Sea level rise and a Florida mortuary pond: how oysters (crassostrea virginica) reveal past climate change at the Manasota key offshore archaeologyical site

Price, M.R.

CHAPTER 1. INTRODUCTION

1.1 Introduction

The early archaeological record in North America and the Caribbean is an incomplete representation owing to drastic sea level rise beginning circa 18,000 years ago after the Last Glacial Maximum (LGM) (Anderson and Sassaman 2012:2; Balsillie and Donoghue 2004; Faught 2002; Peros et al. 2006; Siegel et al. 2015; Upchurch et al. 2019:72; Waters 1992). Evidence of past human lifeways exists on drowned paleolandscapes located on the continental shelves (Anderson and Sassaman 2012:2; Duggins 2012; Faught 1987, 2004; Krivor 2016; Milanich 1994:34; Wentz and Gifford 2007), a frontier in archaeology that desperately requires more consideration and exploration to expand this sparse archaeological record. Inundated archaeological landscapes are relevant to any number of research questions, from the peopling of the Americas to the impacts of climate change and sea level rise on coastal regions and archaeological sites.

Beginning in the 1960s, oceanographers and archaeologists theorized that archaeological sites existed in drowned contexts on the continental shelves (Emery and Edwards 1966; Gusick and Faught 2011; Hofman et al. 2021; Pendergast et al. 2001; Stouvenot and Bérard 2019). Unfortunately, these sites are not well studied due to challenges locating and accessing them, as well as questions concerning their preservation following destructive transgressive processes (Dunbar 1987; Faught 2004; Faught and Donoghue 1997; Faught and Flemming 2008; Gusick and Faught 2011; Grøn et al. 2021; Murphy 1990 Ruppé 1980; Stright 1987; Waters 1992:262–280). Nevertheless, focus on continental shelf archaeology is increasing owing to developments in remote sensing technology, archaeological theory, and methodology. Remote sensing of the continental shelf in the Gulf of Mexico, for example, has prioritized low energy environments hypothesized to contain intact drowned paleolandscapes [e.g., (Adovasio and Hemmings 2009; Anuskiewicz 1987; Anuskiewicz and Dunbar 1993; Duggins 2012; Faught 1987, 2002, 2004, 2014; Faught and Donoghue 1997; Ruppé 1980; Stright 1987)]. Studies around the globe have also targeted robust archaeological site elements, such as lithics and shell middens, that are likely to appear in remote sensing data [see for example (Astrup et al. 2021; Cook Hale et al. 2021; Grøn et al. 2021)]. Other more ephemeral sites are located accidentally rather than as a result of focused research [e.g., (Duggins and Price 2016; Bullen et al. 1968; Murphy 1990)]. While there is a fluorescence of continental shelf research in recent years, there is greater emphasis on pinpointing drowned precontact sites (referring to human activities, events, and occupations before European contact) and developing or refining methods for finding them [e.g., (Adovasio and Hemmings 2009; Faught and Joy 2019; Gusick

and Faught 2011; Mackie et al. 2013)]. Detailed, in-practice investigation of these types of sites, however, is lacking. Development in this area of research must occur in order for the subfield to advance.

1.2 Research Problem Statement

Currently, in the field of precontact continental shelf archaeology, the effects of marine transgression on site integrity are not well understood. While studies indicate the possibility for contextual preservation on submerged continental shelf sites [e.g., (Adovasio and Hemmings 2009; Davis et al. 2018; Emery and Edwards 1966; Erlandson 2002:65,81; Faught 2004; Faught and Donoghue 1997; Mackie et al. 2013; Murphy 1990; Ruppé 1980; Stright 1987, 1995)], we do not fully understand how climatic forces affect archaeological site preservation. Sites that contain delicate organics and are ephemeral in nature (i.e., those that contain more than lithic material or shell) particularly lack research. It is only with additional site discoveries, coupled with detailed investigation of site preservation, that explicit data concerning these themes can be generated. Detailed analysis of sites in their post-transgressive context allows for examination of the paleoenvironment and investigation of specific inundation processes. Therefore, as more inundated offshore sites are discovered, questions concerning impacts of sea level rise on the archaeological record can be answered.

