Ancient engineering of fish capture and storage in southwest Florida

Victor D. Thompson[a,b,1], William H. Marquardt[c], Michael Savarese[d], Karen J. Walker[c], Lee A. Newsom[e], Isabelle Lulewicz[a], Nathan R. Lawres[f], Amanda D. Roberts Thompson[b], Allan R. Bacon[g], and Christoph A. Walser[h]

[a]Department of Anthropology, University of Georgia, Athens, GA 30602; [b]Laboratory of Archaeology, University of Georgia, Athens, GA 30602; [c]Florida Museum of Natural History, University of Florida, Gainesville, FL 32611; [d]Department of Marine and Earth Sciences, Florida Gulf Coast University, Fort Myers, FL 33965; [e]School of Humanities and Sciences, Flagler College, St. Augustine, FL 32084; [f]Department of Anthropology, University of West Georgia, Carrolton, GA 30118; [g]Department of Soil and Water Science, University of Florida, Gainesville, FL 32611; and [h]Department of Biology, The College of Idaho, Caldwell, ID 83605

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In the 16th century, the Calusa, a fisher-gatherer-hunter society, were the most politically complex polity in Florida, and the archaeological site of Mound Key was their capital. Based on historic documents, the ruling elite at Mound Key controlled surplus production and distribution. The question remains exactly how such surplus pooling occurred and when such traditions were elaborated on and reflected in the built environment. Our work focuses on the "watercourts" and associated areas at Mound Key. These subrectangular constructions of shell and other sediments around centralized inundated areas have been variously interpreted. Here, we detail when these enclosures were constructed and their engineering and function. We argue that these structures were for large surplus capture and storage of aquatic resources that were controlled and managed by corporate groups.

archaeology | Calusa | Florida | fisher-gatherer-hunters

The study of hydrological engineering in the ancient world has long fascinated archaeologists, many of whom saw such architectural feats as integral to the development of the state and linked primarily to agricultural production. Less frequently discussed is the role that such engineering played in the development of nonagricultural societies, specifically those that relied upon aquatic resources. Indeed, such resources are thought to have been the foundations of cultural complexity elsewhere in the world (1–4). While most researchers are familiar with capture technologies, we are only now beginning to understand these engineered structures as they relate to storage and management (5–8). This research takes important steps in enhancing our understanding of fishing societies that engage in complex engineering and the social and ecological relationships that they engender.

The focus of our research in Florida centers on how the Calusa (9–11), a fisher-gatherer-hunter society, created, maintained, and distributed surpluses of aquatic and wetland resources. Our main research question is how such groups stored fish in the absence of refrigeration in the warm, subtropical environment of southwest Florida. Some of the more intriguing architectural features in this region include "watercourts" found at several large shell midden/mound sites (12). We define these watercourts as subrectangular constructions of shell and other sediments around centralized inundated areas. The earliest interpretation of these features was that they were for fish storage (13); however, no research has systematically evaluated their timing of construction and function. Many, however, have speculated widely on their function without conducting the excavations necessary to evaluate these ideas. For example, Schober (14) argues that the Calusa managed conch ponds, presumably in water courts. We find this interpretation untenable for a number of reasons that we outline in a recent work (15), with the main reason being that juvenile marine gastropods prefer shallow, seagrass-rich environments that would have been difficult to duplicate in watercourts. Thus, while many have speculated over the years, the work presented here represents a systematic evaluation of these features that allows for an interpretation of their function. Our work at the site of Mound Key (8LL2) reveals the complex engineering behind these structures, as well as details of their chronology and function (Fig. 1). We suggest that these structures functioned as large-scale fish traps and storage facilities for live fish surpluses.

During the 16th century, Mound Key was the capital of the Calusa kingdom, which stretched from the Florida Keys to just south of Tampa Bay (16, 17). Mound Key is located in Estero Bay, FL, and is an anthropogenic island comprised mostly of midden shell and other sediments (18); in the 17th century, Mound Key had a population of ca. 1,000 (19). The site covers ca. 51 ha and is a complex arrangement of midden-mounds, canals, watercourts, and other features. By AD 1000, the inhabitants had engaged in substantial modification to the island, with the two largest mounds (mounds 1 and 2) reaching elevations of around 10 m and 6 m, respectively. Our research on mound 1 documents at least three phases of construction and repair for a large building(s) beginning around AD 1000. The last iteration of the mound 1 structure is what we interpret as the "house" of Caalus, the mid-16th century Calusa king. According to Spanish documents, it was able to hold 2,000 people, and it is where Pedro Menéndez de Avilés, the first governor of *La Florida*, met the king and discussed terms (19, 20). Our finding of these structures indicates that mound 1 was the likely seat of power for a long-lived corporate group for around 500 y (20).

Significance

Fish were captured and stored by Native Americans of southwestern Florida in complex walled structures called watercourts, constructed of shell and other sediments. These structures were engineered with knowledge of tidal systems, hydrology, and the biology of species to be stored in these courts. This work documents the considerable ability of the Calusa, a nonagricultural society, to engineer systems that significantly alter their natural environment. These structures are associated with an ever-growing population and complex system of governance among the Calusa of Florida.

