St. Johns (Unspecified) 500 BCE-1700 CE	49
St. Johns I 500 BCE- 800 CE	23
Deptford 500 BCE-200 CE	255
Swift Creek 100-800 CE	61
Santa Rosa 200-500 CE	6
Cades Pond 200-600 CE	63
Weeden Island 450-1100 CE	284
Hickory Pond 600-1250 CE	67
St. Johns II 800-1565 CE	30
Safety Harbor 900-1600 CE	12
Mississippian 1000-1500 CE	6
Fort Walton 1200-1500 CE	14
Alachua 1250-1500 CE	245
Leon-Jefferson 1500-1704 CE	23
Seminole 1715-1842 CE	31

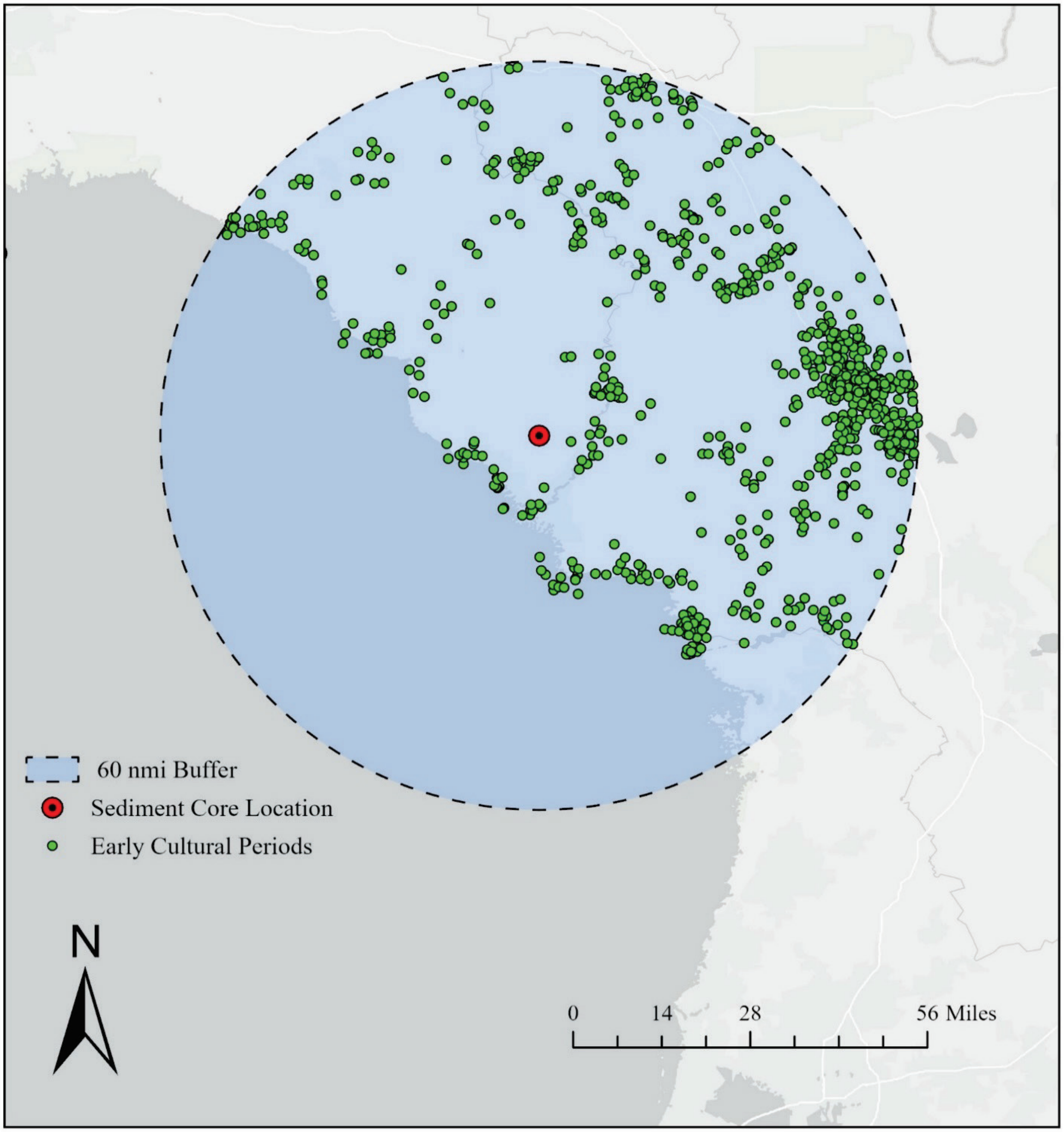

Figure 22. Distribution the obscured locations of early cultural period sites within 60 nmi of the Cedar Key core. Data provided by FMSF 2024. (Original work of the author)