Once an understanding of the process of marine transgression on a site-by-site basis is better understood, archaeologists can extrapolate how that process affected the populations utilizing the site. Human use of the landscape transformed at the end of the Pleistocene and throughout the Holocene due to changes in sea levels (Anderson and Sassaman 2012:66, 110; Milanich 1994:84; Saunders and Russo 2011). Therefore, questions concerning coastal site abandonment are more aptly addressed with in-depth study of inundated offshore sites.

1.3 Objectives

This dissertation assesses a precontact offshore site known as Manasota Key Offshore (MKO hereafter; Florida site designation 8SO7030) as a case study from which to examine marine transgression and preservation of organics. This site was once an inland freshwater pond used by indigenous communities as a burial place circa 7,200 calendar years before present (cal BP, present is 1950, see Chapter 2, section 2.5) (Duggins 2018, 2019; Duggins and Price 2016; Duggins et al. 2018). Over the intervening years, sea levels altered the landscape and shoreline, and this mortuary pond is now located off the southwest Florida coast in the Gulf of Mexico (Figure 1.1). Discovery of a precontact

site containing delicate organics such as textiles, modified wood, and skeletal material that survived marine transgression is unprecedented in the field of archaeology. The presence of oyster shells (*Crassostrea virginica*, *C. virginica* hereafter) attached to Archaic period human skeletal material provides direct evidence of marine transgression at this site (BAR 2016b, 2018c; Price 2020).