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[1]To whom correspondence may be addressed. Email: vdthom@uga.edu.

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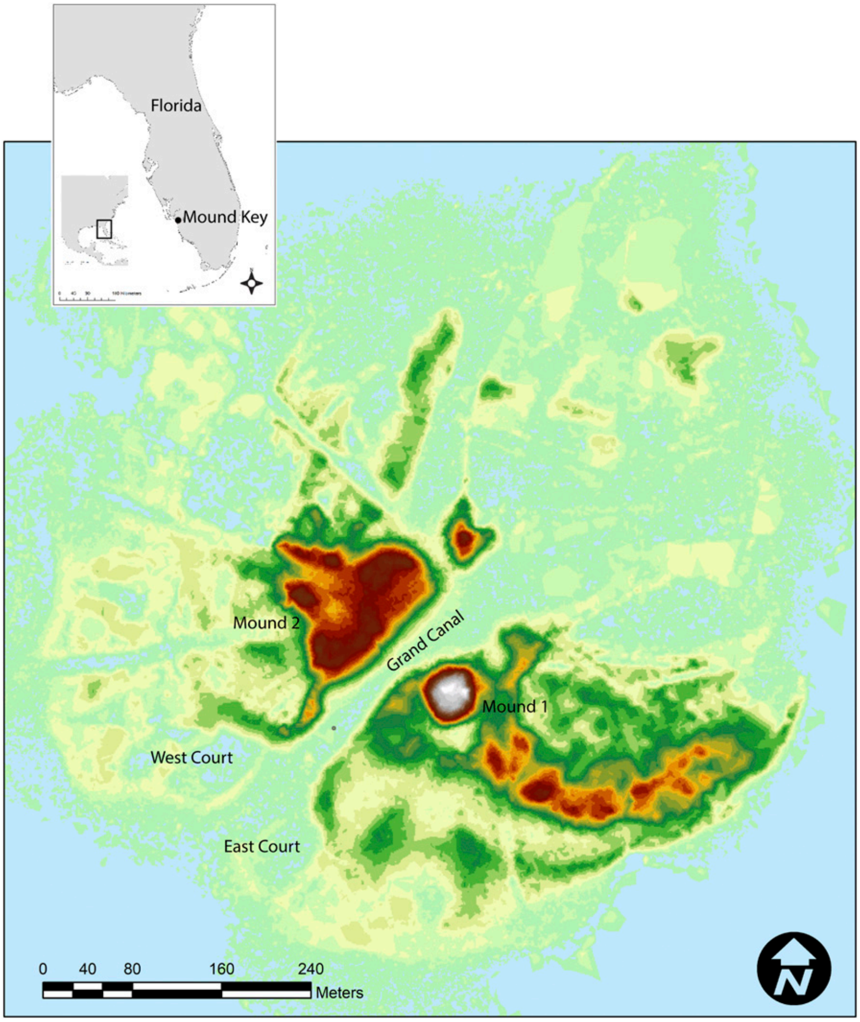

Fig. 1. LiDAR digital elevation model of Mound Key showing the site's prominent features.

The available evidence indicates that the Calusa had a large population (ca. 20,000) and were one of the most politically complex groups of hunter-gatherers of the ancient world. Thus, we are left with one central question: How did the Calusa at Mound Key provide and sustain food sufficient for the complex political and social life observed in the 16th century? We argue that part of the answer to this is that the Calusa engineered sophisticated landscapes for the capture and storage of live surpluses of fish, which could have been obtained on a regular basis in the inshore estuarine bays.

While Mound Key's layout changed over time, it is clear that the canals, watercourts, and other features were thoughtfully engineered. Given its location in Estero Bay, its engineers had to consider the effects of the low-amplitude (<1 m) mixed tidal pattern of the Florida Gulf Coast. Bisecting Mound Key's two main midden-mound complexes is a central Grand Canal running approximately southwest to northeast, measuring around 365 m long and averaging 28 m wide. At its northern terminus, the canal (today a wetland) opens up to constructed causeways of shell ridges and burial mounds. Several tributary canals break off the main canal at right angles and lead to other areas of the site. Two watercourts flank the southernmost section of the canal and mirror one another in form (Fig. 1).

Our research questions at Mound Key are directly related to the role that surplus production played in Calusa society. Specifically, how were surpluses acquired, processed, and stored, and how did they relate to the timing of construction of large-scale storage facilities? To address these questions, we conducted remote sensing and archaeological excavations at one of Mound Key's watercourts in 2017 (Fig. 2).

Remote Sensing

Light detection and ranging (LiDAR) data on the watercourts indicate that the East Court and the West Court enclose a total of around 6,000 square meters of mangrove wetlands. The East Court measures ca. 42 m in maximum width and ca. 70 m long along its longest axis. The West Court measures ca. 50 m wide at its widest and ca. 75 m along its longest axis. The East Court is slightly smaller than the West Court, ca. 2,670 and ca. 3,350 square meters, respectively. The average berm height of both is ca. 1 m.