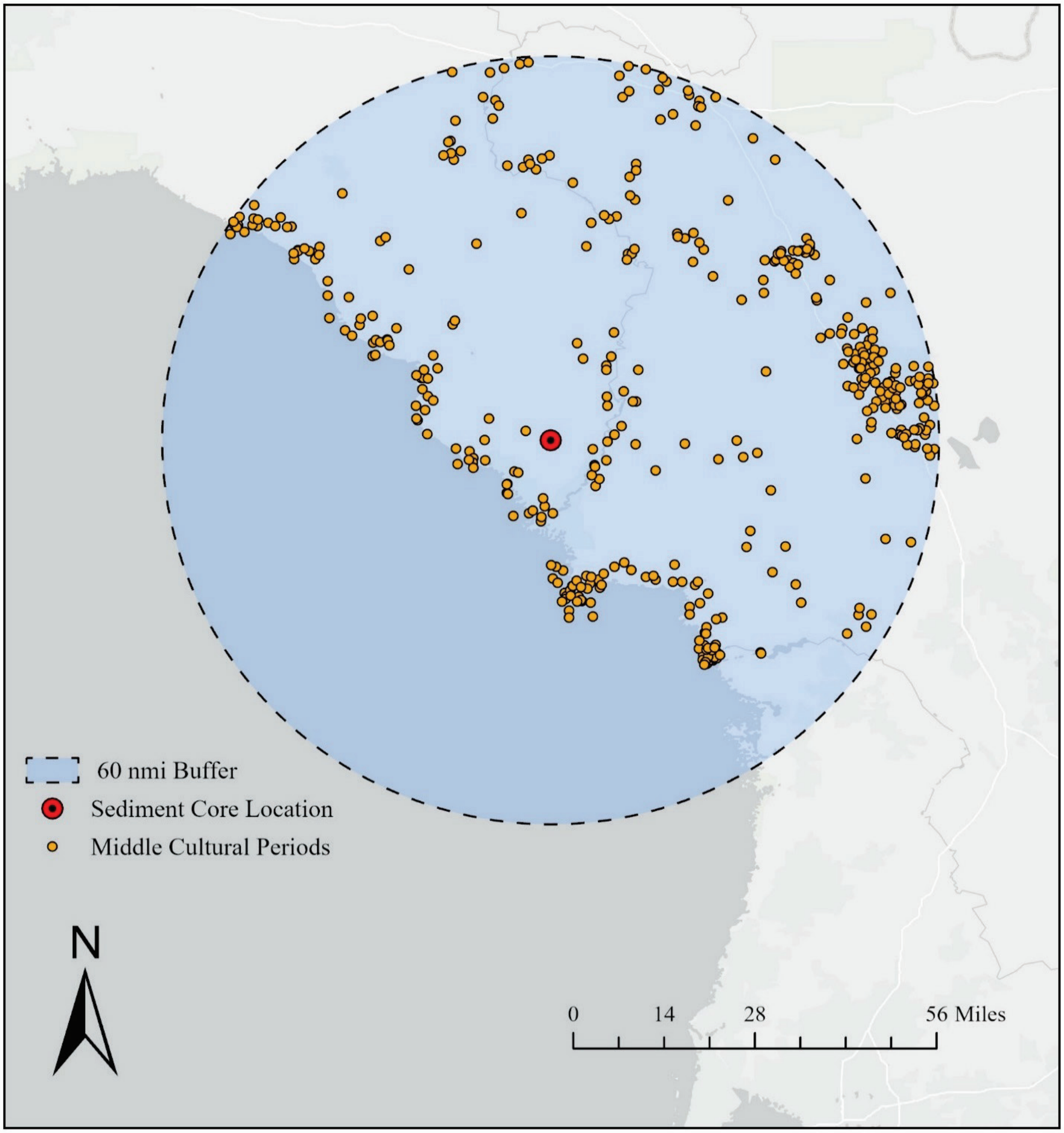

Figure 23. Distribution the obscured locations of middle cultural period sites within 60 nmi of the Cedar Key core. Data provided by FMSF 2024. (Original work of the author)

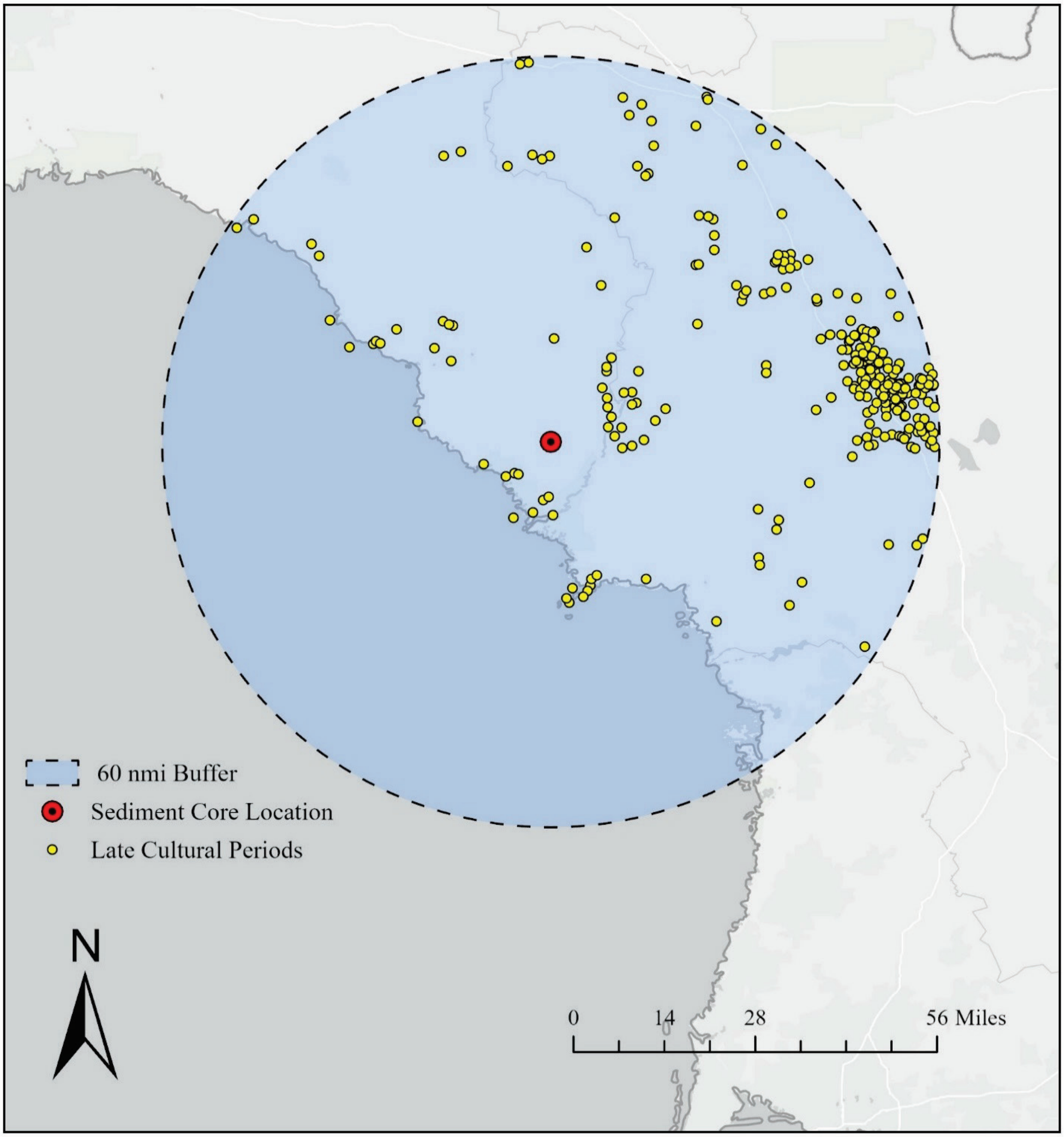

Figure 24. Distribution the obscured locations of late cultural period sites within 60 nmi of the Cedar Key core. Data provided by FMSF 2024. (Original work of the author)

In all three locations the sites display noticeable transition of site density and distribution. Overall, the number of sites decreases in the later cultural periods. In Chapter 6 the analysis of patterns between the site density and distribution over throughout the cultural time frames will be identified and discussed in comparison with the results of the sedimentary particle size analysis data.

The following chapter will draw on these results to provide evidence supporting answers to the guiding research questions. An analysis of the relationship between each dataset will be discussed. Along with the effectiveness of the methodology utilized in this research.