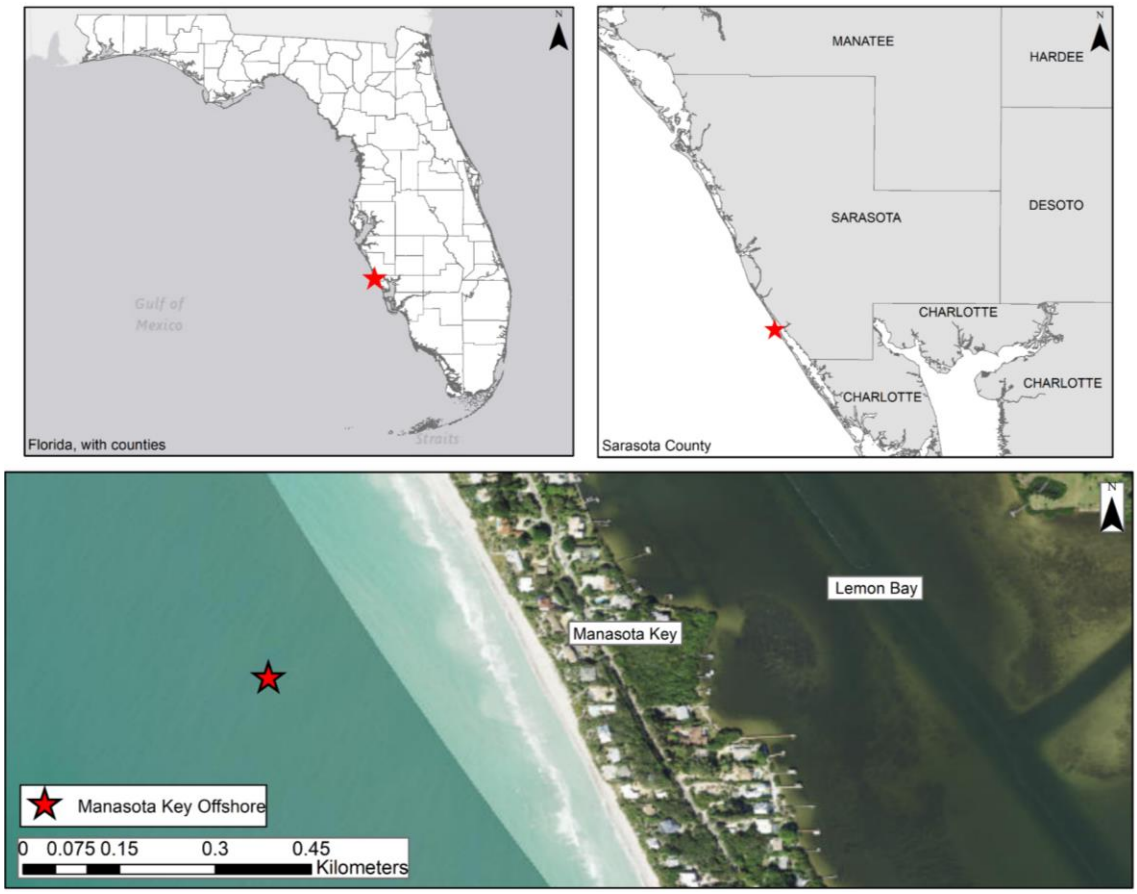

Figure 1.1. Location of Manasota Key Offshore in Sarasota County (Shapefiles courtesy BAR, map compiled by author).

The objectives of this study are to determine when the MKO inland pond became exposed to brackish or marine environments conducive to the growth of oysters and how long it took the oysters to form on exposed skeletal material and modified wooden stakes. Other objectives of this study include—determining if the oysters recovered from MKO represent one instance of inundation or multiple instances, evaluating the paleoenvironment during the period of oyster growth, and comparing MKO oysters to a modern sample from the region. This study assesses whether oyster data are beneficial for the investigation of preservation mechanisms at the site during marine transgression and therefore assesses the comprehensive feasibility of using oysters as a proxy for paleoenvironmental and sea level

rise studies of transgressed sites. A final objective of this study is the investigation of site abandonment at MKO and the abandonment of mortuary ponds as a cultural practice across Florida during the Archaic period.

1.3.1 Research Questions

This dissertation explores the following research questions and sub questions:

1. What can an examination of oysters excavated from MKO reveal about the paleoenvironment, site exposure, and site formation processes during marine transgression?
2. How can this oyster study provide insight into the circumstances that allowed MKO to be preserved?
3. How can oyster data provide insight into how changes in sea levels affected population(s) utilizing the landscape? How can the process of inundation at this site contribute to our knowledge of mortuary pond cultural practice abandonment across Florida during the Middle Archaic period?

1.4 Approach

This study uses data gathered from a Gulf of Mexico coastal setting to determine how Florida's submerged paleolandscape near MKO evolved in association with Holocene sea level rise utilizing oysters as proxy data. The study operates under the following assumptions— (1) MKO retained preservation during Holocene sea level rise in a low energy environment that sheltered the site from the devastating effects of rising water levels. (2) The oysters formed in this protected environment. (3) The oysters contain information about the paleoenvironment, and these data can be used to track changes in environmental parameters over time.

Geoarchaeological approaches are used to examine site formation processes [after (Schiffer 1987); see also (Shahack-Gross 2017)] at MKO, moving backwards through time to understand the process of marine transgression, specifically through the study of *C. virginica* that were attached to skeletal material and associated with archaeological material. Morphometric analysis (after Kent 1988), sclerochronology, stable isotope analysis, and radiocarbon dating are utilized to reconstruct inundation events and the paleoenvironment, providing insight into the circumstances that allowed this delicate site to be preserved.

C. virginica are highly variable organisms according to any number of influencing factors, such as temperature, salinity, predation, food availability, substrate type, and density of organisms. While this

variation has precluded in-depth analysis of these organisms in some archaeological studies, others have used this variation to learn about oyster habitat, paleoenvironmental conditions, and from where past populations collected shellfish for consumption [e.g., (Andrus and Thompson 2012; Cannarozzi 2012; Kirby 2000; Kirby et al. 1998; Lulewicz et al. 2017b)]. Oyster studies typically fall into two categories: those addressing archaeological questions and those centered on paleoenvironmental applications. While this study is paleoenvironmental in nature, it represents the first documented instance in which oysters were attached to Archaic period skeletal material in a submerged offshore setting, affording a unique application to oyster studies.