Each court has an opening in the berm on the northernmost section facing the Grand Canal measuring ca. 10 to 12 m wide. It is these breaks that we believe were once the locations of gates made of perishable materials (e.g., wood, fiber), similar to those that Cushing (13) observed. Interestingly, the southern canal's entrance point is directly in line with a pass between two mangrove islands and then further on to Big Carlos Pass, which leads into the Gulf of Mexico (*SI Appendix*, Fig. S1). These openings and orientation would have facilitated the transport of resources from both the bay and the Gulf.

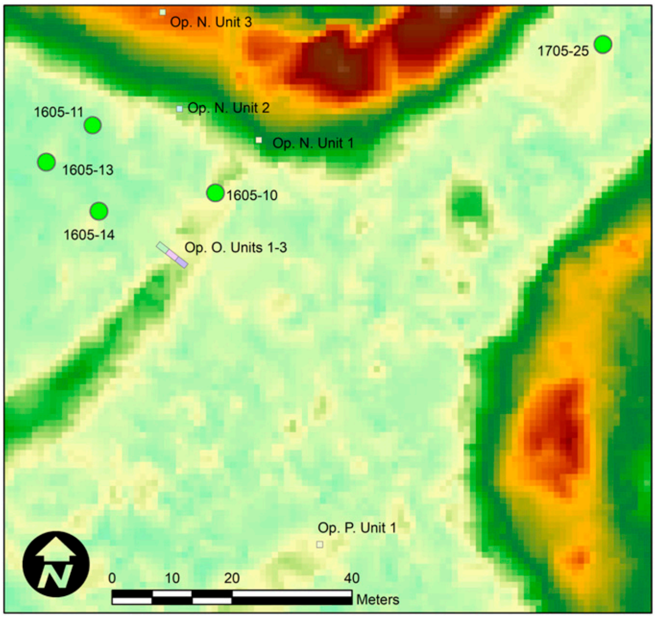

Fig. 2. Location of cores and excavation units in the area of the West Court, East Court, and Grand Canal.

Both the West Court and East Court are also directly adjacent to smaller watercourts and appear in some cases to be connected. In addition, there are two smaller possible "gates" for each court measuring 7 m that lead to the exterior of the site into the bay on each court's southern end. Our analysis of topographic slope based upon LiDAR data reveals two graded causeways leading up to mound 1 and mound 2 from their respective watercourts, connecting each court, possibly for moving food from them to the tops of the mounds (*SI Appendix*, Fig. S2).

We conducted a ground penetrating radar (GPR) survey of several areas. While the survey was limited due to the vegetation and the proximity of the water table, which precluded large-scale coverage near and in the watercourts, we did conduct survey line profiles along the shoreline adjacent to the West Court (*SI Appendix*, Fig. S3). Our GPR radar profile of this area shows distinct changes in strata, one of which, as we discuss later, corresponds to stratigraphic layers that appear to be the result of large-scale burning events (*SI Appendix*, Fig. S4). The GPR data indicate that this stratum, which appears as a high-amplitude planar reflection, is not localized to just the two areas where two excavations are located (see operation N descriptions later), but rather extends along the shoreline of the watercourt for at least 15 m.

Coring

Prior to our larger excavations, we collected a series of hand vibracores and small-diameter percussion cores in the area of the watercourts (Fig. 2). These included one small percussion core (MK2014-core 3) in one of the berms, four vibracores in the West Court (1605-10, 1605-11, 1605-13, 1605-14), and one vibracore (1705-25) in the canal connected to the courts (*SI Appendix*, Figs. S5–S9). Core 1605-13 was located in the center of the West Court, 1605-14 was 12 m to the southeast along the court's long axis, and 1605-11 was 10 m to the northeast along the short axis (Fig. 3).

Core 1705-25 (see *SI Appendix*, Fig. S9) was extracted from the Grand Canal. This core represents 202 cm (decompacted thicknesses reported throughout) of deposition and has four distinct facies (i.e., stratigraphic layers). From bottom to top, their descriptions and interpretations are (*i*) olive gray, mollusk-rich muddy sand, representing a subtidal estuarine environment; (*ii*) very dark grayish brown muddy sand with shell gravel, interpreted as a Calusa activity surface; (*iii*) muddy sand with coarse shell gravel, interpreted as a midden prior to the canal's existence; and (*iv*) black mangrove peat, representing the infilling of the central canal. It is probable that the surface between the precanal midden and the canal fill represents an erosional surface for maintenance of the canal. Likely, the canal would have required some degree of upkeep in the form of dredging to maintain an appropriate water depth for vessels to pass through it. No evidence of disconformity exists elsewhere in the core's stratigraphy, indicating time is relatively conformable for historic interpretation. The existence of estuarine sediments at the core's base and 2 m below NAVD88 (heights relative to this datum shown in Fig. 3) indicates that the entire history of Mound Key is represented with evidence of human occupation at just above this depth.