Chapter 6: Analysis

The results displayed in the previous chapter provided four sets of data: sediment particle size analysis data, historical hurricanes data, oyster height data, and archaeological site density and distribution data. The results of the data will be analyzed to discuss what the data means and what research questions the data helped answer. There are three guiding research questions for this thesis: What hurricane patterns existed along the Gulf Coast of Florida prior to the historic record? How do these patterns compare to hurricane patterns today? What is the relationship between hurricane patterns and early Native settlement patterns?

6.1 Sedimentary Particle Size Analysis

In the previous chapter the results of the sedimentary particle size analysis of three sediment cores were presented. Within each core a set of stormy periods were identified by the percentage of total volume of grain size greater than or equal to very fine sand measuring greater than the mean percent of total volume. Any time the percentage of total volume of the grain size measures greater than the mean, it indicates that a storm with significant strength produced storm surge in the area to deposit the sediment data which is being measured. Within the stormy periods identified some of them had a percentage of total volume of grain size greater than or equal to very fine sand greater than one standard deviation from the mean percentage of total volume. The significance of these stormy periods identified is that the greater percent of total volume indicates a greater occurrence of storm surge, which is typically associated with stronger storms. After comparing the data from all three cores, it appears that the cores in the Panhandle region experience stronger stormy periods more frequently as the years get closer to modern times, whereas the Northwest region is lacking any record of stronger stormy periods after 360 CE.

6.1.1 Mullet Pond

The Mullet Pond sediment core revealed twenty-two (22) stormy periods that occurred between 425 to 1048 CE. The average time between each stormy occurrence is approximately 28 years. Within the set of stormy periods identified, twelve (12) of them had a percent of total volume of grain size greater than or equal to very fine sand greater than one standard deviation from the mean percent of total volume. The occurrence of stormy periods with a percentage greater than one standard deviation ranged from averaged approximately every 34 years. This means that the stronger stormy periods occurred every 34 years, on average. At the bottom of the sediment profile, where the earliest storms are recorded, there is a cluster of six (6) stormy periods with a percentage of total volume greater than one standard deviation. The cluster of stronger stormy periods ranges from 475 to 540 CE with an average interval time of approximately 11 years. The next stormy period with a percentage of total volume greater than one standard deviation does not occur for another 150 years in 690 CE. Then the next pair of stormy periods with a percentage of total volume greater than one standard deviation does not occurs 17 years later. This pair of stronger stormy periods ranged from 707 to 714 CE and had an interval of 7 years. The final cluster of stormy periods with a percentage of total volume greater than one standard deviation occurs 131 years later. The cluster consists of three stronger stormy periods ranging from 1105 to 1070 CE and had an average interval of 12 years. It appears that over time the stronger stormy periods occur less frequently in the data. Overall, from 425 to 1048 CE 55% of the storms were stronger stormy periods. The percent of the stronger stormy periods is significant because it indicated that more than half of the storms recorded were stronger, resulting in stronger winds and increased storm surge in the area.

6.1.2 Western Lake

The Western Lake sediment core revealed twenty-nine (29) stormy periods that occurred between 2140 BCE to 1905 CE. The average time between each stormy occurrence is approximately 139 years. Within the set of stormy periods identified, twenty (20) of them had a percent of total volume of grain size greater than or equal to very fine sand greater than one standard deviation from the mean percent of total volume. The occurrence of stormy periods with a percentage greater than one standard deviation ranged from averaged approximately every 202 years. This means that the stronger stormy periods occurred every 202 years. Starting from the bottom of the sediment profile, the first four (4) stormy periods with a percentage greater than one standard deviation are isolated occurrences with an average interval of 596 years. The first stronger stormy period occurs in 2140 BCE followed by another in 1990 BCE, then 1090 BCE and 243 CE. After the four isolated stronger stormy periods there is a pair of stormy periods with a percentage greater than one standard deviation that occurs 511 years after the last isolated stronger stormy period. The pair ranged from 754 to 800 CE and are 46 years apart. The top of the sediment profile consists of a cluster of fourteen (14) stormy periods with a percentage greater than one standard deviation. The cluster ranges from 1066 to 1905 CE and had an interval of 79 years. It appears that over time the stronger stormy periods occur more frequently in the data. Overall, from 2140 BCE to 1905 CE 69% of the storms were stronger stormy periods. The percent of the stronger stormy periods is significant because it indicated that more of the storms recorded were stronger, resulting in stronger winds and increased storm surge in the area.

6.1.3 Cedar Key

The Cedar Key sediment core revealed nineteen (19) stormy periods that occurred between 887 BCE to 360 CE. The average time between each stormy occurrence is approximately 66 years. All the stormy periods identified had a percent of total volume of grain size greater than or equal to very fine sand greater than one standard deviation from the mean percent of total volume. This indicates that all the storms identified were strong stormy periods. This is significant because it indicated that from 887 BCE to 360 CE that the storms recorded were intense, resulting in higher winds and increased storm surge in the area. The sediment profile shows all the strong stormy periods occurring from 887 BCE to 360 CE followed by an absence of anomalies in the sediment profile after 360 CE. The data expressed that closer to modern times the less frequent the stronger stormy periods occurred.

6.2 Historical Hurricanes

The historical hurricane data identified all the hurricane occurrences within 60 nautical miles of each core location. It was clear that all the locations experience hurricanes frequently with an overall average interval of 2 years. However, in the data it became apparent that some locations were hit more frequently with major hurricanes (category 3-5/sustaining winds greater than 110 mph).

6.2.1 Panhandle Region

Both the Mullet Pond and the Western Lake cores fall within the Panhandle region of Florida. As mentioned in the results chapter, the Mullet Pond location has a hurricane average of every 2 years and a major hurricane occurrence every 29 years. The Western Lake location has a hurricane average of every 3 years with a major hurricane averaging every 15 years. When referring to chapter 2, historical hurricane data showed that the panhandle was impacted by a hurricane every 10 years (NOAA 2024c) The Western Lake location is located on the western end of the Panhandle region of Florida, whereas the Mullet Pond core is on the eastern end of the

Panhandle. Based off the data it appears that the western side of the Panhandle has a higher frequency of major hurricane occurrence.

6.2.2 Northwest Region

The Cedar Key core was the only core to fall into the Northwest Region of Florida. As mentioned in the results chapter the location has a hurricane average of every 2 years and a major hurricane frequency of 32 years. However, the data showed that the location was struck by two major hurricanes within the span of a year. Prior to hurricane Idalia in 2023 the last major hurricane to impact the Northwest region was in 1985 with a 35-year gap. The sudden change in frequency is interesting and may be an indication that the hurricane patterns in the area are changing.

