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News & Reports

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Center for Maritime Archaeology & Conservation

Contents

On the Front Cover: Rachel Matheny records measurements from a Canaanite jar from the Late Bronze Age Uluburun shipwreck.

On the Back Cover: Stephen DeCasian stands next to the beeswax replica of his ancient naval ram casting project.

From the Director:

Welcome to another edition of CMAC News and Reports! While the new discoveries in maritime archaeology and conservation are always exciting, these discoveries can lead to research projects that span decades. As these decades pass and new technologies are introduced, a re-evaluation of legacy assemblages can lead to exciting new revelations. This issue of CMAC News and Reports contains two such studies, on two of the most famous projects carried out by CMAC faculty, the 14th-century BCE Uluburun shipwreck and the 17th-century CE sunken city of Port Royal, Jamaica.

For the Uluburun shipwreck, NAP Ph.D. candidate Rachel Matheny is using statistical analyses to look for patterns in the shape of one of the transport jar types being carried by the ship to try and elucidate typologies and trends not seen in traditional analyses. For Port Royal, NAP Ph.D. student Bethany Becktell is leading the charge to re-inventory the Port Royal collection in a modern museum database program. Not only is this helping us identify new patterns in the assemblage, it is also providing many of our students valuable experience working with a large, complex museum collection.

It is not all legacy collections in this issue though; NAP M.S. alumnus Peyton Harrison writes about his study of some of the recreational items found among the many thousands of artifacts from the C.S.S. *Georgia* (1864 CE) that were conserved at the Conservation Research Laboratory. These types of objects provide a powerful common link to the humanity in those that came before us. Finally, NAP Ph.D. student Stephen DeCasien stuns with his massive work of passion, a full-sized lost-wax replica of a Greek trireme battering ram, based on archaeological research. Watching the ram take shape in the Conservation Research Laboratory has been a real treat for all of us, and we are excited to see the final bronze result of all of his hard work.

As always, if you find yourself impressed with our research and wish to support specific projects or the general mission of CMAC, you can either reach out to me directly or donate through the Texas A&M Foundation (txamfoundation.com).The CMAC account is located under the College of Liberal Arts, Department of Anthropology.

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The Personal Artifacts of C.S.S. *Georgia*

Peyton Harrison
Nautical Archaeology Program, Texas A&M University

The wreck of C.S.S. *Georgia* is a unique shipwreck for a variety of reasons. An ironclad sunk intentionally during the Civil War, the vessel never left the Savannah River, and served as a stationary assignment for the crew on board. The personal artifacts left behind by the crew prior to the sinking, including game pieces and components of musical instruments, were subsequently recovered and studied by archaeologists. These artifacts provide a humanizing glimpse into the lives of those on board, and the ways in which they spent their free time.

C.S.S. *Georgia* was constructed in 1862 as a steam-propelled ironclad warship on the Savannah River in Georgia for the Confederate States of America during the U.S. Civil War. The vessel's construction was funded primarily by the Ladies Gunboat Association, and due to insufficient materials its engine was not powerful enough to truly propel the vessel. *Georgia* served as a floating battlement until it was intentionally sunk, or scuttled, in the Savannah River in 1864. The vessel and associated artifacts were recovered from the wreck site to allow for dredging of the river by the U. S. Army Corps of Engineers beginning in 2012. The majority of the artifacts recovered from the wreck site were transferred to the Conservation Research Laboratory (CRL) at Texas A&M University for conservation. Among the several thousand artifacts recovered from the wreck of C.S.S. *Georgia* were artifacts showing shipboard entertainment of the sailors serving aboard the vessel. Since the vessel was scuttled, the sailors on board would have had an opportunity to re-