The other four vibracores (1605-10, 1605-11, 1605-13, and 1605-14) were extracted from the West Court. The stratigraphy of all four cores is comparable, with the upper three facies described and interpreted as (from lowest to highest) (*i*) sandy shell gravel to muddy sand, representing a shell midden prior to the existence of the watercourt; (*ii*) dark gray, organic-rich sandy mud, representing the watercourt environment; and (*iii*) black mangrove peat, representing the infilling of the watercourt by mangrove root mass after the watercourt became inactive. Core 1605-13 is significantly longer than the other watercourt cores. Its lowermost stratigraphy includes a light gray sand with shell gravel, overlain by a dark brown-gray, organic-rich sandy mud, interpreted as a Calusa activity surface. The base of this core sits 1.7 m below NAVD88, higher than the pre-Mound Key height (of 2 m) in core 1705-25, suggesting that no pre-Mound Key history was captured in any of the watercourt cores.

The sedimentology, stratigraphy, and paleoecology of the watercourt facies are consistent with this environmental interpretation. The sediments are dark gray and organic-rich, suggesting dysaerobic conditions within the substrate, something indicative of poor or limited estuarine water circulation. The grain size distribution is dominated by mud, and these muds exhibit sedimentary laminations. Such characteristics are unlikely in an open subtidal estuary. Here, the environment was dominated by suspension-load deposition, with little water agitation and little to no infaunal activity that would otherwise disrupt the laminations.

Our final core is a percussion core and comes from the West Court berm. Designated as 2014MK-core 13, this core was placed to look at the overall depositional processes of Mound Key (18). The upper layer of this core represents the construction of the berm with sediments from the watercourt. We selected two samples from this core to help date the construction of the courts.

Excavations

We conducted excavations along the northeast edge of the West Court (excavations N-1 and N-2), on top of the ridge above (excavation N-3), across and into a portion of the eastern berm that defines the court itself (operation O), and along one of the berms that delineates the East Court (operation P; Fig. 2).

The operation O excavations (O-1, O-2, O-3) began in the middle of the West Court's eastern berm and continued northwest into its interior. The upper levels are comprised of more nonshell sediments (e.g., fine sands and vertebrate remains) and fragmentary, mostly oyster, shell than the lower portions, which grade into nearly whole shell below the water table. The orientation of the shell fragments appears to be a result of dumping for construction in both the upper layers. The orientation of the shell fragments that grade into the first few

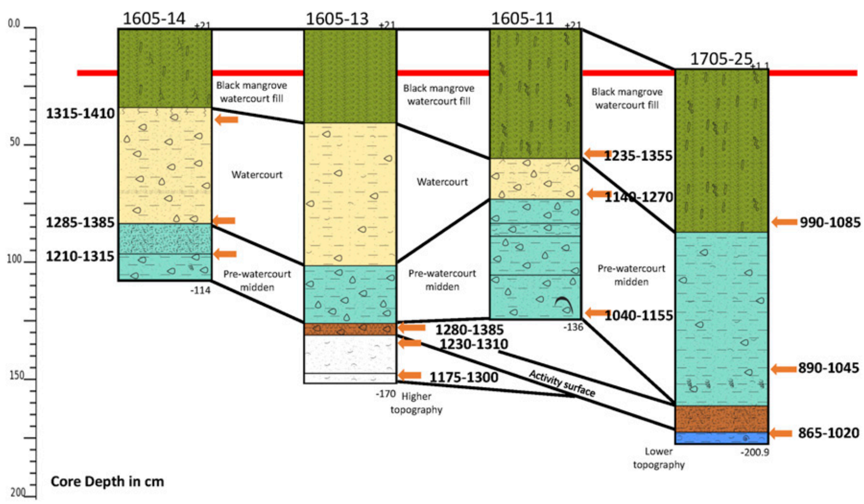

Fig. 3. Fence diagram of cores from the West Court and Grand Canal showing examples of stratigraphic relationships and modeled radiocarbon date ranges (68% probability). Stratigraphic columns are hung from NAVD88 (noted by the position of the red line). Similar lithofacies (activity surface, prewatercourt midden, watercourt, black mangrove watercourt fill, etc.) are color-coded and correlated between neighboring cores. Sections have been decompacted; heights of section tops and bottoms are shown in centimeters above or below NAVD88 and noted at the top right and bottom right, respectively, of each column.

submerged layers indicates that the berm's construction extends below the current water level.

The eastern half of O-2 was our deepest excavation, which was excavated well below the water table (*SI Appendix*, Fig. S10). Under the constructed berm. there is a large expansive shell midden comprised of many intact shells. This was apparent in our excavations, as well as in our cores. This shell midden graded into sediments characteristic of the current bay system in its deepest levels. Below the water table, we encountered preserved wood debitage and cordage, as well as *Cucurbita* sp. gourd/squash seeds (*SI Appendix*, Fig. S11). This suggests that these elements were possibly carpentry debris from dugout canoe manufacture and/or the creation of racks for smoking/drying fish, as well as parts of fishnets and potentially net floats.

Along the northeast edge of the West Court in excavations N-1 and N-2, we encountered dark, distinct strata with many fragments of carbonized wood suggestive of burning (*SI Appendix*, Fig. S4). In addition, there were many associated small post molds. In comparison with post molds previously encountered in excavations on the tops of the mounds, these posts are much smaller and do not seem to represent structural support posts for large structures, but rather appear to represent drying and smoking racks (see ref. 20), similar to patterns observed in other regions, such as in Peru (21).