6.3 Oyster Height Data

The oyster height data identified the height of shells from six (6) different archaeological sites. The shell height average was calculated for every core location the sites were spatially associated with. When analyzing the data the shell heights will be compared to the average shell height of eastern oysters, which is the most common species of oyster in Florida. Florida Fish and Wildlife Conservation Commission reports the common size of eastern oysters is 3 inches (76.2 mm) (FWC 2024). When comparing the data overall by region, the Panhandle averaged a shell height of 67.45 mm which is below the common shell height. The Northwest region averaged a shell height of 54.93 mm which is also marginally lower than the common shell height for oysters in Florida. The data suggests that an outside force impeded the growth and development of the oysters during the timeframe of site inhabitance. In **Figure 25** the average shell height for each archaeological site is recorded and compared to the common shell height for oysters in Florida.

Figure 25. Graph displaying the Average shell height of each site compared to the average shell height of eastern oysters (Original work of the author).

6.4 Archaeological Site Density and Distribution

In the results chapter site density and distribution data was expressed in a table with the number of sites per cultural period and with maps of the site locations expressed in broader categories of early, middle, and late cultural periods. The number of sites per cultural period is difficult to analyze due to the amount of cross over between sites and the large quantities of sites throughout all timeframes. However, the maps showing the site locations in the broader categories of early, middle, and late did show transitions between site locations over time. For all core locations, sites within 60 nmi of the cores expressed some transition in favorability from coastal to inland sites. Each location's transitions were at different timeframes, but the data shows that there was an influence for all locations to switch favoritism between coastal locations and inland locations.

6.4.1 Mullet Pond

Sites within 60 nmi of the Mullet Pond core location expressed favoritism of inland locations during the early cultural periods. During middle cultural periods the site locations still expressed favoritism towards inland areas, but the number of coastal sites increases. Then during the late cultural periods, the favoritism continues to inland locations with the number of coastal site decreasing. Throughout all the cultural timeframes, site locations are placed along or near a water resource.

6.4.2 Western Lake

Sites within 60 nmi of the Western Lake core location were distributed evenly between inland and coast areas during early cultural periods. During the middle cultural periods there is a strong favoritism towards coastal locations and the overall density of sites significantly increases. Then in the later cultural periods site density exceptionally decreases with most of the remaining sites favoring the coast. Over time it appears that the sites around the Western Lake core transitions to be more coastal but with an unusually drastic change in the overall density of the area. Throughout all the cultural timeframes, site locations are placed along or near a water resource.

6.4.3 Cedar Key

Sites within 60 nmi of the Cedar Key core location favored locations more inland during the earlier cultural periods. Then during the middle cultural periods, sites become denser along the coast, but distribution is even with inland sites. During the later cultural periods sites favored inland locations with the overall site density significantly decreasing. Throughout all the cultural timeframes, site locations are placed along or near a water resource.

6.5 Overall Analysis

Throughout the chapter all the data resources were analyzed individually for significantly noticeable patterns. Now the analysis of data sets needs to be compared to see if any of the research questions are answered. The frequency of stormy periods compared to the frequency of hurricanes in the historical record is difficult to compare. The data is difficult to compare since the sedimentary particle size analysis cannot express intensity of the storms in a way that is comparable to the hurricane categorization used today. Therefore, the frequencies of stormy types are not compatible to compare.

6.5.1 Mullet Pond

The Mullet Pond core location was impacted by twenty-two (22) stormy periods with twelve (12) of the stormy periods shows signs in the data of being notably stronger. The stronger stormy periods occur from 475 to 880 CE which falls during the middle cultural period categorization. During the middle cultural period the density and distribution of archaeological sites expressed favoritism of inland locations but there was an increase of coastal sites. However, following the middle cultural periods the number of coastal sites decreases, and inland locations continue to be favored. This potentially shows the influence of the stronger stormy periods of the distribution of site locations. Interestingly the oyster height data collected from site 8FR0014 show no impact from the stronger stormy periods on the growth or development of oysters. The average shell height for site 8FR0014 was greater than the common size for oysters. **Figure 26** shows the timeline of stormy periods in comparison with the cultural periods associated with site 8FR0014.

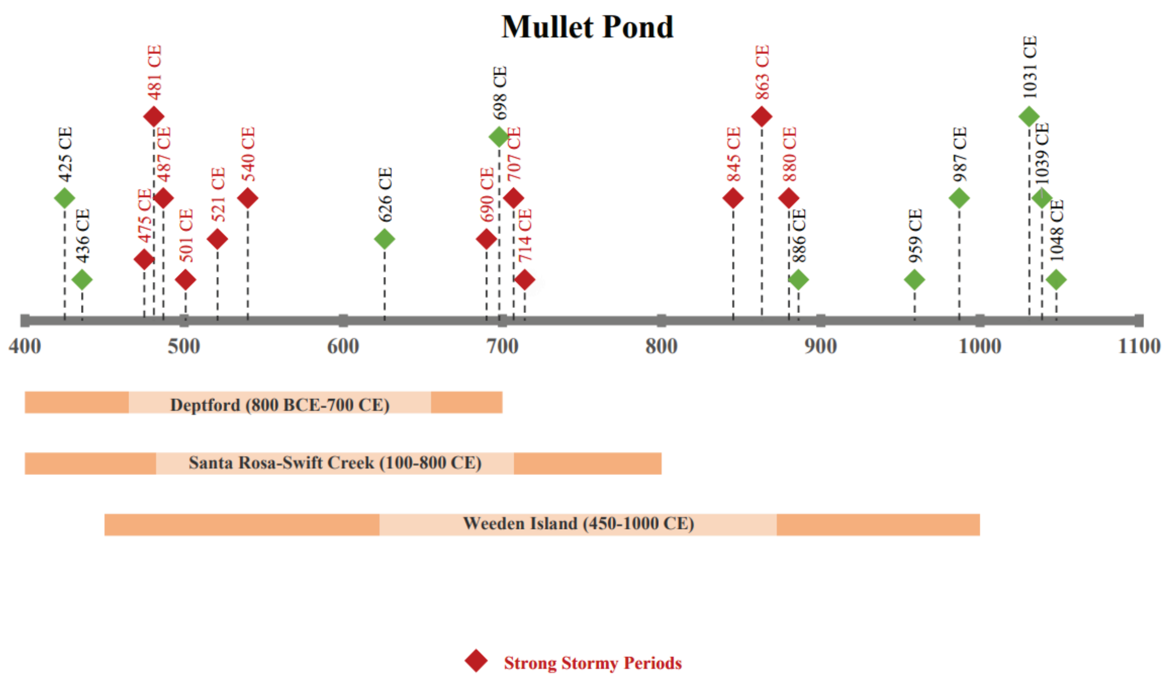

Figure 26. Timeline of stormy periods at Mullet Pond in comparison with timeframe of cultural periods site 8FR0014 contributes to (Original work of the author).