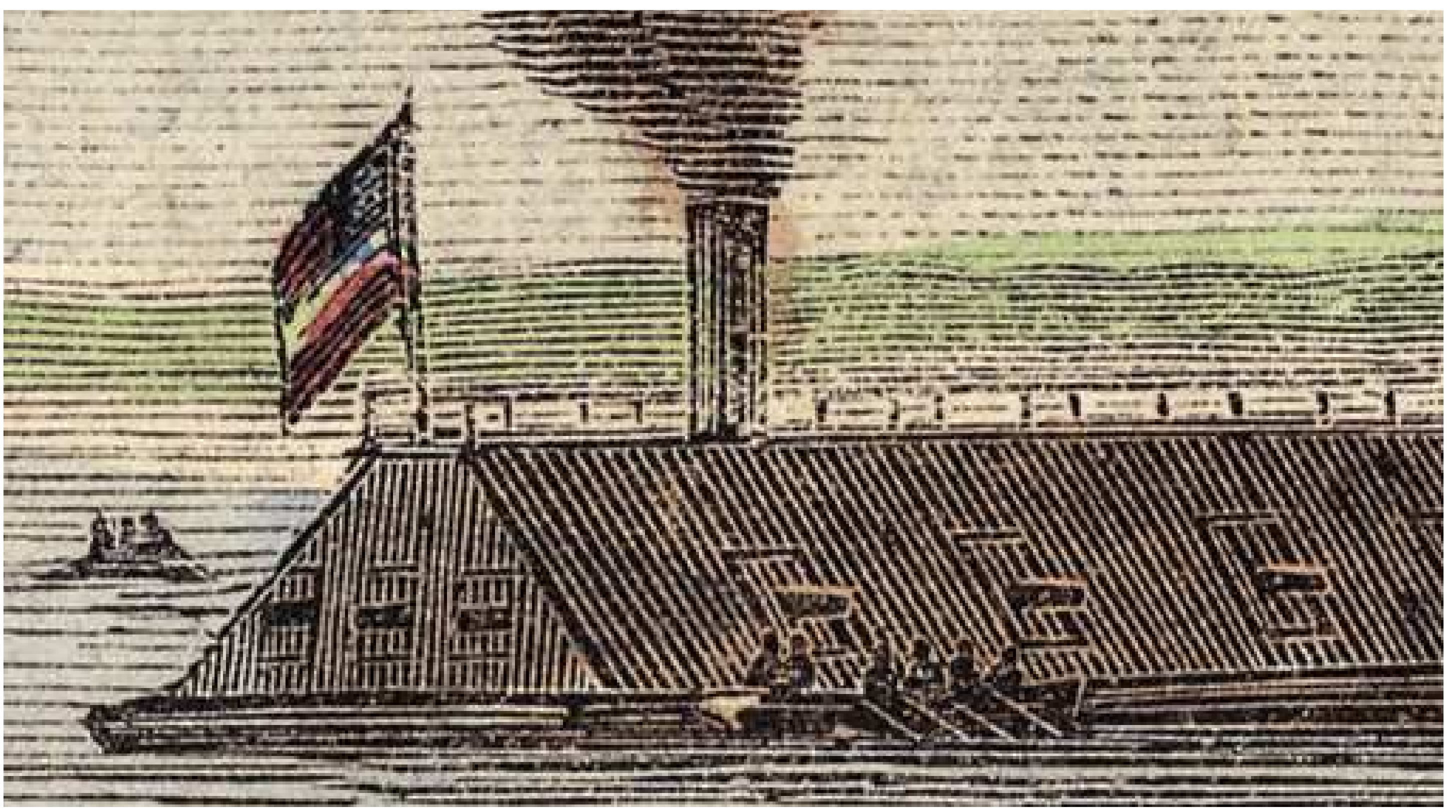

Figure 1: The Confederate ironclad C.S.S. *Georgia*. Image courtesy of the Naval History and Heritage Command.

Figure 2: The wooden domino recovered from the wreck of C.S.S. *Georgia*. Image courtesy of the Naval History and Heritage Command.

Figure 3: The wooden domino after conservation. Photo by Karen Martindale, courtesy of the Conservation Research Laboratory.

move their belongings before the sinking. It is therefore likely that the personal artifacts recovered from the wreck site were left behind on accident. A wooden domino, a carved bullet, and three sets of instrument reeds offer insight into how the sailors and soldiers passed their time.

The domino was hand-carved from a piece of wood. The six dots on its face were burned in, with a dividing line carved out at a slight angle. Although dominoes are originally a Chinese invention dating back to the 13th century, their popularity in America didn't take off until the 1860s, the same time as *Georgia*'s construction and scuttling.

The carved bullet was made from a Maynard style bullet, one of the major styles used in the American Civil War. The bullet has several rings carved into it, along with a notch and a protrusion at the point that makes it resemble a bishop piece from chess. The Maynard style bullet was one of the two different types of small arms ammunition found aboard *Georgia*. Although the

Figure 4: The carved bullet resembling a chess piece. Image courtesy of the Naval History and Heritage Command.