Given the margins of error for radiocarbon dating and morphometric analysis, stable isotope analysis of oysters (specifically carbon and oxygen) bolsters interpretations of past environmental parameters. Isotope analysis of mollusks is based on a number of premises [for thorough discussions, see (Andrus 2011; Kirby 2000; Surge et al. 2001, 2003; Zimmt et al. 2019)]. The oxygen and carbon isotope composition of mollusk shells reflect their environmental conditions. Oxygen isotopic ratios in oyster shells are in or near isotopic equilibrium with the surrounding water, but carbon is drawn from different reservoirs. Carbon exists naturally in the environment in several forms, and the ratio of this isotope varies according to different environmental factors. Carbon isotope ratios in mollusk shells are influenced by factors such as the oysters' diet, metabolic rate, and isotope composition of dissolved inorganic carbonate (DIC), which is dependent on several related environmental variables. Oxygen isotopic ratios in mollusk shells are influenced by temperature and the oxygen isotopic composition of local water, which in turn is influenced by fresh and saltwater mixing and evaporation. *C. virginica* take up and incorporate these isotopes into their shells when they precipitate calcite (Kirby et al. 1998). Because the mineral phase of calcium carbonate is less susceptible to diagenetic alteration than aragonite in *C. virginica*, the carbon and oxygen isotopic signals of the geochemical environment in which the shell developed are preserved in and therefore isotopically sampled from the calcite layers in the shell.

Ultimately, fluctuations in the environment and subsequent isotope ratios are reflected in shell isotope values. Stable isotope analysis is a valuable tool within sclerochronology of mollusks. Sclerochronology examines sequential shell deposits (similar to dendrochronology) and provides information on growth rate and age of specimens, as well as season of death (Andrus 2012; Andrus and Thompson 2012; Blitz et al. 2014; Kirby et al. 1998; Zimmt et al. 2019). Within sclerochronology, stable isotope analysis strengthens confidence in growth rate and age interpretations.

The data from MKO's Archaic oysters have the potential to provide information regarding changes in water salinity and temperature as MKO shifted from a freshwater mortuary pond to a fully marine environment during Holocene sea level rise. Furthermore, taken in conjunction with visual growth band analysis, geochemical analysis will inference oyster age and growth rate, thereby revealing how long archaeological material was exposed during oyster growth. Given that oysters are highly variable according to environment and regional location, sclerochronology will also reveal information about periodicity of band formation in an Archaic oyster sample in southwest Florida, contributing much needed baseline data for the region. A comparison to modern oysters and water data from the region will facilitate this aspect of the research. Finally, radiocarbon dating will reveal timing of transgressive inundation. This is the first instance in which oysters attached to Archaic period skeletal material are used to draw wider conclusions about early marine transgression and environmental change. The potential for oyster shell to exist within coastal and submerged precontact sites is great.

This study is the first step in the development of broader conclusions about human use of the landscape at a time when the climate was vastly different and rapidly changing. While studies suggest mortuary ponds in Florida were utilized as a cultural practice for upwards of 3,000 years (Anderson and Sassaman 2012:63; Dickel and Doran 2002:57; Doran 2002b; Duggins 2019), it is not well understood why the practice of interment in ponds was abandoned by the Middle Archaic period (Anderson and Sassaman 2012:63; Dickel and Doran 2002:57; Doran 2002b; Milanich 1994:70). One hypothesis relates to changes in sea level (Anderson and Sassaman 2012:100; Milanich 1994:84), but previous studies focused on mortuary ponds located in inland settings. This study of MKO is the first instance in which a mortuary pond was recorded to be preserved in an offshore setting and will add to archaeological knowledge concerning abandonment of sites due to marine transgression.