6.5.2 Western Lake

The Western Lake core location was impacted by twenty-nine (29) stormy periods with twenty (20) of the stormy periods shows signs in the data of being notably stronger. The stronger stormy periods occur more frequently from 1066 to 1905CE which falls between the middle and late cultural periods. The site density and distribution from the middle to late cultural periods drastically decrease in quantity. However, the few later cultural period sites are located closer to the coast. The only archaeological site that was inhabited during the period of frequent stronger stormy periods is site 8WL2269. **Figure 27** shows the timeline of stormy periods in comparison with the cultural periods associated with site 8WL2269.The average shell height of 8WL2269 was drastically lower than the common shell height for oysters. With all this information combined it is possible that the stronger stormy periods had an impact on the density of sites in the region especially since the oyster data suggest significant impact from the stronger stormy periods.

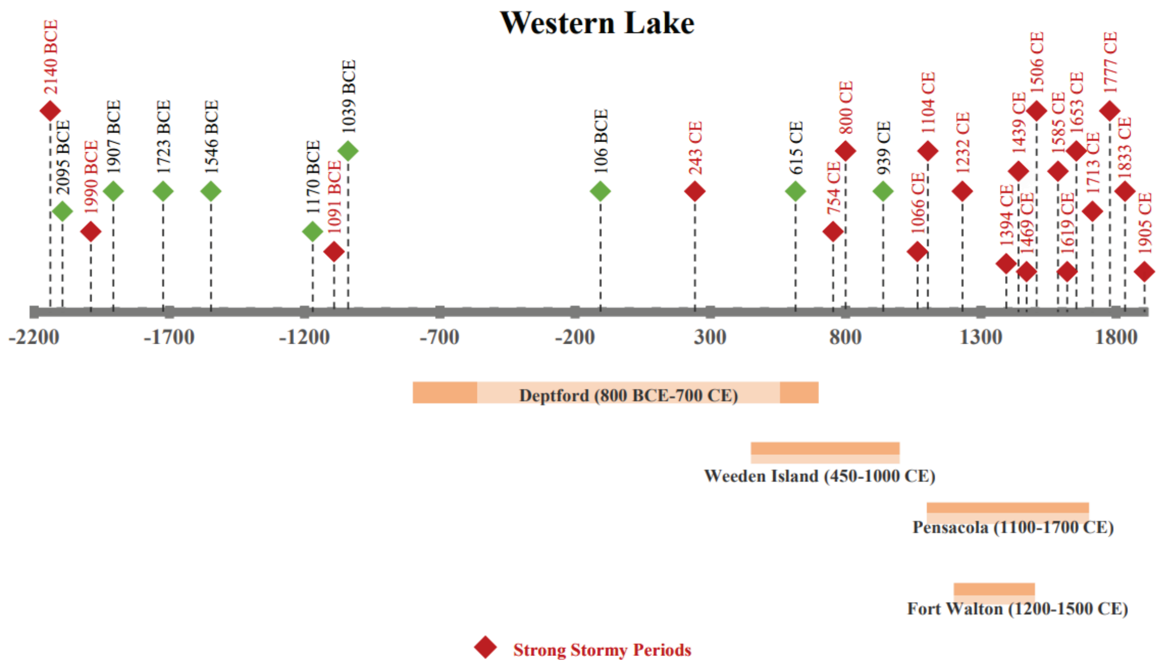

Figure 27. Timeline of stormy periods at Western Lake in comparison with timeframe of cultural periods site 8WL2269 contributes to (Original work of the author).

6.5.3 Cedar Key

The Cedar Key core location was impacted by nineteen (19) stormy periods and all of them were suggested by the data to be intense storms. These strong stormy periods occurred during the early and middle cultural periods. During both the early and middle cultural periods archaeological site locations tend to favor more inland locations. However, the number of coastal sites increase during the middle cultural periods. During the late cultural periods number of coastal sites decrease along with the overall quantity of sites. There is nothing in the data that aligns with this timeframe to provide a potential explanation. The archaeological sites that were inhabited during the strong stormy periods with oyster shell height data collected are sites

8LV0032 and 8LV0537. **Figure 28** shows the timeline of stormy periods in comparison with the cultural periods associated with sites 8LV0032 and 8LV0537. The average shell height for both sites is notably lower than the common shell height for oysters. With site locations tending to be more inland and shell height averaging significantly lower it is possible that the strong stormy periods may have impacted these variables.

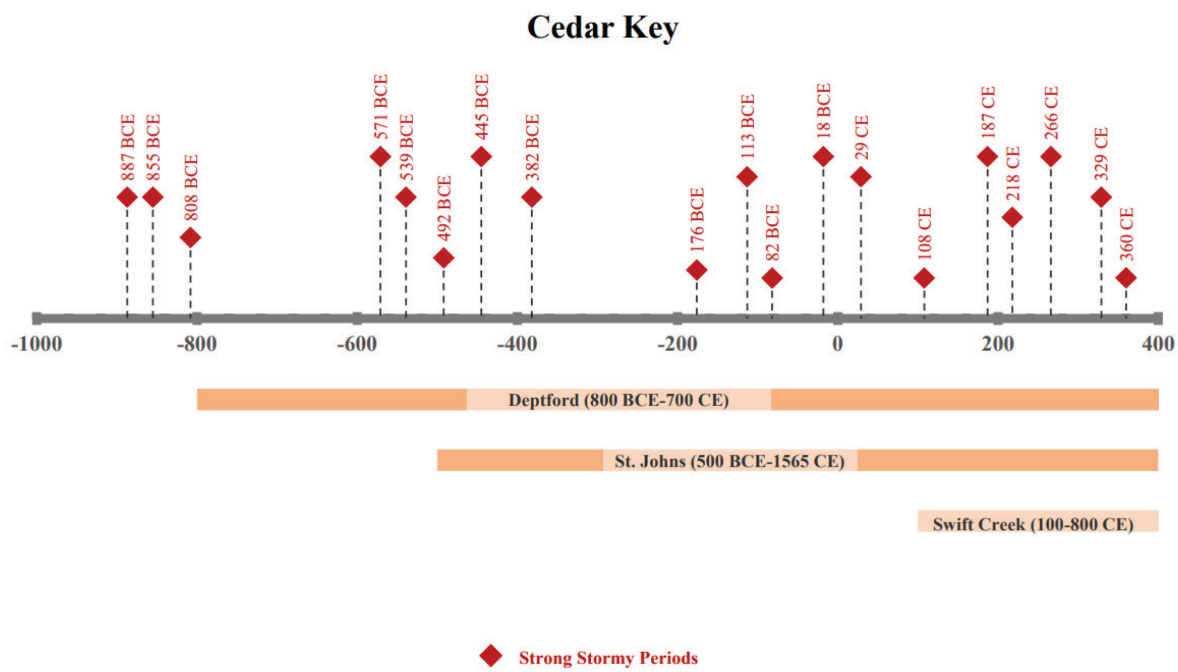

Figure 28. Timeline of stormy periods at Cedar Key in comparison with timeframe of cultural periods sites 8LV0032 and 8LV0537contributes to (Original work of the author).