Figure 5: The carved bullet after conservation. Photo by Karen Martindale, courtesy of the Conservation Research Laboratory.

Figure 6: An example of the brass instrument reeds found on C.S.S. *Georgia*. Photo by Karen Martindale, courtesy of the Conservation Research Laboratory.

design of chess pieces have changed many times since its creation, this carved bullet resembles the bishop piece of a Staunton design chess set, which is the style used in modern chess pieces as well.

In addition to the two game pieces, three instrument reeds were recovered. Based on the design, the brass instrument reeds were likely for a pump organ, a cousin of the larger pipe organ. Pump organs were popular in America for their convenience and small size. The force from the pump air would vibrate a thin brass strip and produce sound for the instrument. This instrument was moderately portable, and the presence of spare reeds onboard *Georgia* indicates that there was likely a pump organ on board for the crew's entertainment and leisure.

Since each of these artifacts is constructed of a different material, they each underwent slightly different conservation processes. The domino was put through an incremental dehydration process, going from deionized water to acetone, and was then treated using silicone oil. For the bullet, a very dilute solution of hydrochloric acid was used to remove concretion and expose minute details without risking damage to the very soft metal. Once it had been properly cleaned the artifact was thoroughly rinsed to remove the acid and sealed with microcrystalline wax. Finally, the instrument reeds were treated using electrolytic reduction to remove salts from the brass and halt the corrosion process. The reeds were then immersed in benzotriazole (a corrosion inhibitor) and sealed with microcrystalline wax.

The personal artifacts recovered from the wreck site of C.S.S. *Georgia* and conserved at the Texas A&M University Conservation Research Laboraty provide insight into the recreational activities of the sailors on board. In addition to their duties on board this floating, stationary battery, the sailors evidently had at least some recreational time to fill. These artifacts demonstrate that the sailors filled this time, at least in part, with music and homemade games, crafted from the materials that the sailors had on hand. ■

Ancient Naval Ram Casting Project (2021 - Present)

Stephen DeCasien
Nautical Archaeology Program, Texas A&M University

More than 31 naval rams exist in the archaeological record, many of which are three-bladed waterline rams. The first archaeologically attested three-bladed waterline ram was discovered off the coast of Athlit, Israel in the 1980s (Figure 1). The Athlit ram was the first to be studied by archaeologists and historians. The bronze ram and its intact bow timbers revealed that the ram served as an integral part of warship construction and a complex naval weapons system. It also suggested that rams were cast in bronze to the highest standards using the direct lost-wax casting method.

31 rams have been discovered since the Athlit ram. Each subsequent discovery has helped scholars gain deeper insight into naval warfare from the Classical to the early Roman Imperial periods. Of those 31 rams, 26 were recovered at the Egadi Islands near western Sicily. RPM Nautical Foundation in cooperation with the Sicilian government and the Soprintendenza del Mare are at the head of these recovery efforts. Other notable discoveries include the Acqualadroni, Bremerhaven, Follonica, and Piraeus rams, along with a supposed Mithridatic ram that was found in the Black Sea (Figure 2). Proembolia, or 'subsidiary,' rams such as the Belgammel, Canellopoulos, Turin, and an unpublished Imperial Roman era proembolion have also been found.

Figure 1: Athlit ram at the National Maritime Museum in Haifa, Israel. Photo by Dr. Shelley Wachsmann.

Figure 2: Piraeus ram at the Piraeus Archaeological Museum in Piraeus, Greece. Photo by the author.

While it is known that the ancient craftsmen used the lost-wax casting method to produce large bronze objects, such as the famous Riace Warriors, the intricate details of this process as it relates to ram production is debatable. I am currently in the final stages of conducting an experimental project in recreating a trireme-sized ram using a three-step process: (1) false bow construction, (2) beeswax model creation, and (3) lost-wax casting. The purpose of this experimental reconstruction is to better understand the time, manpower, and materials needed to create ancient rams. By knowing the production process of rams, it is possible to better understand the economic, social, and political apparatuses of ancient navies.