The N-3 excavation was located on the ridgetop directly northeast of the West Court. Interestingly, no post mold or other features of discernable function were identified in this excavation. The upper strata of this excavation contain whole and fragmented oyster with abundant vertebrate faunal remains and artifacts. The lower strata, in contrast, contain more whole shell and few artifacts.

Radiocarbon Dating

Establishing the chronology of construction for these watercourts is important if we want to link their use to other Mound Key architecture. To do this, we obtained 22 AMS dates from our excavations and cores (*SI Appendix*, Tables S1–S3). Two models were constructed. The first model (model 1) was a three-sequence sequential model to examine the timing of construction of the West Court berm (operation O and core 13), use of the adjacent West Court shore line (N-1), the linear ridge adjacent to the West Court (N-3), and the construction of the Grand Canal (core 1705-25; *SI Appendix*, Fig. S12). The other model (model 2) was a three-phase overlapping model to examine the onset of watercourt conditions from the cores taken in the currently wet area of the West Court (cores 1605-13, 1605-14, and 1605-11; *SI Appendix*, Fig. S13).

Model 1 returned statistically significant results and shows good agreement between the ^{14}C dates and the model assumptions (A_{model} = 104; $A_{overall}$ = 101.3; Fig. 4). It appears that the Grand Canal, based on core 1705-25, is the earliest in the sequence of features. Understanding when this feature was in place is critical to interpreting the functioning of the watercourts, as they are thought to comprise a single hydrological system. The model estimates deposits and the onset of the anthropogenic activity surface to cal. AD 885 to 1010 (68% probability) and end date of cal. AD 1015 to 1095 (68% probability). Thus, it appears the canal was constructed and was an established hydrologic feature a few hundred years before the construction of the West Court (as detailed later).

Our N excavations are located on the former shoreline of the large western half of Mound Key. This area also makes up a portion of the West Court. This area too appears to have been used prior to the construction of the West Court. Modeling of the three dates for N-1 estimates a start date of shoreline midden formation at cal. AD 1025 to 1120 (68% probability) and an end date range midden formation activity in this area at cal. AD 1115 to 1155 (68% probability).

Operation O was across the West Court, with excavation O-2 going through the constructed berm down into prewatercourt midden. Our model examines the formation of the prewatercourt midden and the formation of the berms to construct the West Court. In this part of the model, there is a sequence of three radiocarbon dates from the excavations and two dates modeled as a phase from core 13 in a stratigraphic order. In addition, the dates from N-3 on the ridge adjacent to the West Court overlapped considerably with the ones from operation O and core 13 and were therefore modeled as an overlapping phase with these dates. The three dates from operation O that are part of the prewatercourt midden are in stratigraphic order and agree with the overall model. Only one of the two dates from the berm agrees with the overall model, with the other showing poor agreement (UGAMS 20071). This, however, is not surprising if the berm was constructed from contemporary or slightly older midden deposits, a pattern observed in other deposits (18). The model places the start of the prewatercourt midden at cal. AD