In summation the hurricane patterns that existed prior to the written record showed that before common era (BCE) to 360 CE the Cedar Key core location and the Northwest region of Florida was frequently impacted by stronger stormy periods. Then from about 475 to 880 CE the Mullet Pond core location in the Panhandle became more frequently impacted by stronger stormy periods. After that from 1066 to 1905 CE the area which is more frequently impacted by the stronger stormy periods transitions further west towards the Western Lake core location in the Panhandle. The overall observation is that over the timeframe recorded the area at risk for stronger stormy periods continuously shifts towards the west. When this is compared to the historical record of hurricanes, the patterns still show that the Panhandle is more frequently impacted by hurricanes and major hurricanes. However, with the Northwest region oddly being struck by 2 major hurricanes within a year, it could potentially be the beginning of another transition in hurricane patterns along the Gulf Coast of Florida. The frequency of the stronger stormy periods appears to have some influence on the distribution and density of sites. Most of the regions experienced a favoritism of inland sites during the timeframes of higher frequency of stronger stormy periods. It also appears likely that these stronger stormy periods had an impact on the growth and development of oysters, which would give another explanation for site density and distribution change since a major food source is potentially impacted by the storms. In the next chapter the thesis will be concluded with an assessment of the overall success of the research methods applied and suggestions for future research on the subject.

Chapter 7: Conclusion and Recommendations

Hurricanes are a frequent foe of the state of Florida. This thesis aimed to answer the following questions: What hurricane patterns existed prior to the historic record? How do these patterns compare to hurricane patterns today? What is the relationship between hurricane patterns and early Native settlement patterns? The first data set, discussed below, helped answer the initial two research questions.

The first research question was answered by the results of the three cores from Brett Parbus (2018) thesis and dissertation that were processed through sedimentary particle size analysis. The data showed that from 887 BCE to 360 CE the Northwest region of Florida was targeted by stronger storms more frequently. Then from 475 to 880 CE the eastern side of the Panhandle region of Florida was targeted more frequently by stronger storms. After that from 754 to 1905 CE the data showed the western side of the Panhandle region of Florida was targeted more frequently by stronger storms. Overall, the data showed that over time the areas with the higher frequency of stronger storms has shifted west. Some refinement of this sedimentary analysis was necessary to apply Parbus's data in this thesis.

The second research question was how do these patterns compare to hurricane patterns today? This question was difficult to answer with certainty due to the incompatibility of the data sets being compared. The sediment analysis of the cores does not provide an interpretation of intensity of the storms to how storms are measured today. The current sedimentary particle size analysis data identifies early storm occurrence and when analyzing the data the differences between the strength of the storm can be recognized. However, the data does not recognize the storm categorization used today. Both datasets do recognize that the Panhandle region of Florida is impacted by intense storms more frequently, especially the western side of the Panhandle.

The third research question was what is the relationship between hurricane patterns and early Native settlement patterns? The comparison of the stormy periods identified, and Florida's archaeological site records showed there is apparent relationship between storm occurrence and settlement patterns. For all the areas of study, there was a shift in the distribution of sites during or after periods of higher frequency of stronger storm occurrence. For some of the study areas the overall density of sites decreased after periods of higher frequency of stronger storm occurrence. The variation in the distribution of sites seems to fit best with the resiliency model. The change of the distribution of sites during and after the periods of stronger storms demonstrates the reorganization and conservation phases of the resiliency model which follows the release phase of the model. The oyster height data is consistent with the occurrence of stringer stormy periods, displaying the potential impacts the storm had on the environment and oysters as a food resource to early Native settlements. The only site that was not consistent with the data was 8FR0014 which showed an average shell height greater than the common height of eastern oysters reported by Florida. Florida Fish and Wildlife Conservation Commission (FWC). However, these noticeable settlement patterns can also be caused by other factors such as political changes, environmental changes, and cultural changes.

Further research on the topic is suggested for certainty of the results provided by this thesis. Due to some of the difficulties with the data it is suggested that the sedimentary particle size analysis data be examined further and additional methods for analysis be created in order for the data to apply to the subject more thoroughly. The data has the potential to answer the research questions in greater depth if a scale is created measuring the intensity of the storm that translated to today's categorization of storms. For example, if it could be defined that a certain percent of total volume of grain size greater than or equal to very fine sand was equivalent to the production of washover a category 3 or higher hurricane could produce. Another recommendation would be to apply all the methods utilized to specific archaeological sites rather than a general overview of all locations in Florida. The site density and distribution dataset reflect many biases such as survey bias and cultural bias. Applying the research to a specific site would help eliminating some of the uncertainty of the datasets provided in this thesis. For example, the determination of site abandonment after storm occurrence would become better defined especially if the site is able to be dated with more specific methods such as radiocarbon dating. Radiocarbon dating the oysters would also be very beneficial to determining if it was the storm occurrence causing the reduction in shell height or another influence not recognized by the scope of this thesis.

Future research in the paleotempestology and marine historical ecology fields on storms and settlement patterns can contribute to the world of archaeology. The research has the potential to create predictive models to help identify sites with a high risk of storm impact. This in return would help archaeologist identify which sites may need to be revisited for data recovery to ensure that information for future research is collected. Future research in the topic can also assist in determining how to better prepare for hurricanes today and influence the approach of hurricane preparations and evacuations. This would ultimately benefit many residents whose lives have been impacted in many ways over the years by hurricanes. Until then, communities will continue to rebuild as disaster occurs, Florida will remain strong.