The first step of the project was to construct a trireme-sized ramming bow to serve as the beeswax model's core. The bow was based on a culmination of archaeologically attested ramming bows such as those found inside the Acqualadroni, Athlit, and Egadi rams. The bow consisted of six major timbers: the ramming timber, port and starboard wales, keel, chock, and stem. These six pieces of wood in combination reflect a bow that may have been constructed as part of a frontal ramming vessel after 413 BCE. The entire bow was built using Douglas fir, a pine that is native to the northwestern United States. This type of timber was chosen due to its similarity to Mediterranean pine species, availability, and affordability. In total, the bow was made from eight 4x4s and one 2x4 of Douglas fir that were cut and planed to the specifications and dimensions needed to create the false ramming bow (Figure 3).

The second step of the project involved the use of beeswax to fashion a model of a trireme-sized ram onto the false bow (Figure 4). Around 40 pounds of beeswax was used to make the final beeswax model. Based on relevant academic scholarship and personal experience working with beeswax, the following measures were taken to create the beeswax ram model.

1. The bow was coated in pine tar to slightly oversize the model to compensate for shrinkage during casting and to create a working surface for the beeswax.
2. The cold beeswax blocks were broken-down and separated for each specific section of the ram model.
3. The beeswax was melted into blocks, sheets, and semi-hot "half-blocks" using pre-made molds and some small sheets were worked by hand.
4. The beeswax was hard-pressed and sculpted directly onto the bow while it was still warm.
5. Each section was sculpted to a desired thickness and smoothed together.
6. Once the central core was finished, the fins were added and fixed to the rest of the beeswax model.
7. The fins were built in two methods using both freehand sculpting and pre-made molds.
8. After the addition of the fins, the fins and fin cavities were shaped and smoothed.
9. Once the beeswax ram was completed, decorative additions were made, such as an inscription on the cowl.

Based on the initial stages of the project, it is safe to assume that in antiquity a trireme-sized naval ram required an average of 30 to 50 pounds of beeswax to create a model. It would take as

Figure 3: Fully constructed false trireme ramming bow. Photo by the author.

many as three to four skilled craftsmen to build one beeswax model in a span of one to four working days, depending on its size and complexity. The process of working the beeswax likely consisted of a combination of pre-made slabs and semi-hot wax pieces worked together followed by the addition of the fins in a similar manner. The last step of the project is to cast the beeswax model which is scheduled to occur in Fall 2022. Currently, the beeswax model has been removed from the false bow and delivered to the local foundry. The foundry will follow the lost-wax casting method to produce the bronze ram. The finished ram will then be set on the bow for final placement and recording. ■

Acknowledgements: I would like to thank Dr. Christopher M. Dostal and the Center for Maritime Archaeology and Conservation (CMAC) for sponsoring my experimental project. I would also like to express special gratitude to Glenn Greico for his assistance and encouragement throughout this project. Additional thanks to Dr. Cemal M. Pulak and Dr. William M. Murray for their valuable project suggestions.

Figure 4: Various construction stages of the beeswax ram model. Photo by the author.

Revisiting Port Royal: Digital Archiving of Port Royal Artifacts Using PastPerfect Museum Software

Bethany Becktell
Nautical Archaeology Program, Texas A&M University

During the 1980s, archaeological excavations were carried out on the underwater remains of the English colonial city of Port Royal, Jamaica. Among the artifacts recovered were over 20,000 clay pipes and pipe fragments. These artifacts have since been stored at Texas A&M University, where they are currently being studied and digitally archived by TAMU students in preparation for their repatriation to Jamaica.

In 1655, Port Royal was captured as a consolation prize for Lord Oliver Cromwell by Admiral Penn and General Venables. The English had just been soundly defeated by the Spanish following an attempt to conquer Hispaniola. Port Royal quickly grew to become the second largest mercantile center in the English colonies during the late 17th century after Boston, Massachusetts, and served as a haven for privateers and pirates. Between 1655 and 1692, Port Royal grew faster than any town founded by the English in the New World and became the most economically important English port in the Americas. It was a wealthy city of merchants, artisans, ships' captains, slaves, and pirates, and earned the reputation as the 'wickedest city in the world.'