1.5 State and Federal Law and Ethical Considerations

This dissertation operated within the framework of various state and Federal laws pertaining to archaeological sites. State laws discussed here include Chapter 267 and Chapter 872, *Florida Statutes*. United States Federal law includes the Native American Graves Protection and Repatriation Act (NAGPRA). An overview of these laws and how they affected this dissertation's study are provided below. Florida's Historical Resource law (Chapter 267, *Florida Statutes*), outlines the cultural resource management responsibilities of state agencies regarding archaeological sites and materials on state-owned and managed lands, including sovereignty submerged lands. Under Chapter 267, the Florida Department of State, Division of Historical Resources, Bureau of Archaeological Research (BAR

hereafter) is charged with the protection, preservation, acquisition, and interpretation of archaeological resources on Florida state lands and state waters to foster an appreciation of Florida history and culture.

Archaeological sites that contain unmarked human burials (whether they are located on state lands or not) are also protected by Chapter 872.05, *Florida Statutes*, which provides the State Archaeologist, and thereby the Division of Historical Resources, jurisdiction over and responsibility for human remains greater than 75 years deceased and any associated burial artifacts. The State Archaeologist is also responsible for locating persons who may have a direct kinship, tribal, community, ethnic, or other connection to the disinterred individuals for consultation concerning final disposition of human remains. Under Chapter 872.05, the State Archaeologist is entrusted with facilitating disposition consultation of human remains of Native American ancestry with the Tribal Nations represented under the Governor's Council on Indian Affairs— the Miccosukee Tribe of Indians and the Seminole Tribe of Florida. In accordance with this statute, BAR notified these tribes about the MKO archaeological site.

Human remains and associated funerary objects of Native American ancestry accessioned into curatorial facilities that receive federal funding are subject to federal compliance under NAGPRA. The human remains and associated funerary objects resulting from MKO excavations and accessioned into State of Florida collections underwent NAGPRA compliance, including— submission of a collections inventory to National NAGPRA, initiation of government-to-government consultation with the Federally Recognized Tribal Nations with Aboriginal Land Rights to Florida[1], and a publication of a Notice of Inventory Completion in the Federal Register (National Park Service, Department of the Interior 2020). All human remains and associated funerary objects from MKO were repatriated to these Tribal Nations— the Miccosukee Tribe of Indians, the Seminole Tribe of Florida, and The Seminole Nation of Oklahoma— and reburied in a secure location under Tribal direction. Furthermore, no destructive analyses (i.e., radiocarbon dating or isotope analyses) were conducted on MKO's human remains in accordance with tribal requests [for discussions about conservation and cataloging of skeletal material, see (Walsh-Haney 2019)].

This dissertation's research was conducted on material that was not deemed to be of NAGPRA significance. Out of due diligence, however, BAR notified Florida's federally recognized tribes prior to conducting stable isotope analysis and radiocarbon dating on a selection of oysters recovered from MKO. Finally, *in situ* depictions of burials at MKO are not included in this dissertation out of an

[1] As a result of final judgements of the Indian Claims Commission in 1978, the Treaty with the Florida Tribes of Indians in 1823, and the Treaty with the Seminoles in 1832, which state that the land on which MKO is located is the aboriginal land of the Tribes.

abundance of sensitivity and respect for the tribes and the individuals interred at MKO. These various legal and ethical considerations influenced all aspects of this dissertation, from research question development to methods chosen to investigate the questions.

1.6 Organization of the Dissertation

Chapter 2 contextualizes the Manasota Key Offshore archaeological site. The chapter begins with a discussion of the role of climate change and sea level rise during the Pleistocene and Holocene Epochs to provide pertinent environmental context for the landscape that early populations inhabited. Following is a brief discussion of submerged precontact archaeology, as it is important to understand the history and context of inundated site studies to understand why offshore sites are underrepresented in academic research. The succeeding sections discuss the Archaic period (11,500 to 3,200 cal BP) of the Southeastern United States, with a targeted discussion of Sarasota County's archaeological record to place MKO within its wider cultural setting. The chapter concludes with a presentation of the study site, with particular attention on the oyster assemblage excavated between 2016 and 2018.