Appendix A: Stormy Period Data Conversion

Mullet Pond			
#	**Core (cm)**	**Age (Cal yr BP)**	**Year**
1	14.4	902.1333333	1048 CE
2	15.3	910.7047619	1039 CE
3	16.2	919.2761905	1031 CE
4	20.8	963.0857143	987 CE
5	23.7	990.7047619	959 CE
6	31.4	1064.038095	886 CE
7	32	1069.752381	880 CE
8	33.8	1086.895238	863 CE
9	35.7	1104.990476	845 CE
10	49.4	1235.466667	714 CE
11	50.2	1243.085714	707 CE
12	51.1	1251.657143	698 CE
13	52	1260.228571	690 CE
14	58.7	1324.038095	626 CE
15	67.7	1409.752381	540 CE
16	69.7	1428.8	521 CE
17	71.8	1448.8	501 CE
18	73.3	1463.085714	487 CE
19	73.9	1468.8	481 CE
20	74.5	1474.514286	475 CE
21	78.6	1513.561905	436 CE
22	79.8	1524.990476	425 CE

Western Lake			
#	Core (cm)	Age (Cal yr BP)	Year
1	1.2	45.11278195	1905 CE
2	3.1	116.5413534	1833 CE
3	4.6	172.9323308	1777 CE
4	6.3	236.8421053	1713 CE
5	7.9	296.9924812	1653 CE
6	8.8	330.8270677	1619 CE
7	9.7	364.6616541	1585 CE
8	11.8	443.6090226	1506 CE
9	12.8	481.2030075	1469 CE
10	13.6	511.2781955	1439 CE
11	14.8	556.3909774	1394 CE
12	19.1	718.0451128	1232 CE
13	22.5	845.8646617	1104 CE
14	23.5	883.4586466	1066 CE
15	26.9	1011.278195	939 CE
16	30.6	1150.37594	800 CE
17	31.8	1195.488722	754 CE
18	35.5	1334.586466	615 CE
19	45.4	1706.766917	243 CE
20	54.7	2056.390977	106 BCE
21	79.5	2988.721805	1039 BCE
22	80.9	3041.353383	1091 BCE
23	83	3120.300752	1170 BCE
24	93	3496.240602	1546 BCE
25	97.7	3672.932331	1723 BCE
26	102.6	3857.142857	1907 BCE
27	104.8	3939.849624	1990 BCE
28	107.6	4045.112782	2095 BCE
29	108.8	4090.225564	2140 BCE

Cedar Key			
#	**Core (cm)**	**Age (Cal yr BP)**	**Year**
1	30.2	1589.473684	360 CE
2	30.8	1621.052632	329 CE
3	32	1684.210526	266 CE
4	32.9	1731.578947	218 CE
5	33.5	1763.157895	187 CE
6	35	1842.105263	108 CE
7	36.5	1921.052632	29 CE
8	37.4	1968.421053	18 BCE
9	38.6	2031.578947	82 BCE
10	39.2	2063.157895	113 BCE
11	40.4	2126.315789	176 BCE
12	44.3	2331.578947	382 BCE
13	45.5	2394.736842	445 BCE
14	46.4	2442.105263	492 BCE
15	47.3	2489.473684	539BCE
16	47.9	2521.052632	571 BCE
17	52.4	2757.894737	808 BCE
18	53.3	2805.263158	855 BCE
19	53.9	2836.842105	887 BCE

Appendix B: List of Stronger Stormy Periods

Mullet Pond			
#	**Core (cm)**	**Age (Cal yr BP)**	**Year**
1	32	1069.752381	880 CE
2	33.8	1086.895238	863 CE
3	35.7	1104.990476	845 CE
4	49.4	1235.466667	714 CE
5	50.2	1243.085714	707 CE
6	52	1260.228571	690 CE
7	67.7	1409.752381	540 CE
8	69.7	1428.8	521 CE
9	71.8	1448.8	501 CE
10	73.3	1463.085714	487 CE
11	73.9	1468.8	481 CE
12	74.5	1474.514286	475 CE

Western Lake			
#	**Core (cm)**	**Age (Cal yr BP)**	**Year**
1	1.2	45.11278195	1905 CE
2	3.1	116.5413534	1833 CE
3	4.6	172.9323308	1777 CE
4	6.3	236.8421053	1713 CE
5	7.9	296.9924812	1653 CE
6	8.8	330.8270677	1619 CE
7	9.7	364.6616541	1585 CE
8	11.8	443.6090226	1506 CE
9	12.8	481.2030075	1469 CE
10	13.6	511.2781955	1439 CE
11	14.8	556.3909774	1394 CE
12	19.1	718.0451128	1232 CE
13	22.5	845.8646617	1104 CE
14	23.5	883.4586466	1066 CE
15	30.6	1150.37594	800 CE
16	31.8	1195.488722	754 CE
17	45.4	1706.766917	243 CE
18	80.9	3041.353383	1091 BCE
19	104.8	3939.849624	1990 BCE
20	108.8	4090.225564	2140 BCE

Appendix C: List of Historical Hurricanes

Mullet Pond			
#	Name	Category	Year
1	Helene	4	2024
2	Debby	1	2024
3	Idalia	4	2023
4	Nicole	TS	2022
5	Mindy	TS	2021
6	Fred	TS	2021
7	Elsa	TS	2021
8	Michael	5	2018
9	Hermine	1	2016
10	Colin	TS	2016
11	Andrea	TS	2013
12	Debby	TS	2012
13	Fay	TS	2008
14	Alberto	TS	2006
15	Jeanne	TS	2004
16	Frances	TS	2004
17	Bonnie	TS	2004
18	Earl	1	1998
19	Josephine	TS	1996
20	Alison	TS	1995
21	Beryl	TS	1994
22	Kate	2	1985
23	Unnamed	TS	1976
24	Agnes	1	1972
25	Becky	TS	1970
26	Alma	2	1966
27	Dora	TS	1964
28	Brenda	TS	1960
29	Unnamed	TS	1957
30	Unnamed	TS	1953
31	Love	TS	1950
32	Unnamed	TS	1947
33	Unnamed	1	1941
34	Unnamed	1	1939
35	Unnamed	TS	1937
36	Unnamed	TS	1937
37	Unnamed	TS	1936
38	Unnamed	2	1935
39	Unnamed	TS	1933
40	Unnamed	TS	1932
41	Unnamed	TS	1929
42	Unnamed	TS	1928
43	Unnamed	TS	1928