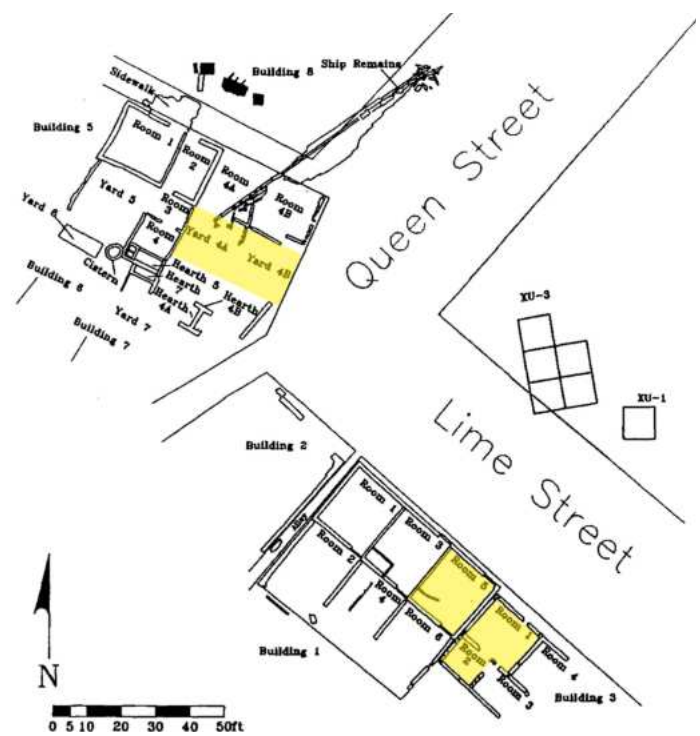

Figure 1: Map of Port Royal with greatest concentrations of smoked pipe bowls highlighted. Building 1 also functioned as a pipe shop. Modified image from Georgia Fox, "The Study and Analysis of the Kaolin Clay Tobacco Pipe Collection from the Seventeenth-Century Archaeological Site of Port Royal, Jamaica," 1998.

Unfortunately, Port Royal's prestige was short-lived. An earthquake struck the island on June 7th, 1692, which caused the town to collapse into the sea. Subsequent attempts to rebuild were met with further natural disasters, and the settlement never regained its former prosperity. From 1981 to 1990 archaeological investigations of Port Royal were conducted under the direction of Dr. Donny Hamilton, with the Institute of Nautical Archaeology and the Nautical Archaeology Program at Texas A&M University (TAMU), in cooperation with the Jamaica National Heritage Trust (JNHT).

Due to the cost and space requirements needed to conserve and store the extensive collection of materials from Port Royal, the artifacts have been kept in College Station, Texas, at TAMU. There are developing plans, however, to repatriate the Port Royal collection back to Jamaica. To maintain an archive of the Port Royal collection at TAMU, the archaeological materials are currently undergoing cataloging efforts using PastPerfect museum cataloging software.

Aggie Research Program Collaboration

During the Spring 2021 semester, nautical graduate student Olivia Brill began documenting the Port Royal collection using PastPerfect to create a digital database. After extensive research, Brill had selected PastPerfect due to its universal use throughout museums and other research institutions. Brill began data entry on a variety of ceramics, metals, and a group of miscellaneous unknown artifacts. This cataloging was continued the next Fall by the author with the assistance of one undergraduate student. The author and student reviewed and standardized the previously cataloged entries, finished any remaining artifact photography, and continued cataloging artifacts, focusing specifically on the extensive collection of white clay pipe stems. Due to the sheer volume of artifacts, it was clear that a larger workforce would be required to continue the digitization process. It was decided that the continuing cataloging project would make use of the Aggie Research Program (ARP) to reach a greater number of students who may be interested in assisting with the ongoing research efforts.

The ARP creates professional development opportunities by pairing graduate students, postdocs, and junior faculty seeking leadership experience with undergraduates university-wide who

Figure 3: Jonathan Chang and Savannah Bedsole work together to record pipe stems with bowls. Photo by the author, 2022.

