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Assessing village life and monument construction (cal. AD 65–1070) along the central Gulf Coast of Florida through stable isotope geochemistry

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ABSTRACT

Given recent debates and reinterpretation of large-scale shell deposits as monuments rather than midden in the emerging dialogue in world archaeology regarding shell sites, we need better quantitative assessments of the temporality of shell deposit formation. Here we couple Bayesian analysis of radiocarbon dates with the results from our study of shell isotopes from *C. virginica* from the Crystal River and the Roberts Island Shell Mound Complex, neighboring and temporally overlapping shell mound sites on the central Gulf Coast of Florida. Linking these two lines of data is a new methodological approach which provides a more detailed understanding of the temporality of traditions. The results indicate that midden accumulation occurred throughout the year in the later phases of occupation at both sites. In contrast, oyster from mound deposits appears to indicate season of collection predominately during the colder months of the year. This contrast between mound and midden season of collection suggests that episodes of feasting and associated monument construction may have been of relatively limited temporal duration.

1. Introduction

The shell mounds that dot the coastline of the southeastern United States inspire controversy among archaeologists who work in the region (Claassen, 2010; Marquardt, 2010a, 2010b; Sassaman, 2010; Thomas, 2011). The debate centers on whether large, dense, deposits of shell represent purposeful mounding, the remains of large scale feasts, or instead simply the gradual accumulation of daily food refuse deposits (Thompson and Worth, 2011). The discussion extends beyond this area to similar sites in other regions of the world, inspiring a global dialog (Luby et al., 2006; McNiven, 2013; Roksandic et al., 2014). Archaeologists once viewed these shell midden sites only within the context of subsistence and post-glacial adaptations (see Binford, 1968). Now, however, researchers increasingly draw on concepts from literature on feasting, ritual practices, and the meaning of early monument construction to explain the formation of shell-bearing deposits (e.g., Russo, 2004; Saunders, 2014; Thompson and Andrus, 2011).

Despite this shift in perspective, perennial problems in evaluating large archaeological deposits of shell remain. Foremost among these is the timing of shell deposition. As Marquardt (2010a:566) observes, the starting point for any discussion of shell deposits as monuments or midden is dependent upon obtaining "sound temporal control to justify interpretations of short term construction episodes". Empirical archaeological approaches to temporal control of shell deposition include microstratigraphy (Vila et al., 2010), and intensive radiocarbon dating of sediments (Pluckhahn et al., 2015a, 2015b; Stein et al., 2003). All of these approaches offer viable ways to assess the temporality of large shell sites. We emphasize these empirical approaches not to devalue arguments based on form or macro-stratigraphic observations, as insights from such perspectives also play a role in our own interpretations. However, arguments that rely solely on evidence such as form often fall short in convincing other researchers that a certain feature or deposit represents an intentionally constructed monument and not the alternative. This is especially the case when arguments center on some of the earliest archaeological features that could possibly represent shell monument construction, such as the shell ring sites located along the coasts of the southeastern United States (Russo, 2004, 2014; Sanger and Thomas, 2010; Saunders, 2014; Thompson, 2007, 2010). Most recently, Andrus, Thompson, and colleagues began a systematic exploration of large-scale shell deposits to explore the range of depositional rates through the use of stable isotope chemistry on shellfish at a variety of different site types from several time periods (Andrus, 2012; Andrus and Thompson, 2012; Blitz et al., 2014; Thompson and Andrus, 2011, 2013). This method, used to determine "season" of capture of various shellfish species, is most commonly employed to evaluate issues

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related to sedentism and seasonal exploitation of resources (Andrus, 2012; Burchell et al., 2013; Jew et al., 2013; West, 2013). Our work in the Southeast likewise addresses these questions; however, we also use the method to evaluate the nature of early monumental constructions in the region. The underlying assumption behind the studies aimed specifically at identifying feasting events and related monument construction is that shellfish collected for these purposes would have been gathered rapidly and deposited in mass, and thus indicates one season of collection. This work reveals that shell deposits that appear similar macroscopically (i.e., that exhibit similar stratigraphic profiles) sometimes represent radically different rates of deposition.

The stable isotope studies that have been conducted to date have generally demonstrated that even relatively large and homogenous piles of shell with little soil development or artifacts may represent multiple seasons of deposition, thus negating the interpretation of these as products of an isolated feast (or even a single season of feasting) and rapid monumental construction (Thompson and Andrus, 2011).

Only two previous studies using this method provide exceptions that indicate possible feasting and mounding events of limited duration. The first is from shell ring 1 on Sapelo Island which dates to around 3800–4200 cal. B.P. and is located off the coast of Georgia. Shellfish sampled from this ca. 95-meter diameter, almost three meter tall deposit, indicated collection primarily during the cooler months of the year (i.e., winter). We thus interpreted this pattern as possibly representing feasting and subsequent mounding on top of the ring. However, we could not rule out the possibility that this was the residue of mass processing for surplus production and storage (Thompson and Andrus, 2011:320), an explanation not frequently considered by researchers working at such sites (see Waselkov, 1987).

The other example comes from the recent study of the marsh clam (*Rangia cuneata*) and oyster (*Crassostrea virginica*) from mound fill dating to cal A.D. 590–780 at the Graveline site in southern Alabama by Blitz et al. (2014). Their results indicate that people consumed these animals during short-term events throughout spring and summer months. This is perhaps the best evidence that mound building with the remains of shellfish from communal meals took place in the past. Given the context of these shells (e.g., mound fill), this study appears to be on firmer ground regarding its identification.

No previous studies have looked across multiple related sites to examine the nature of shellfish consumption, monument construction, and the diversity of activities associated with such practices. In addition, few have examined samples from both mound and midden context to gauge the temporality of monument construction and the waxing and waning of village life. This is the goal of the present study, which allows us to better differentiate special purpose feasting and the construction from quotidian subsistence and waste disposal. We present the results from our study of shell isotopes from *C. virginica* from the Crystal River (8CI1) and the Roberts Island Shell Mound Complex (8CI36, 37, 39, 40, 41 and 576) (hereafter simply Roberts Island), neighboring and temporally overlapping shell mound sites on the central Gulf Coast of Florida (Fig. 1). The results indicate that midden accumulation occurred throughout the year, while oyster from mound deposits appears to indicate season of collection during the colder months of the year. This contrast between mound and midden season of collection suggests

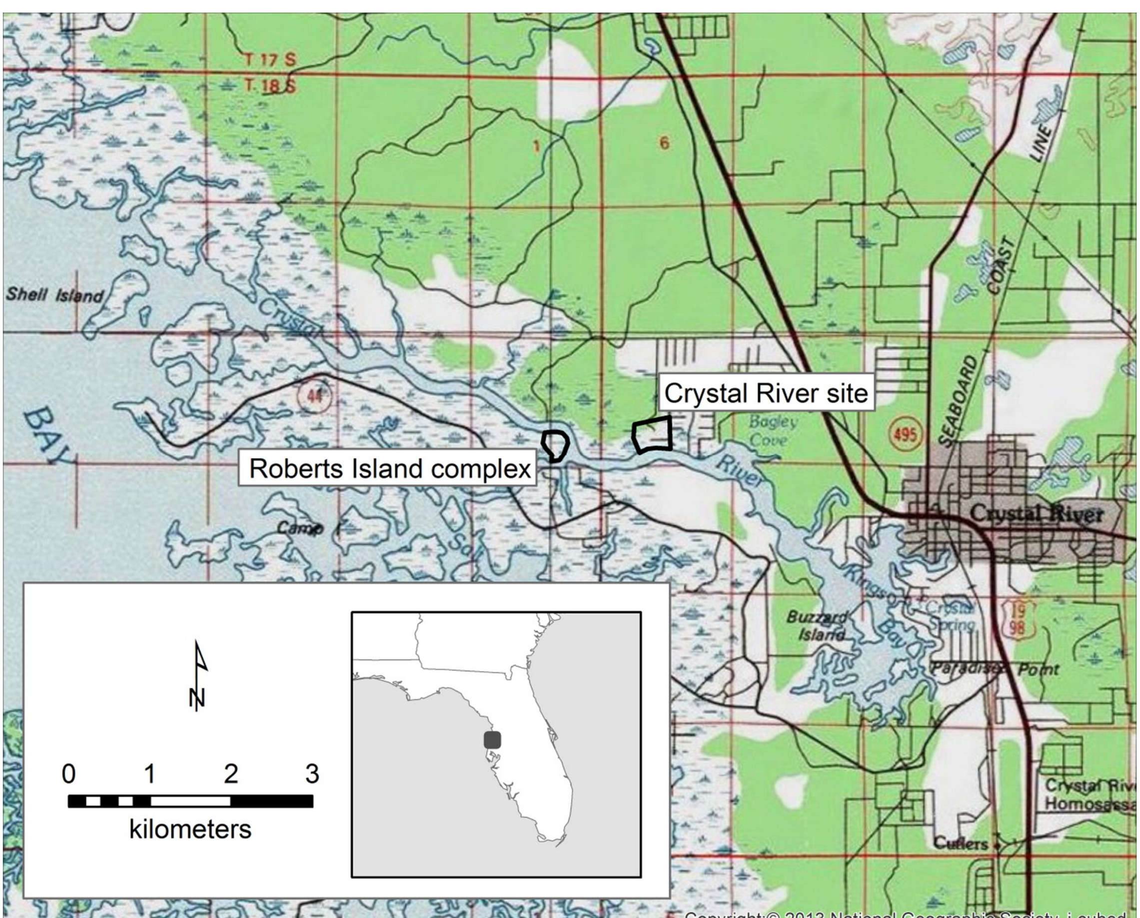

Fig. 1. Location of Crystal River and Roberts Island in Florida.
Adapted from Pluckhahn et al. (2015a, 2015b).

that episodes of feasting and associated monument construction may have been of relatively limited temporal duration.