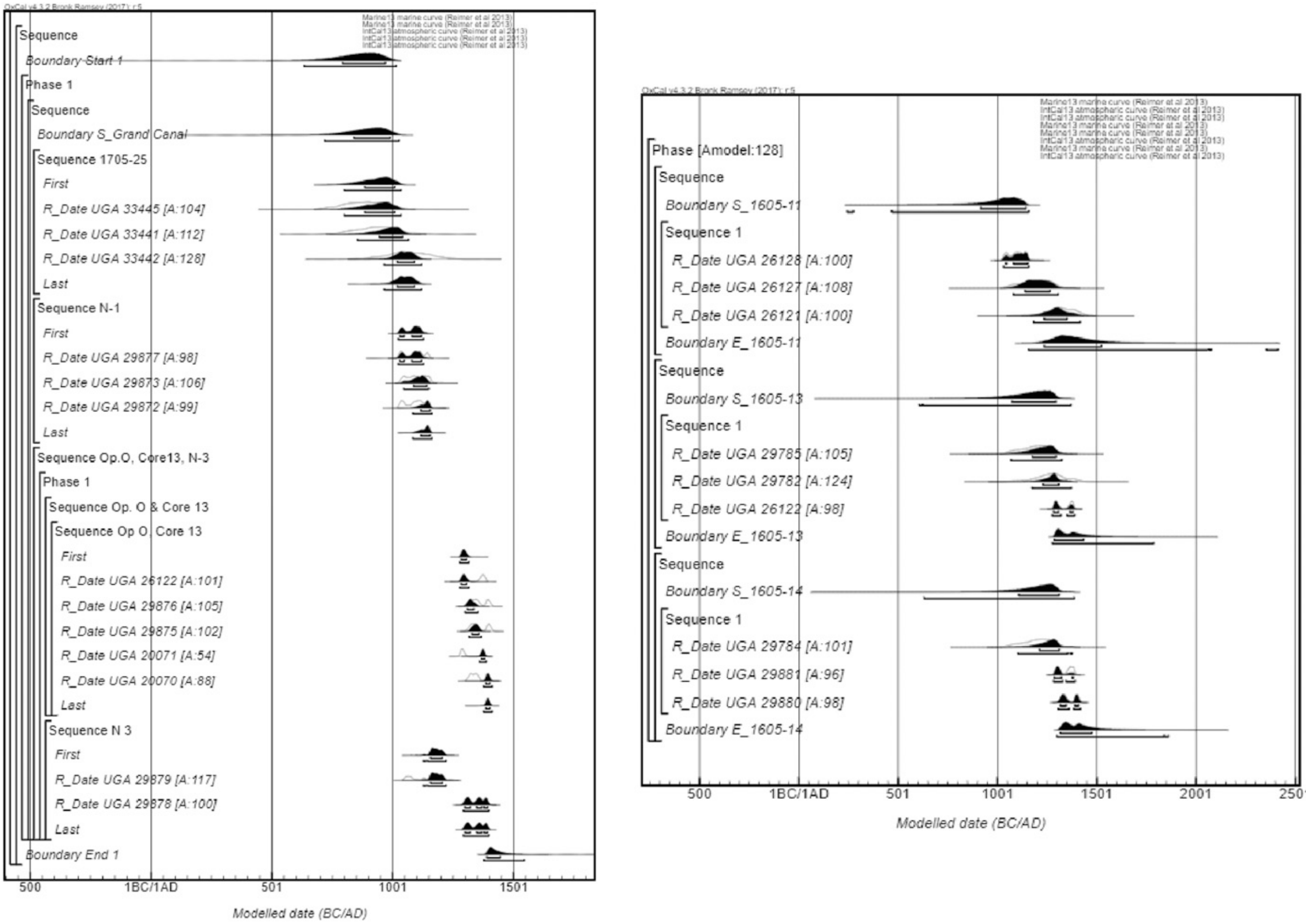

Fig. 4. Probability distributions for model 1 (*Left*) and model 2 (*Right*) from cores and excavations from the West Court and Grand Canal. The clear line and black together represent calibrated distributions and the black lines represent the posterior density estimates based on the models.

1285 to 1305 (68% probability). The model places the end date range of construction of the watercourt at cal. AD 1385 to 1405 (68% probability). These ranges mark the date from which the accumulation began to the end date of watercourt construction, not the end of its use. Therefore, at some point between the start of the prewatercourt midden and end range of construction, the West Court was built.

Model 2 is of the three vibracores in the West Court and dovetails with the results of model 1. To further understand the timing of the canal vis-à-vis the construction of the watercourts, we selected three samples from each core for dating. The stratigraphically lowest radiocarbon date comes from the end of the subtidal estuary deposits and before the onset of the midden deposition. The second lowest sample comes from right after the onset of the precanal midden. The third and stratigraphically highest radiocarbon date comes from right at the end of the precanal midden, just before the onset the of the central canal fill. The model shows a good overall agreement ($A_{model} = 128.2$; $A_{overall} = 112.4$) and refines the radiocarbon dates for the initial layers of the prewatercourt basal midden deposits in the West Court (Fig. 4). In each core, the model estimates the start of prewatercourt midden at 68% probability as cal. AD 915 to 1145 (core 1605-11), cal. AD 1070 to 1295 (1605-13), and cal. AD 1105 to 1315 (1605-14). The end boundary for each core brackets the onset of use of the watercourt and is as follows: cal. AD 1070 to 1295 (core 1605-11), cal. AD 1285 to 1345 (core 1605-13), and cal. AD 1315 to 1475 (core 1605-14).

Vertebrate Faunal Analysis

To evaluate patterns of fish capture, storage, consumption, and disposal at Mound Key as they relate to the function of the watercourts, the vertebrate faunal remains recovered with ¼-inch mesh screen from operations N and O were analyzed. Overall, remains of fish (Actinopterygii and Chondrichthyes) account for the majority of NISP (number of identified specimens) and MNI (minimum number of individuals) in these assemblages, and a variety of fish taxa typical of Estero Bay is represented. The period-III/IV (AD 1200 to 1500) contexts, contemporaneous with the West Court, show that no fish taxon, including mullet (*Mugil* spp.), dominates the assemblages. However, when compared to the earlier, period-IIB (AD 800 to 1200) fish assemblages (*SI Appendix*, Fig. S14), the III/IV samples indicate an increase in mullet percentages, measured by NISP and MNI relative to total fish.