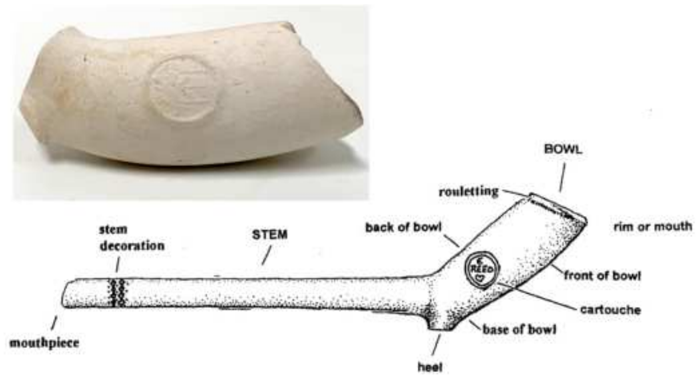

Figure 2: Diagram of English clay pipe with image of a cartouche with an anchor on a shield and the name EVANS underneath on a bowl fragment. Modified image from Georgia Fox, "The Study and Analysis of the Kaolin Clay Tobacco Pipe Collection from the Seventeenth-Century Archaeological Site of Port Royal, Jamaica," 1998.

are looking for involvement in research. The ARP provides no restrictions to the project type or how team leaders select their undergraduate researchers, leaving the process completely in the hands of the team leaders. The Debakey Executive Leadership Program targets research in academia (compared to other tracts of ARP that focus on mentorship and teaching or research in genetics and genomics or neuroscience specifically). The ARP trains team leaders in team management through monthly meetings and guidance of leadership principles, weekly surveys to analyze how team goals are progressing, as well as provide support for any needs. If team leaders participate in ARP for at least two semesters, they earn certification as a DeBakey Executive Research Leader. Undergraduates earn certificates for each semester they participate. To continue the Port Royal artifact documentation project in Spring 2022, the author worked with the ARP to enlist the assistance of interested students. A highly qualified team of eight undergraduates enrolled in the ARP joined the project, as well as three graduate assistants and two undergraduates outside of the ARP.

Documenting White Clay Pipes

There were 21,575 bowl and stem fragments and whole pipes excavated from Port Royal. According to Georgia Fox, whose dissertation focused on the kaolin clay tobacco pipes from Port Royal, the "majority of pipes fall within the occupation period closest to the earthquake, from 1680 to 1710." The greatest concentrations of smoked pipe bowls appeared in Building 1, Room 5; Building 3, Rooms 1/2; and Yards 4A/4B. Building 1 also seems to have functioned as a pipe shop.

The students worked as pairs to create a manual record of elements of the pipes (without bowls), such as ObjectID, weight, length, bore diameter and description of the bore, diameter at each end, and any details deemed worthy of note, including whether the pipe appeared to have been smoked. By working together, the students checked each other's measurements and descriptions for consistency and maintained good recording practices. After the pipes were manually recorded, they were photographed with a scale bar. The pipe stems without bowls were photographed from the 'front' or the side with the ObjectID and then rolled 180 degrees to photograph the 'back.' The photographs were then relabeled with the ObjectID to make it easier to pair the images with their digital entries in PastPerfect. Each pipe stem's ObjectID was then entered into PastPerfect (with a continued parenthetical number for same ObjectIDs, as PastPerfect only allows unique entries) and the images matched to the entry. Each pair of students have participated in manual recording of pipes, artifact photography, and the creation of initial PastPerfect entries with corresponding images. Along with pipe stems, the students have begun cataloging pipe stems with bowls, which have more details to observe (such as ornamentation on the bowls regarding rouletting, makers' marks, or the presence of cartouches).

At this time, nearly 500 records have been completed in PastPerfect for the Port Royal collection. The pipe stems as well as pipe stems with bowls have been the focus of the Spring 2022 semester. Hopefully, the collaborative efforts between undergraduate and graduate students through the ARP will continue in future semesters to further the digital archiving of the Port Royal materials before their repatriation back to Jamaica. ■

Figure 4: From left to right, Willow Grote photographs a pipe stem fragment; Hudson Spillers creates new entries in PastPerfect. Photo by the author, 2022.

Investigating the Canaanite Jar Assemblage from the Late Bronze Age Uluburun Shipwreck

Rachel L. Matheny
Nautical Archaeology Program

During the Late Bronze Age (c.a. 1320 ± 20 BCE), a 15-meter long sailing vessel, ladened with over 10 tons of raw materials and luxury goods, sank just off the promontory of Uluburun near Kaş, along the southwestern littoral of Turkey. Studies of the cargo, ballast, and anchors indicate that the ship was likely a Levantine merchantman heading west towards the Aegean. The shipwreck was discovered by a local sponge diver in 1982 who reported his sighting – described as "metal biscuits with ears", referencing oxhide ingots carried as part of the cargo – to the Bodrum Museum of Underwater Archaeology and the Institute of Nautical Archaeology (INA). Between 1984 and 1994, excavations by INA raised over 15,000 artifacts, and research focused on the different assemblages is ongoing at INA's Bodrum Research Center in Turkey.