2. Ecology and oyster exploitation on the Springs Coast

The Crystal River and Roberts Island sites are located in an area of Florida known as the Springs Coast. This area has a varied sub-tropical to warm-temperate climate with hot humid summers and brief winter freezes (Wolfe, 1990:211). The spring-rivers of this region contain the "most diverse and productive wildlife habitat in the region" (Wolfe, 1990:155). The Springs Coast supports not only a wide variety of fish species, but also a number of invertebrates. This productive river habitat provides ample resources for certain marine species as well, including striped mullet (*Mugil cephalus*) and the West Indian manatee (*Trichechus manatus latirostris*). The latter species takes advantage of Crystal River's near constant temperature springs, which is one of the largest winter aggregations of manatees in Florida (Wolfe, 1990:156). Along with marsh and terrestrial flora and fauna along the river and coastal estuaries, this environment provided the Native American inhabitants with a stable, reliable, and predictable resource base.

Foremost among the invertebrates consumed at Crystal River and Roberts Island was the American oyster (*C. virginica*) and the crested oyster (*Ostrea equestris*). Oyster reefs are found throughout the Springs Coast, primarily along river mouths (Wolfe, 1990:170). Some reefs extend up to 5.5 km into the Gulf of Mexico off of Crystal River (Dawson, 1955; Wolfe, 1990). Both species of oyster tolerate a wide salinity range (Wolfe, 1990:170). *C. virginica* can bear 5 to 10 psu to open ocean values of 32 to 37 psu (Andrus and Thompson, 2012; Eastern Oyster Biological Review Team, 2007; Shumway, 1996); however, *O. equestris* may be more abundant in higher saline bays and estuaries (Abbott, 1974). Most interesting is the fact that in both the field and laboratory we noticed perforations on *C. virginica* by boring sponges from Roberts Island, which also indicate that these reefs' habitat was in higher salinity environments.

During all four phases identified, occupants of both sites collected and deposited shellfish, with oyster being the most prevalent in both the middens as well as the mounds. Recent studies of the oysters from Mound A at Roberts Island by Sampson (2015) suggest that there may be differences between ones collected and deposited in midden fill and those used for mound construction. Her study shows that the oysters in the mound do not exhibit the full range of sizes that are recovered from midden context. Based on this evidence, she argues that inhabitants of Roberts Island collected and deposited the oysters that comprise the mound in short term, possibly feasting, events. Unfortunately, due to limited excavation, we do not have a comparable study from the Crystal River site.

3. Chronological context and settlement history

The Crystal River and Roberts Island sites consist of temporally overlapping mound centers separated by less than a kilometer. As described in more detail below, the sites are located approximately midway on the Crystal River, which flows about 8 km from its headwaters at a series of springs to Crystal Bay and the Gulf of Mexico (Figs. 2 and 3).

Crystal River has been subject to more extensive archaeological investigation of the two sites in the study, due in large part to its well-preserved architecture and the elaborate, non-local, Hopewellian artifacts recovered in the early and middle twentieth centuries (Pluckhahn et al., 2010; see also Bullen, 1951, 1953; Bullen, 1966; Greenman, 1938; Milanich, 1999; Moore, 1903, 1907, 1918; Weisman, 1995a; Willey, 1948, 1949, 1966). This site encompasses seven hectares and has an extensive midden, one 8-m tall platform mound (Mound A), two smaller flat-topped mounds (Mounds H and K), two burial mounds (one a complex comprised of several parts) (Mounds G and C–F, respectively), a large plaza, and several other features of less certain interpretation (e.g., "Mound" J) (Pluckhahn et al., 2010).

Roberts Island is one of the largest and most complex of several smaller mound centers that dot the landscape around Crystal River (Weisman, 1995b). Located just over one kilometer downstream from the latter site, the complex encompasses around two hectares and includes three relatively small shell platform mounds (Mounds A–C), an apparent plaza, and extensive midden deposits (Pluckhahn et al., 2015a, 2015b).

The general period of occupation of the two sites has been understood for some time. The Hopewell artifacts recovered by Moore and Bullen at Crystal River pointed to settlement during the Woodland period of eastern North American prehistory, from around 1000 B.C. to A.D. 1050 (Willey, 1966). Limited radiocarbon dating supported this association (Pluckhahn et al., 2010; Weisman, 1995a). Ceramic collections from Roberts Island pointed to a roughly contemporaneous occupation (Weisman, 1995b).

Recent research at the sites, including extensive radiocarbon and OSL dating, supports much more detailed understanding of the timing and form of midden formation and monument construction (Cherkinsky et al., 2014; Pluckhahn et al., 2015a, 2015b; Pluckhahn et al., 2010; Pluckhahn and Thompson, 2009). Pluckhahn et al. (2015a, 2015b) constructed a Bayesian model of the chronology of occupation on these two sites based on dated samples from excavation, coring, and museum collections. Specifically, we identified four phases of midden accumulation (Pluckhahn et al., 2015a, 2015b) (Fig. 2). Radiocarbon and OSL dates from mounds were modeled separately and matched to the midden chronology (Norman, 2015; Pluckhahn et al., 2015a, 2015b). Phase 1 has a modeled start date of cal AD 65–224 and end date of cal AD 143–265 (here and elsewhere we refer to the 95% probability ranges) (Pluckhahn et al., 2015a,b:29). During this phase there is evidence for the onset of midden accumulation and for the initiation of activities in the area of Mound J, at the Crystal River site (Fig. 4). The modeled start and end dates for Phase 2 are cal AD 221–321 and cal AD 435–544, respectively (Pluckhahn et al., 2015a,b:31). During this interval, the inhabitants of Crystal River expanded the midden to its later j-shaped appearance constructed two small platform mounds (Mounds H and K) (see Fig. 4). The modeled start date for Phase 3 is cal AD 479–634 and its end date is cal AD 663–809 (95% probability ranges) (Pluckhahn et al., 2015a,b:32). During this phase, there is a contraction of the midden at Crystal River (Fig. 5). Around the same time, settlement began at Roberts Island. Despite the apparent reduction of settlement at Crystal River, this also the interval during which the largest platform mound (Mound A) was constructed, or at least begun. Finally, Phase 4, has modeled start and end dates of cal AD 722–881 and cal 890–1068, respectively (Pluckhahn et al., 2015a, b:34). In this interval, the occupation of the Crystal River site continued to decline as Roberts Island supplanted it as the primate ceremonial center in the region (Fig. 6). Two of the three platform mounds at Roberts Island were constructed during this phase; the third is undated but the spatial arrangement of the shellworks suggests that it is contemporaneous with the other two.

4. Sea level and climate: a brief history

Sea level history for the Florida Gulf Coast is a complex issue. Studies from southwest Florida indicate that there has not only been sea-level rise, but various fluctuations over the last two millennia (Walker, 1992:275–290; Walker et al., 1994, 1995). What is unclear is how the broader Gulf Coast and the Springs Coast in particular experienced such changes in sea level. The timing and magnitude of sea-level fluctuations can vary significantly over a wide geographic area. That said, the Crystal River region correlates with some of the variations noted for southwest Florida.