Museum collections of ¼-inch–screened vertebrate faunal remains from multitemporal midden contexts at Pineland, Mound Key (operation C), and a group of other sites in the Charlotte Harbor/Pine Island region also were reexamined with a focus on mullet (*SI Appendix*, Figs. S15–S17). The regional samples were smaller in area but were fine-screened (<¼-inch mesh). Again, results show that later samples contain more mullet remains than those dating to earlier times. Like the Mound Key N and O assemblages, this is true based on NISP, MNI, and their relative percentages of total fish. Although none of these samples—like N and O—show a dominance of mullet, the fact that a pattern of increased mullet is repeated in all cases

Fig. 5. Specimens of mullet (*Mugil* sp.) fish scales recovered from the West Court core 1605-14 (Figs 2 and 3), sample 72 to 77 cm, one of several representing the watercourt facies. Image credit: Zachary S. Randall (Florida Museum of Natural History, Gainesville, FL).

supports the idea that there may have been an increased regional focus on capturing mullet coeval with the watercourts. Within this pattern, of note, one of the latest IV-period samples from Mound Key's operation C exhibits a significantly higher mullet percentage (58% MNI) than all others, suggesting that Mound Key, in particular, may have been a late center for mullet production. Operation C was located on a 3.09-m-high shell-midden ridge just to the east of Mound 1. This ridge may have been the disposal area for the remains of fish and shellfish that were taken to the summit of mound 1 for consumption.

Another analysis focused on the small, fragile remains present in several of the West Court's coarse (¼-inch) and fine (<¼-inch) screened vibracore samples representing the watercourt facies (*SI Appendix*, Table S4). Specifically, fish bone and scale specimens were identified in the watercourt facies of cores 1605-13 (17 NISP) and 1605-14 (123 NISP). Their numbers can be considered abundant compared to an open estuarine bay setting, where fish remains are rarely if ever found in subtidal sediments. In our parallel work to reconstruct the bay history, we conducted coring away from the site (n = 5) itself. Employing the same screening techniques, we found that fish remains are essentially absent from bay sediments and through a few thousand years of estuarine history. Two of these cores (1703-21 and 1703-22) were taken from shallow, soft-bottom, subtidal environments just east and west of Mound Key with the explicit purpose of comparing facies here with those from the watercourt (*SI Appendix*, Figs. S18 and S19). Again, there are no fish remains in these cores. The relative abundance of scales from the watercourt, subtidal muds is highly unusual and not likely given background taphonomic processes. In the watercourt cores, many of the scale specimens (Fig. 5) are ctenoid forms and compare well with modern scales of the region's mullet (*Mugil*) species, *Mugil cephalus*, *Mugil curema*, and *Mugil trichodon*, the three being archaeologically indistinguishable. A few other specimens compare well with modern herring (Clupeidae) and pinfish (*Lagodon rhomboides*) scales. Consistent with these are three herring vertebrae and a [cf.] pinfish quadrate. Herring and pinfish remains are typically abundant in <¼-inch mesh-screened midden samples from Pine Island Sound sites just to the north. The presence of scales and small specimens of these three schooling fishes (i.e., netable/trappable) in the watercourt facies makes sense if the enclosures were used for holding fish temporarily while consumption and disposal occurred on or near the mound summits.

Hydrological Experiments

To test the hypothesis that Mound Key watercourts conserve enough water to maintain live fish—and possibly shellfish—populations between high tides, we constructed hydrologic models from measurements of hydraulic conductivity (K_{sat}) of the West Court berm sediments and architecture (*SI Appendix, Supplementary Material*). Using Darcy's Law (22), our models temporally constrain water loss from the West Court under two berm compaction, or bulk density (D_b), scenarios that capture the range of typical uncompacted (bulk density = $1.4\ g\ cm^{-3}$) and compacted (bulk density = $2.0\ g\ cm^{-3}$) soils. Further, because LiDAR data suggest the presence of a sill, our models also constrain water loss rate under two sill height scenarios (0.30 and 0.45 m) for both berm compaction scenarios.

Our hydrological model results (Table 1) indicate that West Court water level would lower to 0.2 m (an assumed minimum height to sustain fish) at 20.7 h and 26.8 h after high tide and lower to 0 m at 72.7 h and 78.8 h after high tide with uncompacted berm

Table 1. **Parameters and results for watercourt hydrologic models**

Model	Description	Db, g cm^{-3}/Ksat, μm s^{-1}	Time to 0.2 m of water, h	Time to 0 m of water, h
1	Uncompacted with 0.30-m sill	1.4/123	20.7	72.7
2	Uncompacted with 0.45-m sill	1.4/123	26.8	78.8
3	Compacted with 0.30-m sill	2.0/9	275.2	965.1
4	Compacted with 0.45-m sill	2.0/9	355.7	1,045.5

sediments and a 0.30-m and 0.45-m sill, respectively. With compacted berm sediments, West Court water level would lower to 0.2 m at 275.2 h and 355.7 h after high tide and lower to 0 m at 965.1 h and 1,045.5 h after high tide with a 0.30-m and 0.45-m sill, respectively. Considering that the tidal cycle of Estero Bay is roughly 12 h (23), our temporal estimates not only distinguish these architectural features as effective water-holding structures, they also demonstrate that compaction and sill height appreciably influence watercourt hydrology, factors that were likely considered by the Calusa in construction. Although our hydrological estimates are extremely conservative (see *SI Appendix*, *Supplemental Materials*), they still provide water retention estimates that can exceed, sometimes by more than an order of magnitude, the Estero Bay tidal cycle and thus provide support for the hypothesis (*SI Appendix*, Fig. S20 and Tables S5 and S6).