Figure 1: Canaanite jars from the Uluburun shipwreck. Note the variety, from small conical jars with semi-straight shoulders (top left) to extra-large bulbous jars with rounded shoulders (bottom right). Image by the author.

Study of the wreckage indicates that the cargo was loaded onto the vessel all at once. Raw and worked ivory, thousands of beads, and various pieces of jewelry were among the artifacts that made up the luxury items of the cargo. The raw materials on board included copper, glass, and tin ingots, and organic cargo in ceramic transport jars. The ceramic transport jars included 153 Canaanite jars, which have a broad range of sizes, shapes, and construction features, and constitute the largest corpus of complete Canaanite jars found from a single, closed context. Analysis of this assemblage has the potential to shed light on elements of Late Bronze Age industry and economy, such as variations between workshops and regions, standardization of volume/weight, and the structure and interconnectedness of trade networks.

The jars within the assemblage exhibit significant variation in size and shape, with a volumetric range from 5 liters to over 35 liters (Fig. 1). However, despite this variation, they all fall under a singular umbrella term, "Canaanite jar," loosely defined as Bronze Age storage and transport jars with two to four handles. This term does not capture the array of morphologies and functions present within the known corpus of Bronze Age Canaanite jars, including the assemblage from the Uluburun shipwreck. Therefore, under the direction of Dr. Cemal Pulak, I created a Canaanite jar typology, dividing the assemblage into discrete categories based on a statistical analysis of the volumetric and diagnostic measurements and 2-D geometric morphometric analysis. By breaking these shapes and sizes down into types, I can

Figure 2: Volumetric measurement of a Canaanite jar filled to the narrowest area of the neck. Photo courtesy of the Uluburun Shipwreck Project.

then investigate and contextualize the assemblage and answer the following questions: are the various types related to their contents and/or their geographic production region? Was there an attempt at size or shape standardization and what degree of standardization can be expected from Late Bronze Age Canaanite jar production? Are certain sizes and shapes of Canaanite jars found only in certain areas of the Mediterranean, indicating directionality and consumer choice impacting trade networks?

Part of documenting and recording the Canaanite jar assemblage consisted of performing volumetric measurements. While some computer programs can calculate the volume of an object based on its drawing (e.g. Amphoralex, Pot Utility, Cre-A-Patimoine, and AutoCAD), the accuracy of these programs depends on a few factors, including the symmetry of the jar and the accuracy of the jar profile. A majority of the Canaanite jars from the Uluburun shipwreck have thick, irregular interiors with undulating grooves and ridges. Therefore, the only way to obtain accurate volumetric measurements for the assemblage was to measure them by hand using Styrofoam beads (Fig. 2). Each jar was filled with Styrofoam beads to three different levels (the lip, narrowest point of the neck, and shoulder-neck junction) three separate times. Styrofoam beads were the preferred medium as opposed to grain or water, as both compressed too much and were too heavy and would strain reconstructed jars. Furthermore, water would dissolve the jars' fabric and destabilize the glue used to reconstruct the broken jars. Various methodologies were employed to reduce cumulative errors and to minimize "stacking error", here defined as the irregular stacking of Styrofoam beads. While the resulting process took multiple summers to complete, it was necessary to produce precise results. All of the volumetric measurements, even those taken by different individuals, are within one percent error of the average for each specified measurement level.

While investingating this assemblage and typology, it was important to determine whether the volumes of the Canaanite jars correlated to any known Late Bronze Age standard measurements, like the Ugaritic *kadu*, or the Iron Age *bath* and *hin*. Correspondence to known volume standards would suggest some level of standardization within Canaanite jar production. To determine whether the Canaanite jar assemblage corresponds to volume standards, I analyzed the volumetric measurements within the assemblage for repeating units using Kendall's formula (also known as Kendall's tau). This statistical analysis can reveal potential ordinal association between two measured quantities, thereby indicating the presence of a standardized measurement system, even if the quantities in question are not the same. In this way, the analysis can demonstrate the presence of a unit of measurement within the Canaanite jar assemblage, even if some jars represent, for example, half units or double units. Applying Kendall's formula to the Canaanite jar dataset reflected multiple repeating units, which likely reflects at least some degree of volumetric standard measurements.