During the time that Native Americans occupied both Crystal River and Roberts Island sea levels fluctuated dramatically based on the available data from other parts of Florida and surrounding states (Colquhoun and Brooks, 1986; Tanner, 1991, 2000; Walker, 1992, 2013). During the

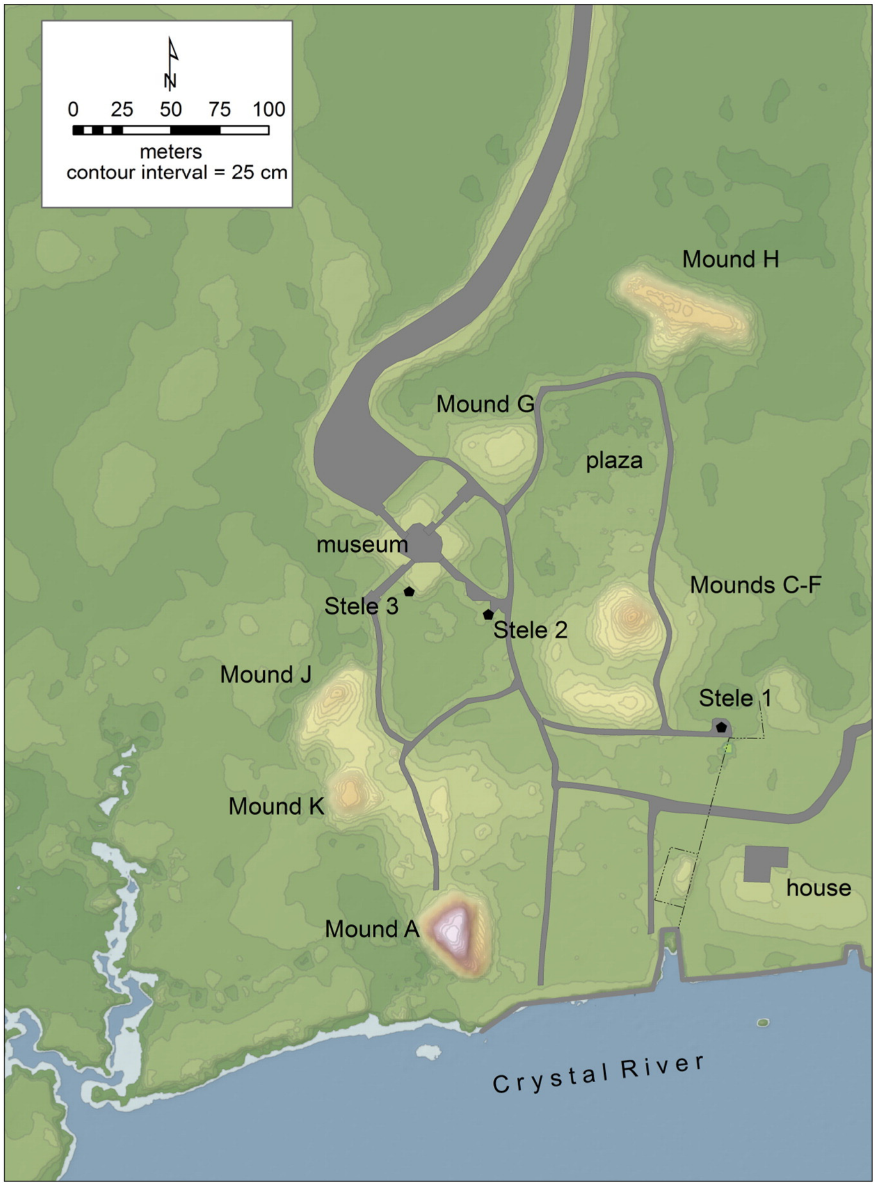

Fig. 2. Topographic map of Crystal River based on LiDAR and topographic total station survey. Adapted from Pluckhahn et al. (2015a, 2015b).

Phases 1 and 2 of our chronological model for the Crystal River site, which roughly corresponds with the Medieval Warm period of A.D. 1 to 500, sea levels were rising and the climate was generally warmer than before; however, there were also shorter-term events of slowed sea level rise and cooler temperatures (Walker, 2013:39; Wang et al., 2013). During Phase 3, sea levels may have lowered; Tanner's (2000:93) research shows a dramatic drop between AD 550 and 600 and again between 600 to 650, with sea level reaching its lowest point around AD 850 (Walker, 2013:40). This time period is associated with a trend toward a cooler and drier climate in the region (Wang et al., 2013). There is much more variability in the climate and sea-level records for the time frame AD 850–1200, which encompasses our Phase 4. However, this period is generally known as the "Medieval Warm Period" and is linked to sea-level rise up to the twentieth-century mean and a warmer climate (Walker, 2013:42).

Some of these shifts co-occur with settlement changes for the Crystal River region. Foremost among these are the decline of the Crystal River site and the subsequent rise of Roberts Island as the primate ceremonial center of the region. This transition is linked to the lowering of sea levels and exploitation of resources from higher saline environments. It may be the case that the lowering of sea levels initiated a conscious decision on the part of the inhabitants of the Crystal River region to shift their activities further downstream closer to the Gulf of Mexico where they could exploit oyster reefs closer to the Gulf. We will return to these observations in our discussion of the season of collection for oysters at the end of this paper.

5. Materials and methods

We selected a total of 52 *C. virginica* shells from various contexts at both Crystal River and Roberts Island to provide an assessment of the various temporal phases and context from the site. Of these 52 shells, 32 are from Roberts Island with the remaining 20 from Crystal River. These samples come from both mound and midden contexts from both Roberts Island and Crystal River. Our samples from the midden at Roberts Island consisted of small 50-x-50 cm shovel tests excavated in 10-cm levels. In the mounds, we excavated trenches measuring 1-m wide and 4 to 6 m long. Samples from mound context from Roberts Island were piece plotted along the profile of our excavation trench down the slope of Mound A, a stepped shell mound that is oriented

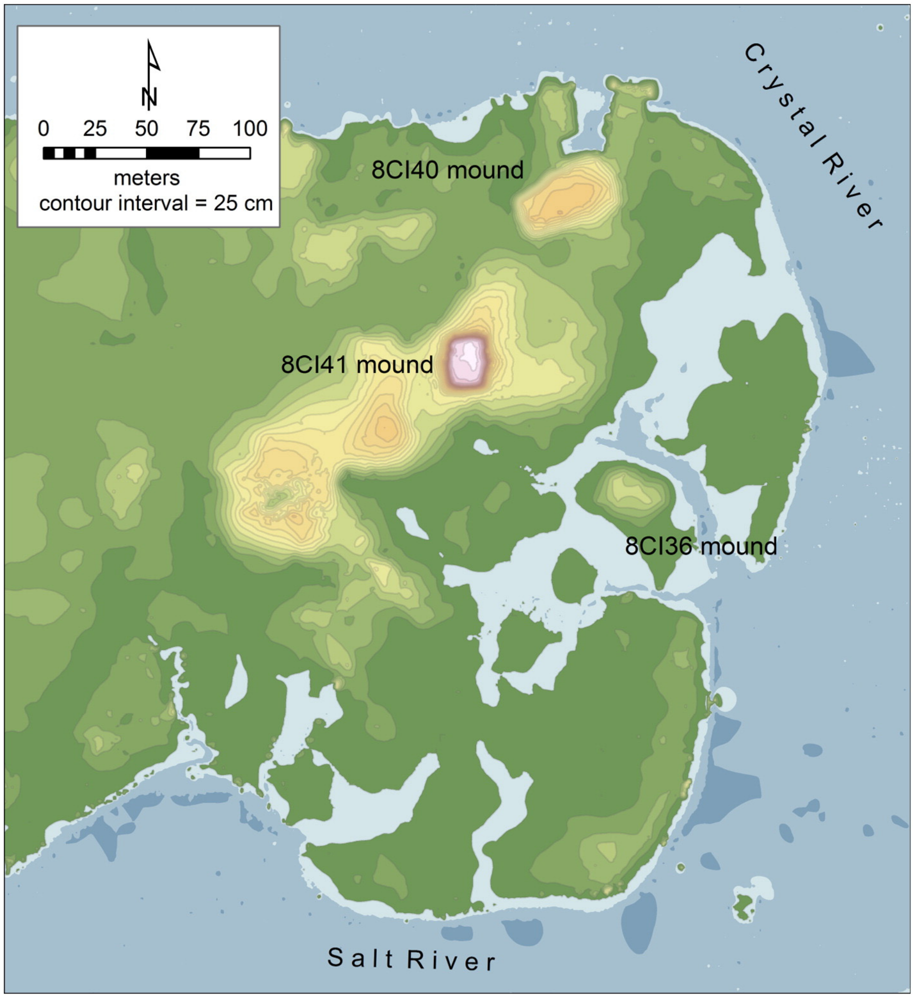

Fig. 3. Topographic map of Roberts Island based on LiDAR and topographic total station survey. Adapted from Pluckhahn et al. (2015a, 2015b).

with the cardinal directions. For Crystal River, we selected samples from our excavation trenches in the midden areas. Unlike Roberts Island, we were not able to conduct trench excavations from the mounds that make up Crystal River. However, we extracted small (4-cm) diameter cores from the mounded architecture at the site. Specifically, we collected samples from Mounds A and K. After cores were taken, we pulled shell samples from the upper researches of the core's profile before filling them back in with sand.