Chapter 3 provides an overview of archaeological and paleoenvironmental approaches to oyster studies and begins with an overview of oyster biology, habitat, parasites, and epifauna (those marine organisms that attach to oyster surfaces). The mechanisms of how oysters form and the environments in which they form is pertinent in interpreting past environmental parameters. A review of morphometric analysis, its uses in archaeological studies, and its limitations is provided. Sclerochronology of mollusks is next reviewed, with a detailed focus on stable isotope analysis, specifically using oxygen and carbon. The focus is on studies of American southeast oysters and comparisons between modern and ancient oysters, as these applications are most useful in the MKO oyster study. The chapter describes how oysters have been used to infer past temperature and salinity regimes, their applications in wider paleoenvironmental or archaeological settings, and the limitations of using this analytical tool. The chapter then presents a review of radiocarbon dating of shell carbonates and the challenges with interpreting shell carbonate dates.

Chapter 4 begins with a discussion of the geoarchaeological framework and methods employed in this dissertation. A review of underwater archaeological frameworks is discussed, with particular attention paid to the lack of theoretical development in the field of submerged precontact archaeology. The chapter then discusses how geoarchaeological approaches are used to examine site formation processes [after (Schiffer 1987); see also (Shahack-Gross 2017)] at MKO using oyster shell.

Following this is a discussion of the specific details of various methods employed in this research project, beginning with an overview of recovery and processing of MKO oysters and two modern comparative oyster sample sets. Measurement of shells for morphometrics and desalination and drying of select MKO shells is outlined, with a justification of shell selection for sclerochronology and stable isotope analysis. Next, the subsampling strategy for stable isotope analysis is detailed, as well as the specifics of sample processing and measurement via isotope ratio mass spectrometry (IRMS). Notes on error, precision, and correction of sampled data according to Vienna Pee Dee belemnite (VPDB) or Standard Light Antarctic Precipitation (SLAP) and Standard Mean Ocean Water (SMOW) standards are included. Methods for water sample collection and analysis are provided, as well as the process for modelling past water parameters using the results of water sample analysis. Finally, the laboratory methods for radiocarbon dating via accelerator mass spectrometry (AMS), sample pretreatment, and calibration of raw dates are discussed, with notes on reservoir corrections, precision, and level of error.

Chapter 5 presents the results of the study and is organized by method of analysis. Results of morphometric analysis of the MKO and two modern oyster samples are presented first. Sclerochronological and stable oxygen and carbon isotope analysis of the MKO oyster sample and one modern oyster sample are next provided, with comparisons to barnacle and gastropod oxygen and carbon isotope analysis. Results of water sample stable isotope analysis follow. Lastly, the chapter presents the results of radiocarbon dating of the MKO oyster sample.

Chapter 6 synthesizes the results into a cohesive discussion of the paleoenvironment during marine transgression at MKO. Sections 6.2 through 6.6 are more technical discussions of the results of the various oyster analytical methods employed in this research. The chapter begins with the habitat as inferred from morphometrics, parasites, and epifauna, as well as a discussion of the modern versus Archaic oyster morphology. Stable isotope analysis is discussed next, with oxygen and carbon discussions separated into different subsections. The results of isotope analysis for each MKO oyster are compared to one another and to the modern oyster sample, as well as to barnacle and gastropod data. A discussion of the sclerochronological findings is presented next. The timeline of inundation at the pond using the results of radiocarbon dating and Bayesian modelling is then provided. The remaining sections of this chapter delve into preservation of material at MKO as revealed by oyster studies, the changing landscape during sea level rise, and the paleoenvironment. The chapter concludes by drawing wider assumptions about site abandonment at MKO in particular and the abandonment of mortuary ponds in Florida in general.

Chapter 7 summarizes the main findings of this research and presents the major conclusions concerning the process of sea level rise at MKO in reference to advances in our understanding of factors that led to the site's preservation following Holocene sea level rise. Insights concerning the various oyster analyses are provided, as well as the larger implications for the feasibility of using oyster studies to examine inundated offshore sites. An assessment of the methodological approach of this oyster research is presented, as well as suggestions for future directions concerning MKO in particular and inundated offshore sites in general.