Mullet Pond Continued…			
44	Unnamed	TS	1924
45	Unnamed	1	1924
46	Unnamed	1	1915
47	Unnamed	TS	1912
48	Unnamed	TS	1909
49	Unnamed	TS	1907
50	Unnamed	TS	1907
51	Unnamed	1	1903
52	Unnamed	TS	1902
53	Unnamed	TS	1901
54	Unnamed	TS	1901
55	Unnamed	TS	1900
56	Unnamed	2	1899
57	Unnamed	1	1898
58	Unnamed	3	1894
59	Unnamed	TS	1893
60	Unnamed	2	1886
61	Unnamed	2	1886
62	Unnamed	TS	1885
63	Unnamed	TS	1885
64	Unnamed	1	1882
65	Unnamed	TS	1880
66	Unnamed	1	1880
67	Unnamed	TS	1878
68	Unnamed	TS	1877
69	Unnamed	3	1877
70	Unnamed	TS	1877
71	Unnamed	TS	1875
72	Unnamed	1	1873
73	Unnamed	TS	1871
74	Unnamed	TS	1871
75	Unnamed	TS	1868
76	Unnamed	1	1867
77	Unnamed	2	1852

Western Lake			
#	**Name**	**Category**	**Year**
1	Fred	TS	2021
2	Michael	5	2018
3	Alberto	TS	2018
4	Claudette	TS	2009
5	Fay	TS	2008
6	Dennis	4	2005
7	Barry	TS	2001
8	Helene	TS	2000
9	Earl	1	1998
10	Opal	3	1995
11	Erin	2	1995
12	Beryl	TS	1994
13	Alberto	TS	1994
14	Kate	2	1985
15	Elena	3	1985
16	Eloise	3	1975
17	Agnes	1	1972
18	Becky	TS	1970
19	Unnamed	TS	1969
20	Unnamed	TS	1965
21	Debby	TS	1957
22	Flossy	1	1956
23	Florence	2	1953
24	Alice	TS	1953
25	Unnamed	TS	1948
26	Unnamed	1	1939
27	Unnamed	TS	1937
28	Unnamed	TS	1937
29	Unnamed	2	1936
30	Unnamed	TS	1934
31	Unnamed	1	1929
32	Unnamed	TS	1928
33	Unnamed	3	1926
34	Unnamed	1	1924
35	Unnamed	TS	1919
36	Unnamed	3	1917
37	Unnamed	1	1915
38	Unnamed	TS	1914
39	Unnamed	1	1911
40	Unnamed	TS	1907
41	Unnamed	TS	1907
42	Unnamed	TS	1906
43	Unnamed	TS	1904
44	Unnamed	1	1903
45	Unnamed	TS	1902

Western Lakes Continued…			
46	Unnamed	TS	1901
47	Unnamed	2	1899
48	Unnamed	1	1898
49	Unnamed	2	1896
50	Unnamed	3	1894
51	Unnamed	TS	1889
52	Unnamed	1	1887
53	Unnamed	TS	1885
54	Unnamed	TS	1885
55	Unnamed	TS	1885
56	Unnamed	3	1882
57	Unnamed	1	1880
58	Unnamed	TS	1879
59	Unnamed	TS	1878
60	Unnamed	3	1877
61	Unnamed	1	1877
62	Unnamed	TS	1875
63	Unnamed	TS	1868
64	Unnamed	1	1867
65	Unnamed	2	1856
66	Unnamed	3	1851

Cedar Key			
#	**Name**	**Category**	**Year**
1	Helene	4	2024
2	Debby	1	2024
3	Idalia	4	2023
4	Nicole	TS	2022
5	Elsa	TS	2021
6	ETA	TS	2020
7	Irma	1	2017
8	Collin	TS	2016
9	Andrea	TS	2013
10	Debby	TS	2012
11	Fay	TS	2008
12	Alberto	TS	2006
13	Jeane	TS	2004
14	Frances	TS	2004
15	Gordon	1	2000
16	Josephine	TS	1996
17	Jerry	TS	1995
18	Erin	TS	1995
19	Marco	TS	1990
20	Elena	2	1985
21	Isidore	TS	1984
22	unnamed	TS	1982
23	unnamed	TS	1976
24	Gladys	2	1968
25	unnamed	TS	1966
26	unnamed	TS	1965
27	Dora	1	1964
28	Brenda	TS	1960
29	unnamed	TS	1953
30	Love	TS	1950
31	King	1	1950
32	Easy	3	1950
33	unnamed	1	1949
34	unnamed	TS	1947
35	unnamed	1	1946
36	unnamed	1	1945
37	unnamed	TS	1941
38	unnamed	TS	1939
39	unnamed	TS	1937
40	unnamed	TS	1936
41	unnamed	2	1935
42	unnamed	TS	1933
43	unnamed	TS	1932
44	unnamed	1	1928
45	unnamed	TS	1928

Cedar Key Continued…			
46	unnamed	TS	1924
47	unnamed	TS	1920
48	unnamed	TS	1916
49	unnamed	TS	1909
50	unnamed	TS	1902
51	unnamed	TS	1900
52	unnamed	TS	1898
53	unnamed	3	1896
54	unnamed	TS	1893
55	unnamed	TS	1889
56	unnamed	2	1888
57	unnamed	TS	1888
58	unnamed	1	1886
59	unnamed	2	1886
60	unnamed	TS	1885
61	unnamed	1	1882
62	unnamed	1	1880
63	unnamed	TS	1880
64	unnamed	1	1880
65	unnamed	TS	1879
66	unnamed	2	1878
67	unnamed	TS	1877
68	unnamed	1	1874
69	unnamed	TS	1871
70	unnamed	1	1871
71	unnamed	TS	1871
72	unnamed	1	1871
73	unnamed	1	1867

Appendix D: Major Hurricane Landfall Within Florida Regions

Panhandle Region			
#	**Name**	**Category**	**Year**
1	Michael	5	2018
2	Dennis	3	2005
3	Opal	3	1995
4	Eloise	3	1975
5	Unnamed	3	1926
6	Unnamed	3	1917
7	Unnamed	3	1894
8	Unnamed	3	1882
9	Unnamed	3	1877
10	Unnamed	3	1851

Northwest Region			
#	**Name**	**Category**	**Year**
1	Helene	4	2024
2	Idalia	4	2023
3	Easy	3	1950
4	Unnamed	3	1896

Appendix E: Major Hurricane Landfall Within 60 nmi

Mullet Pond			
#	**Name**	**Category**	**Year**
1	Helene	4	2024
2	Idalia	4	2023
3	Michael	5	2018
4	Unnamed	3	1877

Western Lake			
#	**Name**	**Category**	**Year**
1	Michael	5	2018
2	Dennis	3	2005
3	Opal	3	1995
4	Eloise	3	1975
5	Unnamed	3	1917
6	Unnamed	3	1894
7	Unnamed	3	1882
8	Unnamed	3	1877
9	Unnamed	3	1851

Cedar Key			
#	**Name**	**Category**	**Year**
1	Idalia	4	2023
2	Helene	4	2024
3	Easy	3	1950
4	Unnamed	3	1896

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