We attempted to sample across all four of the phases that we identified in our Bayesian analysis of the radiocarbon dates. However, given that each of the phases is not equally represented in the deposits at each site, some phases of occupations are better sampled than others. For example, Roberts Island deposits primarily date to Phase 4, thus this period tends to be over represented in our analysis. In contrast, we sampled few deposits that date to Phase 1, therefore it is underrepresented.

5.1. Laboratory methods

We used the standard laboratory methods described in our previous studies (Andrus and Crowe, 2000; Andrus and Thompson, 2012; Thompson and Andrus, 2011, 2013), which we summarize here as well. Briefly, we selected only the left oyster valves with complete chondrophore. If valve interiors exhibited epibiont activity they were excluded from the analysis. Once we selected the shells for analysis, each one was bisected along the chondrophore and then mounted onto a slide with a Crystalbond™ thermal adhesive. Thick sections (ca. 1 mm) were cut using a diamond wafering saw. If shells appeared fragile and prone to fracture during preparation, a thin layer of metal epoxy (JB Kwik Weld) was painted on the portion of the valve in contact with the saw blade, similar to methods used by Schöne et al. (2005). This epoxy was excluded from the sampled portions of the shell.

We sampled each oyster following its ontogeny using a New Wave/Merchantek micromilling system. Sampling focused on the calcitic regions of the shell and avoided aragonite areas (Carriker and Palmer, 1979). On average we extracted 19 samples from each oyster, capturing approximately one-year or more worth of growth. Samples were immediately adjacent to one another equidistantly, typically between 300 and 350 mm and milled to a depth of between 300–400 mm. Powered carbonate samples were then weighed and loaded into 4.5 ml borosilicate vials.

All samples were analyzed for $\delta^{13}C$ and $\delta^{18}O$ using a Thermo Gas Bench II coupled to a either a Thermo Delta V or Thermo Delta Plus isotope ratio mass spectrometer in continuous flow mode at the University of Alabama Stable Isotope Laboratory in the Department of Geological Sciences. After flushing with ultra pure He prior to extraction, we reacted the carbonate sample with orthophosphoric acid in the sealed vials at 25 °C.

Values are reported in parts per mil (‰) relative to the VPDB standard by correcting to multiple NBS-19 analyses (typically 14) per run. NBS-19 was also used to assess and correct for drift and sample size linearity if needed. Average precision (1σ) of all runs was ±0.07‰ for $\delta^{13}C$ and ±0.1‰ for $\delta^{18}O$ as measured on each sample run (1σ range for $\delta^{13}C$ was ±0.02–0.19‰ and $\delta^{18}O$ was ±0.02–0.2‰).

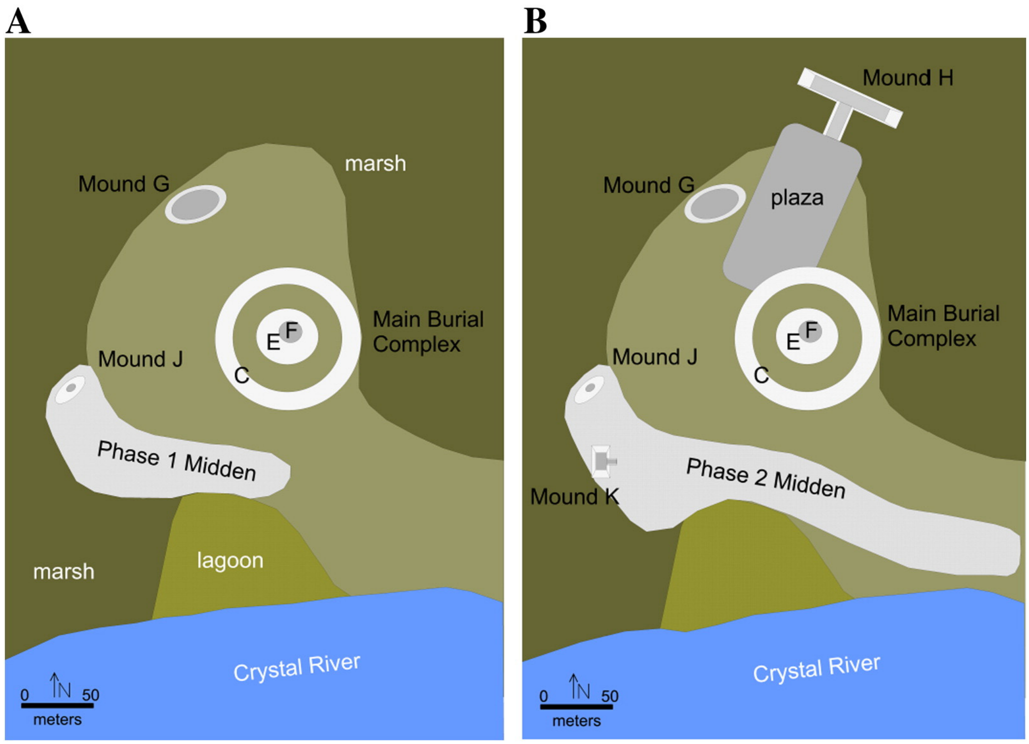

Fig. 4. Map of Crystal River showing the extent of midden and architectural features during Phase 1 (A) and Phase 2 (B). Adapted from Pluckhahn et al. (2015a, 2015b).

We interpreted the resulting $\delta^{18}O$ profiles for season of capture following the methods previously outlined by Andrus and Crowe (2008) and Thompson and Andrus (2011, 2013). The rationale for the process of assignments to seasons of collections is fully described in the above references. In these publications, seasonal water temperature changes are posited as the primary driver of shell $\delta^{18}O$ variation displays an inverse relationship during ontogeny. Thus, to assess the seasonal range of each oyster shell, we divided each isotope profile into three equal parts (Fig. 7). We compared last $\delta^{18}O$ value for the hinge area of oysters to the maximum range of the prior oscillations. “Winter” was

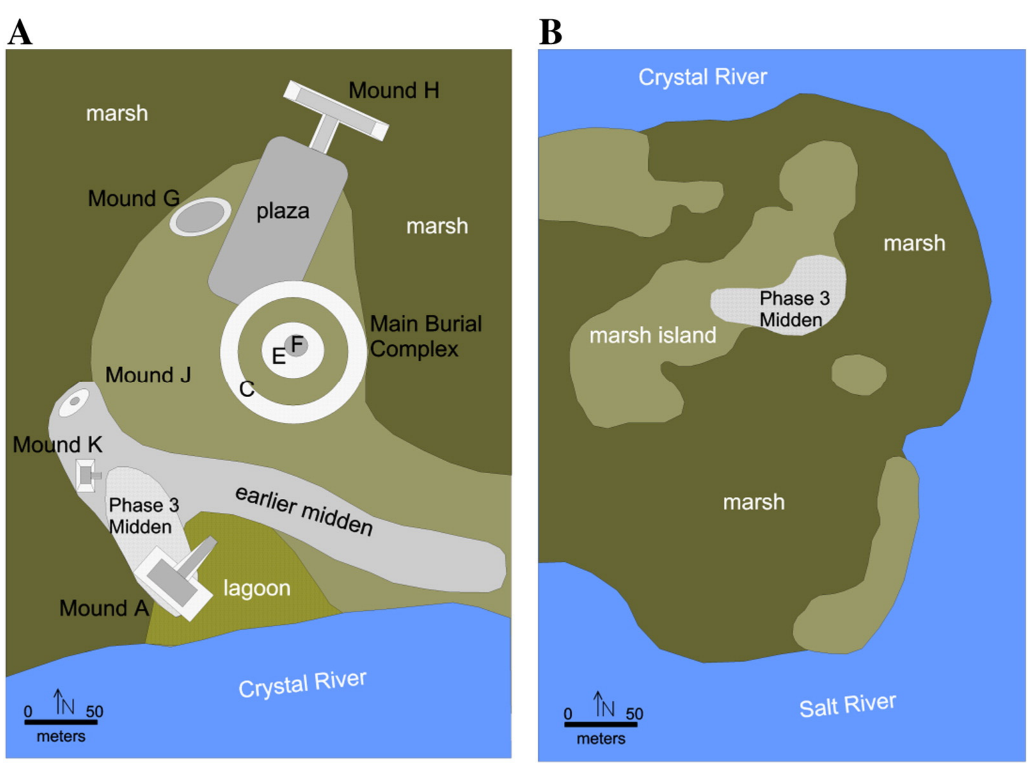

Fig. 5. Map of Crystal River (A) and Roberts Island (B) showing the extent of midden and architectural features during Phase 3. Adapted from Pluckhahn et al. (2015a, 2015b).