Data Availability Statement

All physical archaeological materials (i.e., artifacts, sediment samples, paperwork) are curated at the Florida Museum of Natural History for future reference. Copies of all digital data (i.e., excavation database, digital photographs, and drawings) are curated at both the Florida Museum of Natural History and the University of Georgia Laboratory of Archaeology. These data are available upon request from these repositories. All data relevant to the arguments presented in this study can be found in the manuscript and *SI Appendix*.

Discussion and Interpretation

The first line of evidence that these structures are more than accumulations of midden remains lies in their physical form. As we note, both the West and East courts are roughly rectangular and symmetrical, adding to the degree of bilateral symmetry of the site. Each court, in similar locations, contains an opening, a "gate," allowing access to its interior (*SI Appendix*, Fig. S21). This layout also could have facilitated the capture of fish. If, during certain times, the Calusa strung nets across the southern end of the canal nearest the courts and opened the gates, fish could then be easily corralled into the watercourts.

A second line of evidence comes from the N-1 and N-2 excavations and GPR survey, which provide evidence of fish processing in the form of small post features and layers associated with drying and smoking racks, along what was the shoreline prior to watercourt construction. Dates for this shoreline use correspond to the time when the two largest mounds reached almost their zenith and the earliest construction of the "king's house" on mound 1 (18, 20). Excavation across and into the West Court berm (operation O), combined with coring of the court's interior, demonstrate the reconfiguring of the shoreline into a court form corresponding temporally with the second phase of the king's house (20). Furthermore, the presence of fish elements, primarily mullet scales, in the West Court sediments, particularly when such remains are not typically found in the bay's open-water subtidal environments, supports the interpretation of fish storage in the courts (Fig. 5).

Through time, this area of Mound Key clearly was the focus of fishing-related activity including procurement, processing, canoe manufacture, and fishnet use (if not also construction and repair). The latter two may be evidenced by waterlogged wood and netting remains from O-2. It appears that the watercourts were constructed to intensify (i.e., store for later processing) the production of mullet and possibly other fish and shellfish. The regional pattern of increased mullet through time, most significantly noted near mound 1 (operation C) coeval with the West Court, supports the idea that mass capture and short-term storage of mullet may have provided a primary surplus food for the Calusa. While we do not know the chronology for the two graded paths leading up to the mound summits, they likely facilitated the movement of processed foods to the inhabitants of these mounds. The N-3 excavation, at the top of the West Court ridge leading to the graded way to mound 2's summit, exhibited some of the latest midden, which included numerous fish remains. The greatest quantities of mullet remains, however, were located behind mound 1 (operation C), in other words, just off-mound of the king's house (*SI Appendix*, Fig. S22).

The creation of surpluses required overcoming considerable challenges in terms of storage and distribution of products. Mound Key is located in a subtropical climate, which surely would have caused problems for maintaining the surplus stability and freshness, particularly with animal products. We suggest that the Calusa of Mound Key were able to solve this unique problem in a highly sophisticated manner, which partly involved keeping live fish in watercourt storage areas. The construction of these facilities would have likely required coordinated effort and collective buy-in from larger segments of society (20).

Surplus food stores in particular are frequently used to support large-scale labor projects and feasts, as well as a host of other institutions in human societies that lead to greater investments in complex social and political formations (24–28). Based on our modeling of the radiocarbon dates from the watercourt excavations and cores, it appears that the Calusa built these structures between AD 1300 and 1400. This chronology corresponds with the tail end of the second phase of the king's house on top of mound 1 at the site. Shortly after this time, the Calusa initiated the final phase of construction on this large structure, adding additional deposits to the mound and modifying the large house, the one that Pedro Menéndez de Avilés would see during his visit in 1566 (19). We also know from 16th-century Spanish documents that certain sections of Calusa society (i.e., warriors, royalty) did not have to produce their own food. We argue that continued population growth and the increasingly centralized power of ruling lineages at Mound Key were likely underwritten by the surplus production of fish, akin to such trajectories observed among stratified agricultural societies (29).

We argue, following our earlier work at the site (20), that the creation of these large surplus storage areas was part of a collective fiscal strategy of powerful house lineages to support an increasingly complex political structure. As Blanton and Fargher (30) note, collective strategies for state-building are dependent upon buy-in from the general populace to support such endeavors. Large-scale public storage in watercourts is an effective means by which various segments of Calusa society could be engaged in the functioning of the capital and polity in general. The growth of the Calusa polity and the power and influence of Mound Key would have been a highly complex system that required a large degree of confidence (i.e., food security and surpluses) among participating groups to build such a system. In sum, we view the construction of the watercourts as part of the economic base of Mound Key's prominence as the capital. The Calusa were capable of creating anthropogenic islands and constructing canals, commanding a military, and controlling vast networks of trade throughout Florida, among many other characteristics usually associated with better-known polities of the Americas (e.g., Cahokia, the Maya). Ultimately reaching their zenith in the 16th century at the time Europeans began landing on their shores, they are one of the few examples of this level of political complexity not supported by large agricultural surpluses, but rather by the bounty of the sea.

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