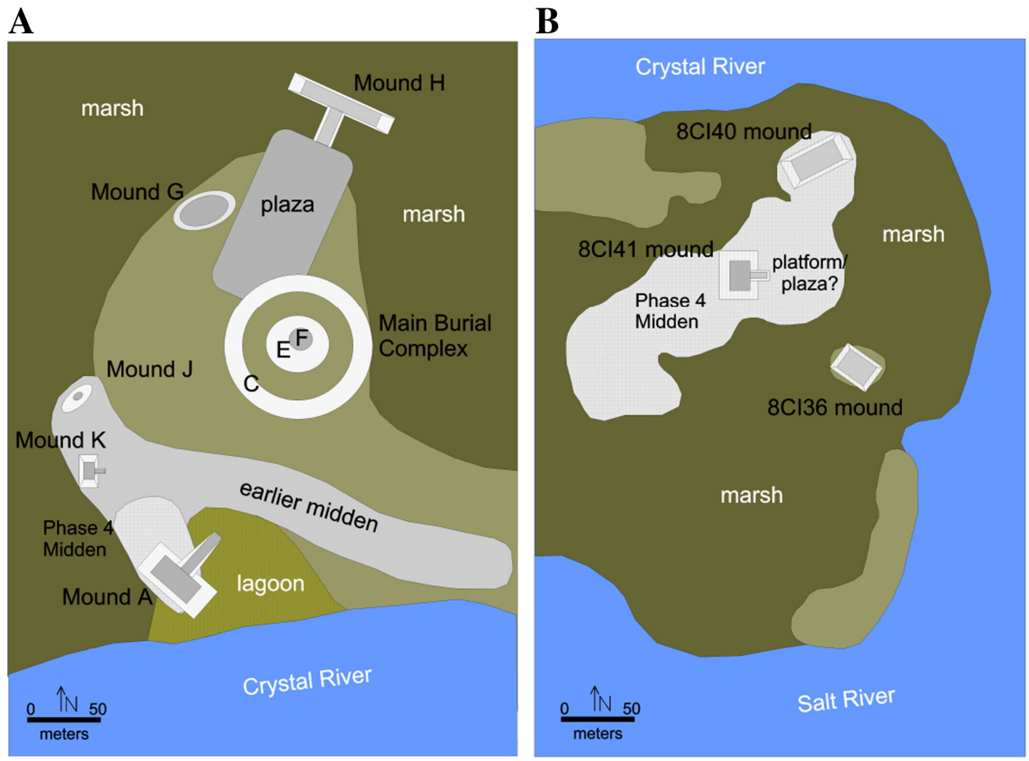

Fig. 6. Map of Crystal River (A) and Roberts Island (B) showing the extent of midden and architectural features during Phase 4. Adapted from Pluckhahn et al. (2015a, 2015b).

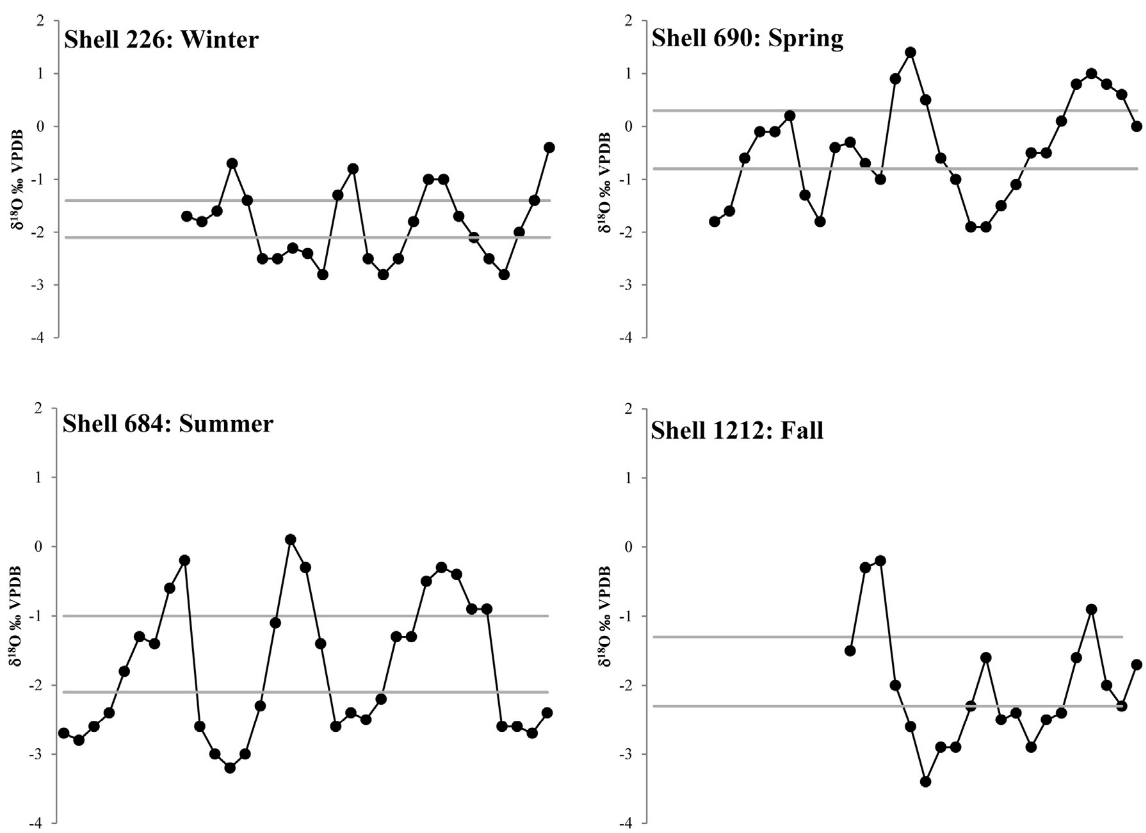

Fig. 7. Examples of shell oxygen isotope profile from each season. Y axis is ^{18}O in parts per mil versus VPDB. X axis is sample following ontogeny (left to right) at roughly equidistant intervals. Gray lines divide the profile amplitude in thirds as described in text. Symbol diameter equals average analytical precision (1 sigma).

Table 1
All isotope data from analyzed oysters are reported relative to the VPDB standard in parts per mil (‰). Samples are in sequence from the growing edge (left) toward earlier in the ontogeny (toward the right). Season of collection estimates are based on the methods described in the text.

Shell																				
Winter																				
279	0	−0.1	−1.4	−1.8	−2.1	−1.9	−1.7	−0.3	0	−0.6	−2.2	−2.1	−2.1	−1.9	−2.7	−2.5				
11.0.3	−0.3	−1	−1.3	−1.9	−0.9	−2	−2.4	−1.6	−1	−0.9	−1.2	−1.4	−1.2	−1.2	−1.9	−1.4	−0.8	−0.8	−0.6	
11.0.5	0.1	0.4	−0.6	−0.9	−1.2	−1.9	−1.6	−1.7	−1.8	−1.7	−1.8	−1.6	−0.7	−0.2	−0.1	0.4	−0.7			
7	0	−1.3	−1	−1.4	−1.9	−1.5	−1.7	−1.9	−1.5	−1.3	−1.1									
13.0.2	0.9	0.7	0	−0.3	−1.2	−1.4	−2.2	−1.9	−1											
219	0.6	−1	−1.3	−1.5	−1.5	−1.4	−2	−1.5	−1.8	−1.4	−1.3	−1	−0.3	0	−0.3	−1.2	−1.6	−2.3	−2.7	
222	−0.1	−0.5	−1.1	−1.1	−1.1	−0.9	−1.1	−1.6	−1.8	−2.2	−2.9	−3.3	−2.9	−2.2	−3.4	−2.5	−2.1	−2.4	−2.5	−2.7
223	0.5	−0.5	−1.1	−1.1	−0.9	−1.3	−1.1	−1.6	−1.4	−1.5	−1.4	−1.5	−1.4	−1.2	−1.1	−0.6	−0.7	−0.2	0.2	
226	−0.4	−1.4	−2	−2.8	−2.5	−2.1	−1.7	−1	−1	−1.8	−2.5	−2.8	−2.5	−0.8	−1.3	−2.8	−2.4	−2.3	−2.5	−2.5
272	0.1	−1.5	−2.4	−2.3	−2.2	−1.9	−1.7	−0.1	0.3	−0.4	−0.7	−1.2	−1.5	−1.3	−1.8	−2	−2	−2.2	−2.2	
277	−0.2	−1.9	−2.2	−2.1	−2.5	−3	−3.9	−3.5	−3.6	−3.3	−2.2	−1.7	−1.9	−1.8	−1.3	−0.5				
278	−1.2	−0.5	−1.6	−1.9	−2.1	−2.6	−2.7	−2.5	−2.1	−2.8	−3.9	−2.9	−2.3	−2.1	−0.8	−1.6	−2			
280	−0.3	−0.8	−1.2	−1.3	−1	−1.8	−1	−1	0	−1.1	−1.7	−1.8	−1.3	−2	−1.8	−1				
282	0.3	−0.1	−1.1	−1	−1.8	−2	−2.5	−2.4	−2.2	−2	−1.8	−1	−0.6	−0.6	−1.5	−2	−2.8			
287	0.3	0.4	−0.2	−0.2	−0.6	−1.1	−1.7	−2.1	−2.2	−1	−0.5	−0.9	−1.2	−1.5	−1.6	−1.1	−1.5	−1.1	−1	−1.2
687	−0.7	−0.7	−1	−2.6	−2.4	−2.1	−2.3	−2.5	−2.5	−2.2	−1.4	−0.1	0.1	−1.3	−2.2	−2.3	−2.5	−2.5	−2.6	−2.8
696	−1.6	−2.2	−3.5	−1.5	−1.2	−1.7	−1.8	−2.8	−2.9	−3	−3.3	−3.4	−2.8	−1.5	−1.7	−1.8	−2.3	−2.5	−2.5	−2.6
775	0.8	0.9	0.6	−0.6	−2.5	−3	−3.1	−2.8	−2.9	−3	−3	−3	−2.8	−3	−1.1	1	0.6	−0.4		
692	−1	−0.3	−0.4	−0.7	−1.4	−1.5	−1.3	−1.4	−0.8	−1.7	−2	−3	−2.7	−1.7	−1.6	−1.9	−2.3	−2.2	−2.2	−2.2
219	0.6	−1	−1.3	−1.5	−1.5	−1.4	−2	−1.5	−1.8	−1.4	−1.3	−1	−0.3	0	−0.3	−1.2	−1.6	−2.3	Error	−2.7
1209	−0.6	−1.8	−2.3	−2.3	−1.9	−0.9	−0.4	0.1	−0.7	−1.8	−2.4	−2.4	−2.5	−2.1	−2.8	−3.1	−2.8	−2.4	−0.9	−1.8
Spring																				
13.0.3	−1.5	−1.4	−1	−0.1	−1.2	−2.3	−2.2	−1.9	−1.3	−1	−0.9	−0.4	0.2	−1.1	−1.6	−2.1	−1.7			
121	−1	−1.1	−0.4	−0.6	−1.1	−1.2	−1.9	−2.9	−2.9	−2.8	−2.6	−2.8	−2.6	−2.5	−2	−1.7	−1.5	−0.8	−0.6	0.3
122	−2.4	−0.6	−0.8	−0.8	−1.5	−1.8	−1.6	−1.6	−2.5	−3.2	−3.7	−3.9	−3	−3.8	−2.2	−2	−1.9	−1.7		
304	−2.1	−0.6	−1.8	−3.1	−2.7	−3.4	−1.8	−1	−1.4	−2.4	−2.8	−2.6	−3.8	−2.8	−0.7	−1.4	−2.3	−3	−2.5	−1.9
690	0	0.6	0.8	1	0.8	0.1	−0.5	−0.5	−1.1	−1.5	−1.9	−1.9	−1	−0.6	0.5	1.4	0.9	−1	−0.7	−0.3
1211	−1.5	−0.6	−1.5	−1.7	−2.4	−2.8	−2.3	−2.6	−2.9	−2.7	−2.7	−2.2	−2.1	−1.2	−0.7	−2.2	−2.3	−2	−1.9	−1.8
225	−0.7	1.1	1	0.2	−0.3	−1	−0.8	−1.4	−1.8	−1.8	−1.7	−1.9	−2	−2.2	−2.4	−1.9	−2	−1.6	−1.7	−1.8
6	−1.5	−1	−0.8	−1.4	−0.6	0.9	0.9	0.8	0	−0.6	−1.1	−2.3								
Spring/Summer																				
276	−1.7	−1.2	−0.1	−1.1	−2.7	−2.9	−0.4	0	0.3	−0.8	−2.2	−1.7	−1.9	−1.5	−0.9	−0.4	−0.2	−0.5		
Summer																				
2	−2.4	−2.5	−2.2	−2	−2	−1.6	−1.9	−1.1	Error	0	−0.1	−0.7	−1.3	−2.4	−2.2	−1.8	−2.2	−1.6	−1.5	−1.3
13	−2.6	−3	−3.1	−3.1	−2.2	−1.3	0.1	−0.5	−2.5	−2.5	−1.9	−1.8	−1	−1	−1.2	0				
220	−1.7	−1.8	−2.1	−2	−2.2	−2.3	−2.2	−2.1	−2	−2.1	−2.2	−2.2	Error	−1.7	−1.1	0.2	−0.5	−1.5	−1.8	
221	−1.9	−2.3	−2.5	−2.5	−2.2	−2	−1.6	−2.1	−1.7	−1.5	−1.2	−1.3	−1.2	−0.7	Error	0.4	0.4	0	−0.6	−0.9
298	−2.3	−2.1	−1.4	−0.6	−0.7	−1.3	−0.9	−2	−2.4	−2.8	−2.8	−2.3	−1.8	−1.8	Error	−1.8				
1206	−3.5	−3.3	−3.2	−3.1	−2.6	−3	−2.5	−2.1	−2.4	−2	−2.9	−3.7	−2.8	−2.4	−2.1	−1.1	−1	−1.2	−1.6	−2
684	−2.4	−2.6	−1.4	−0.3	0.1	−1.1	−2.3	−3	−3.2	−3	−2.6	−0.2	−0.6	−1.4	−1.3	−1.8	−2.4	−2.6	−2.8	−2.7
Fall																				
4	−2.7	−3.4	−3.4	−3.1	−3.1	−2.9	−2.3	−2.1	−2.1	−2.6										
12.0.2	−1	−1.3	−1.5	−0.2	−0.4	−2.2	−2.3	−2.2	−1.5	0.8	0.4	−0.1	−0.7	−1.2	−2	−2.2	−0.4			
1212	−1.7	−2.3	−2	−0.9	−1.6	−2.4	−2.5	−2.9	−2.4	−2.5	−1.6	−2.3	−2.9	−2.9	−3.4	−2.6	−2	−0.2	−0.3	−1.5
5	−1.7	−1.7	−2.8	−3.4	−3.6	−1.7	−1.7	−2.6	−3.6	−3.1	−3.3	−3	−2.4	−2.6	−1.9	−0.9	−1.9	−3.6	−3.6	
Winter/Fall																				
283	0.1	0	−0.4	−0.5	−0.6	−1.8	−2.4	−2.9	−1.9	−1.6	−1.9	−2.5	−2.6	−2.5	−2.2	−1.8	−1.1	−0.7	−0.5	−0.1
8	−1.1	−1.1	Error	−1.1	−2.1	−2	−1.6	−0.9	−0.8	−1.3										
697	−0.9	−0.7	−2.1	−1.8	−2.3	−2.9	−2.6	−2.9	−2.9	−1.6	−0.1	−0.5	−1.7	−2.2	−2.2	−2.5	−2.4	−2.4	−2.6	−2.6
284	−0.2	−1.1	−2.5	−2.4	−2	−1.1	−0.6	0.3	0.9	−0.8	−0.9	−1.6	−1.1	−1.1	−0.7	−0.7	−0.1	−0.8	0	0.4
Undetermined																				
288	−1.9	−0.7	−0.7	−1.6	−1.7	−1.3	−1.9	−1.8	−2	−1.9	−1.6	−1	−0.9	−1.2	−1.5	−1	−1.4	−1.1	−1	0
305	−3.4	0.3	0.8	0.2	0.1	−0.4	−1.3	−1.1	−3.5	−3.4	−1.8	−1.3	−5.6	−3.9	0	0.3	−4.5	−1.3	−1.5	−5.3
306	−3.3	−1.2	−1.9	−2.3	−4.4	−2.3	−4.7	−3.6	−3.8	−1.4	−2.2	−3.4	−2.6	−4.5	−4.5	−2.2	−0.5			
689	−1.8	−2.2	−2.2	−2.1	−2.4	−2.4	−2.4	−2.8	−3.1	−2.3	−1.9	−2.9	−2.2	−0.7	−1	−2.8	−2.9	−2.6	−1.9	−2.9
11.0.4	−1.7	−2.5	−2.6	−0.5	−2	−2.6	−2.5	−2.9	−2.2	−2.2	−1.2	−1.8	−1.7	−1.5	−1.5	−1.4	−0.7			
224	−0.4	−1.7	−2.1	−2.6	−3	−3.2	−3	−3.3	−1.2	−1.9	−2.1	−1.7	−2.3	−2.9	−2.3	−1.6	−1.1	−0.8	−1.1	−1.1
1207	−1.8	−1.2	−1.3	−1.8	−2.6	−2.7	−2.3	−2.3	−2.4	−1.9	−0.3	−0.1	−0.5	−1.7	−1.2	−1.6	−2	−1.6	−2.1	−2

Sample number are listed with the continuation of data points from preceding page. Samples are in sequence from growing edge (left) toward earlier in ontogeny (toward the right).

Shell
Winter
279
11.0.3
11.0.5
7
13.0.2
219

Table 1 (*continued*)

Sample number are listed with the continuation of data points from preceding page. Samples are in sequence from growing edge (left) toward earlier in ontogeny (toward the right).

Shell																	
222	-3	-2.9	-2.1	-2.6													
223																	
226	-1.4	-0.7	-1.6	-1.8	-1.7												
272																	
277																	
278																	
280																	
282																	
287	-0.6	0.8															
687	-2.6	-2.7	-2.9	-3.1	-3	-2.4	-2.2	-2	-1.8	-1.1	-0.4	-1.9	-2	-2	-1.5	-2.2	-1.5
696	-3.5	-3.3	-2.9	-2.7	-3	-2.2	-2	-1.7									
775																	
692	-1.8	-1.5	-1.4	-1													
219																	
1209	-2.2	-2.7	-2.9	-2.8	-2.6	-2.9	-2.7	-0.8	0.3	-1	-1.6	-1.5					
Spring																	
13.0.3																	
121	0																
122																	
304																	
690	-0.4	-1.8	-1.3	0.2	-0.1	-0.1	-0.6	-1.6	-1.8								
1211	-2.6	-2	-2.2	-2.3	-2.1	-1.8	-2	-2.1	-2	-2.1	-2	-1.7	-1.3				
225	-2.2	-2	-2.1	-2.1	-1.4												
6																	
Spring/Summer																	
276																	
Summer																	
2	0	-1.9															
13																	
220																	
221																	
298																	
1206	-2.7	-2.9	-3	-3.4	-3.8	-4	-3.6	-3.5	-3.7	-2.8							
684	-2.5	-2.2	-1.3	-1.3	-0.5	-0.3	-0.4	-0.9	-0.9	-2.6	-2.6	-2.7	-2.4				
Fall																	
4																	
12.0.2																	
1212																	
5																	
Winter/Fall																	
283	0.1	0.6	1	0.9	1.6												
8																	
697	-1.9	0.1	-0.3	-1.8	-2.1	-2	-2.2	-2.4	-2.7								
284	1.1	-0.7	-0.2	-1.3	-0.9	-1.5	-1.8										
Undetermined																	
288																	
305	-1.7	-5	-3.2														
306																	
689	-2.9	-2.6	-1.9	-2.2	-1.9	-2.9	-2.7										
11.0.4																	
224	-1.5	-1.2															
1207	-1.9	-1.8	-1.3	-1	0	-0.7	-1.3	-1.5	-1.5	-2.1	-2.2	-2.2	-2.3	-1.8			

assigned to shells in which the last $\delta^{18}O$ value was in the upper third. "Summer" was assigned to shells in which the last $\delta^{18}O$ value was in the lower third. Shells with the terminal $\delta^{18}O$ value in the middle third were assigned to either spring or fall, depending on the trend prior to death: Positive trends indicated fall, and negative trends indicated spring. Shell $\delta^{18}O$ profiles that lacked generally sinusoidal shape, or recognizable portion of a sinusoid, were designated as "uninterpretable". In shells where a sinusoid was incomplete, season of capture was only estimated if the range in $\delta^{18}O$ was approximately as large as would be expected based on likely local temperature ranges and modern control oysters of similar time averaging in nearby locations (e.g., Surge et al., 2001, 2003). Shells in which the terminal $\delta^{18}O$ value overlapped two seasons (within 1σ precision limits), a two season estimate was made (e.g., winter/spring). This is not to imply necessarily that the shell was captured at that precise time, but rather it only indicates season of capture could be in either period of time and cannot be differentiated confidently.

There are additional sources of possible uncertainly and error to be considered in making season of capture estimates. For example, seasonal temperatures vary from year to year, thus what may appear as one season in the shells, was in fact several weeks or months earlier or later on the calendar. $\delta^{18}O_{water}$ values at the time of shells growth were unknown and likely varied at multiple timescales, which may obscure temperature-driven seasonal changes and create short-term variations that alter the shape of the $\delta^{18}O$ profile. Shells likely do not grow all year, thus impacting the overall amplitude and shape of $\delta^{18}O$ data profiles. Also, shell growth rate varies at multiple time scales, thus each $\delta^{18}O$ data point represent a slightly different period of time averaging, which will again alter the shape of shell isotope profiles. This will be further impacted by subtle variations in sampling procedures between shells. Also, it is possible, or even likely, that some dead shells were brought to the midden along with living ones and that shells were disturbed or suffered diagenesis after deposition. These concerns, among many others, almost certainly indicate that some season of capture assignments are incorrect, thus the totality of evidence should be considered when assessing the overall seasonality of a feature or site (see Blitz et al., 2014 for a more extensive discussion of these matters) A single shell should not be interpreted as an infallible indicator of season of capture.

5.2. Results

We ran a total of 710 samples from the 52 shells for the analysis. Results for all stable isotope analyses from oyster shells are presented in Table 1. The mean $\delta^{13}C$ value for all oysters is −4.44‰ and −1.55‰ for $\delta^{18}O$. Most shells contain at least part of a generally sinusoidal $\delta^{18}O$ sequence. Of the 52 shells in the analysis, 45 produced interpretable results for season of collection.

While the vast majority of the shells can be placed within a single interpretable season, there are a few (see Table 1) that fall between two seasons and received a split designation (e.g., Spring/Summer). This does not mean that the shell was collected during the transition, but rather the shell could be from either season (see Blitz et al., 2014:705).

Nineteen shells sampled out of 20 from Crystal River yielded interpretable results. Of these, we interpreted 2 as a fall season of capture, 1 for fall/winter, with 9 for winter, 3 for spring, 1 for spring/summer, and 3 for summer respectively. Thus, for the site overall, all four seasons are represented in the data.

Twenty-six shells sampled out of 32 from Roberts Island yielded interpretable results. Of these, we interpreted 2 as a fall season of capture, with 3 for winter/fall, 12 for winter, 5 for spring, and 4 for summer respectively. Three shells could not be differentiated between spring and summer and another three could not for fall and winter. Similar to Crystal River, all four seasons are represented at the site as a whole.

6. Discussion

Given recent debates and reinterpretation of large-scale shell deposits as monuments rather than midden in the emerging dialogue in world archaeology regarding shell sites, we need better quantitative assessments of the temporality of shell deposit formation (see Marquardt, 2010a, 2010b). Only through understanding the tempo of shell deposition can archaeologists make substantive statements

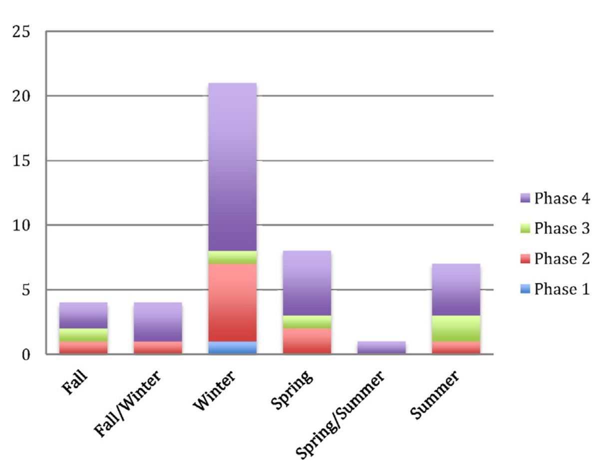

Fig. 8. Histograms of shell season of capture distribution by Phase at Crystal River and Roberts Island.

regarding the nature of such deposits. Our revised chronological model for Crystal River and Roberts Island based on our Bayesian modeling of radiocarbon dates provides us with a more refined temporal framework by which we can interpret our stable isotope results (Fig. 8). These analyses lend us two different perspectives into the timing of shell deposition and allow us to provide a historic perspective, which we present below, regarding the nature of monumentality and site occupation. In turn, at the end of this paper, we use this trajectory to explore some of the broader implications of this research regarding the nature of early monument construction and the emergence of early villages.

During Phase 1 at Crystal River, there appears to have been relatively rapid midden development based on calculated accumulation rates; this deposition is possibly linked to burial ceremonialism (e.g., burials with shell caps) (Pluckhahn et al., 2015a,b). The only architecture in use during this time appears to be the burial mounds (Mounds G and the C–F complex) and Mound J. However, it is possible that Mound J began as part of the Phase 1 midden. The isotopic results from this phase suggest only cold weather occupation (i.e., winter). We offer the tentative suggestion that Crystal River was only seasonally occupied during this early phase. The isotopic data fit well with our previous observation regarding the seasonal occupation of the site based on the rates of accumulation and the lack of artifacts from the midden deposits (Pluckhahn et al., 2015a,b). However, our isotopic sample size for this phase is small and we are hesitant to place too much emphasis on these data.

In Phase 2 the occupation may have shifted to year-round, as the isotopic data suggest collection of oysters throughout the year. Consistent with this, our calculated accumulation rates for this phase suggest that not only did midden deposits accumulate at an increased tempo, but also in areal extent (Pluckhahn et al., 2015a,b:31). It is during this time that occupants of Crystal River constructed the smaller platform mounds, Mounds H and K. The construction of Mound H adjacent to the two burial mounds created a platform and burial mound and plaza complex indicating a more formal conception of space and architecture at the site compared to the Phase 1 layout. It is perhaps because now that Crystal River had a more stable resident population that more formal spatial arrangements were necessary, particularly if the resident population was host to non-locals during ceremonial events.

The patterns in the isotope data in Phase 3 appear to shift slightly according to our previous observation regarding the contraction of the middens at Crystal River (Pluckhahn et al., 2015a,b:33). It is also during this time that we see the beginning of midden accumulation at Roberts Island. This broader settlement may indicate that the foothold that Crystal River held was beginning to wane. The isotopic data from Crystal River during this time do indicate all four seasons of occupation; however, most of our samples for this phase from Crystal River come from Mound A, the largest mound at the site, and specifically from the upper levels of the mound (i.e., the first meter of deposits). As we have seen at other shell mound sites, it is possible that these upper levels were mined, repurposed, midden for mound construction (see Villagran, 2014). Indeed, the fact that we have an inversion in the radiocarbon dates from this mound lends some further support for this interpretation.

It is perhaps unsurprising that Crystal River begins its decline during this period, as sea levels began lowering during this interval (see our earlier discussion). However, as we point out, the largest structure, Mound A, was completed during this phase (Pluckhahn et al., 2015a, b:33). This may have been Crystal River's last gasp as a center, as the distribution of oyster beds changed with sea level lowering and better access to the Gulf Coast, became more important as a result (Pluckhahn et al., 2015a,b:33).

In the final Phase 4, Roberts Island supplants Crystal River as the ceremonial hub for the region. The calculated accumulation rates for this period at the island are higher than any other period, suggesting a rapid rise and construction of the landform. The isotopic evidence

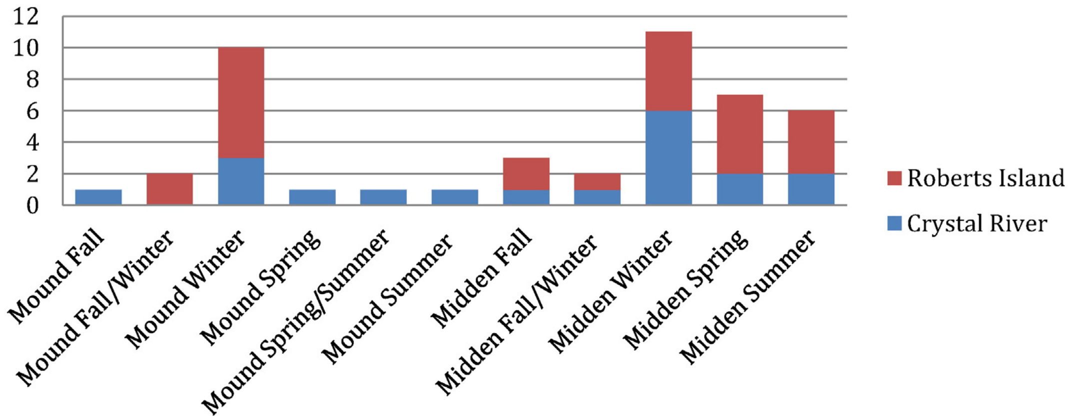

Fig. 9. Histograms of shell season of capture distribution by midden and mounded architecture at Crystal River and Roberts Island.

suggests that Roberts Island had a year-round resident population. Similar to its predecessor, it also likely hosted ceremonial events, given the formal plaza that fronts Mound A of the 8CI41 portion of the site and its continued importation of non-local goods.

While the patterns in the isotopic data for each phase provide insight into the occupational periodicity of these sites over shorter time frames, the aggregation of these data sets provide insight into the long-term trends of oyster collection and its associated activities. When we look at the data for all phases for both Crystal River and Roberts Island several patterns emerge. First, it is apparent that at both sites oysters are collected throughout the year. For both sites, cool weather collection (i.e., winter) is the peak season for oyster collection. This, in many ways, makes sense regarding what we know about oyster physiology along the Springs Coast of Florida, as this is the time they spawn. Harvesting more heavily in the cooler months would allow for sustainable exploitation of beds. All other seasons seem to be more or less equally represented in the isotopic data.

In addition, when we aggregate the isotopic data by specific context, other patterns emerge regarding the season of collection (Fig. 9). Specifically, we divide the data into mound and midden context for both sites. As discussed earlier Mound A appears to have all four seasons represented in its upper meter of the deposits; however, we pointed out that this may be due to the repurposing of midden for mound fill. In contrast, the oysters from all the other mounds at both Crystal River and Roberts Island seem to have been collected during the cooler months of the year (fall and winter). In fact, the vast majority indicate a winter season of collection.

Given these broader patterns regarding the season of collection for oysters at Crystal River and Roberts Island, we can begin to infer some processes that might account for the trends in the isotopic data. We suggest that since the inception of Crystal River as a place of prominence on the landscape that communal rituals associated with shellfish occurred during the winter months. This began with the interment of burials in mortuary facilities and associated feasting rituals and consumption of non-local goods during Phase 1. Given that the oysters in the other mounds at Crystal River evidence cool/cold weather collection, it is plausible that winter aggregation included collective construction and elaboration of the non-burial mound architecture during Phases 2 and 3.

The isotopic values for Mound A at Crystal River depart from the pattern observed above for Phase 3. If resources, i.e., oyster beds, were redistributed during this period due to a lowering of sea levels and greater emphasis on Roberts Island, and engagement was waning for collective rituals, one could imagine that the sponsors of rituals associated with mound building came up with novel ways to constitute the tradition of architectural elaboration. In this case, instead of using the remains of oysters collected for feasts, older mined midden was used to construct the final stage of Mound A at Crystal River. We offer this point here as a possible explanation, but recognize that it will require further testing.

Perhaps the clearest evidence for the temporality of mound construction is the data from Phase 4 at Roberts Island. Here the sample size is robust from both mound and midden context and the pattern of winter as the season of collection for the mound and year-round collection for the middens is apparent in the isotopic results. Thus, despite the fact the Roberts Island replaces Crystal River as the primate ceremonial center, it appears that the temporality of ritual related to the construction of monumental architecture continued from its predecessor. It may be even that the inhabitants of Crystal River shifted their focus and settlement to Roberts Island as a result of perhaps environmental and social pressures that were new on the landscape.

7. Conclusions

Our research at Crystal River and Roberts Island has led us to reconceptualize what we know about not only these sites, but also the temporality of ritual and monument construction along the central Gulf Coast of Florida. In general, the isotopic data support a model that demonstrates some periodicity in ritual and occupational engagement at Crystal River over the course of the region's history. These observations are in turn linked to broader scale environmental shifts experienced in the area.

In terms of methods, our study contributes to how we might approach questions related to the archaeology of time (e.g., Bailey, 2007). Specifically, we use two different chronological measures (i.e., radiocarbon dates and sclerochronology) to assess the temporality of ritual and daily life in the region. These measures allow us insight into both shorter-term time intervals, as well as long-term trends and patterns. We believe that the case study from the Crystal River area provides an example of how such a perspective might be accomplished using available archaeological techniques.

Finally, our research here also speaks to the broader debate regarding the nature of shell mound monumentality. Specifically, if such large, dense, shell deposits indeed represent intentional constructions. As we outlined at the start of our study, such research is emerging as a global discussion. The work presented here demonstrates that care must be taken in evaluating the nature of such deposits if archaeologists hope to understand not only the chronology of events, but also how might the people who lived through these times experienced such changes.

Acknowledgments

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