The Canaanite jar typology evolved throughout the documentation and recording process. I initially grouped the jars into types based on direct observation supplemented with the diagnostic measurements (i.e. height, maximum diameter, toe diameter, volume, etc.). I then used

R-Stats to perform a variety of statistical analyses to identify outliers and test the mathematical viability of the preliminary typology. I first created boxplots for each type, a graphing method that represents both the locality and variability of groups of data. This was to determine the presence of outliers, which I then either reassigned or confirmed their place in the original group based on non-quantifiable characteristics (e.g. internal base structure). Any outlier that remained in it's original group was labelled as aberrant.

To test the statistical significance of the subsequently created types, I performed a one-way ANOVA test, which is designed to determine the presence of statistically significant differences between independent groups. This analysis also allowed me to determine the most statistically significant variables between types (e.g. height, maximum shoulder diameter, toe diameter, and capacity). I then created a dataset for the typology based solely on these variables and performed a Linear Discriminant Analysis (LDA), a method in statistics to find a linear combination of features that characterizes two or more classes of data, to determine the statistical significance of the entire typology. The LDA was able to predict the typological groups with 96% certainty, indicating that the typology likely correctly separated the assemblage into distinct groups. Other statistical tests, however, suggested that there remained some overlap between types, indicating the need for further refinement. In most cases, the overlapping groups were differentiated based on non-quantifiable characteristics, such as neck or base type.

I sought to build on these analyses and investigate whether there were any distinct differences in overall jar shape, in addition to differences between individual characteristics. This required that I create a mathematical representation of the shape of each Canaanite jar, which was a difficult, but necessary, step in creating a typology for this assemblage. If one were to rely solely on a combination of diagnostic measurements, the resulting typology would ignore other important features, such as the curvature of the body and shoulder. Additionally, it is difficult to statistically analyze all diagnostic measurements simultaneously, whereas direct observations often overlook important characteristics beyond jar shape. For this reason, I decided to use a type of morphometric analysis to study the assemblage.

Two-dimensional geometric morphometric analysis, when performed correctly, accurately captures the shape of an artifact and allows for comparison of artifacts regardless of size, scale, and orientation. This technique uses Cartesian landmarks (a coordinate system using unique points) and performs comparative analyses using only a single variable: morphology. Using the completed Uluburun drawings, drawn with incredible accuracy by INA's resident illustrator, Seçil Kayacık Aydar, I placed 33 landmarks (LMs) on the same spot on every jar drawing (Fig 3) and calculated each landmark's Cartesian coordinate using ImageJ, a Java-based image processing program. For example, LM 11 on every jar occurs on the exterior profile side of the drawing halfway between the lower handle attachment (LM 10) and where the base transitions into the toe (LM 13). For this type of analysis, it is essential that each LM corresponds to the same location on ev-

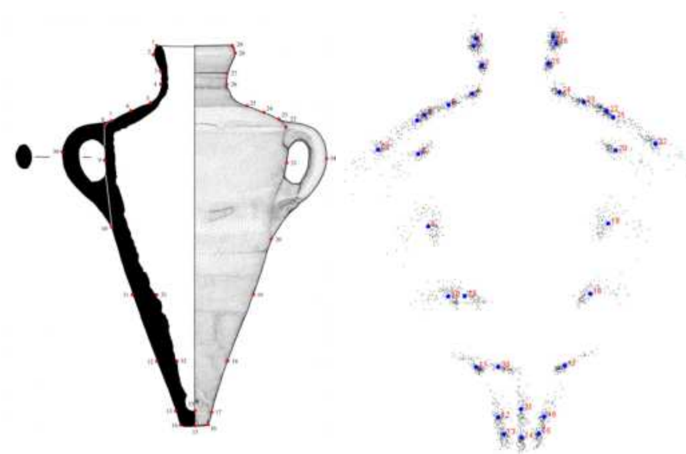

Figure 3: Left: The location of the 33 landmarks used for 2-D geometric morphometric analysis; Right: The 33 LMs from all of the analyzed Canaanite jars superimposed and centered around the common centroid. The red numbers indicate the LMs number and the larger blue dot represents the mean location for that LM.

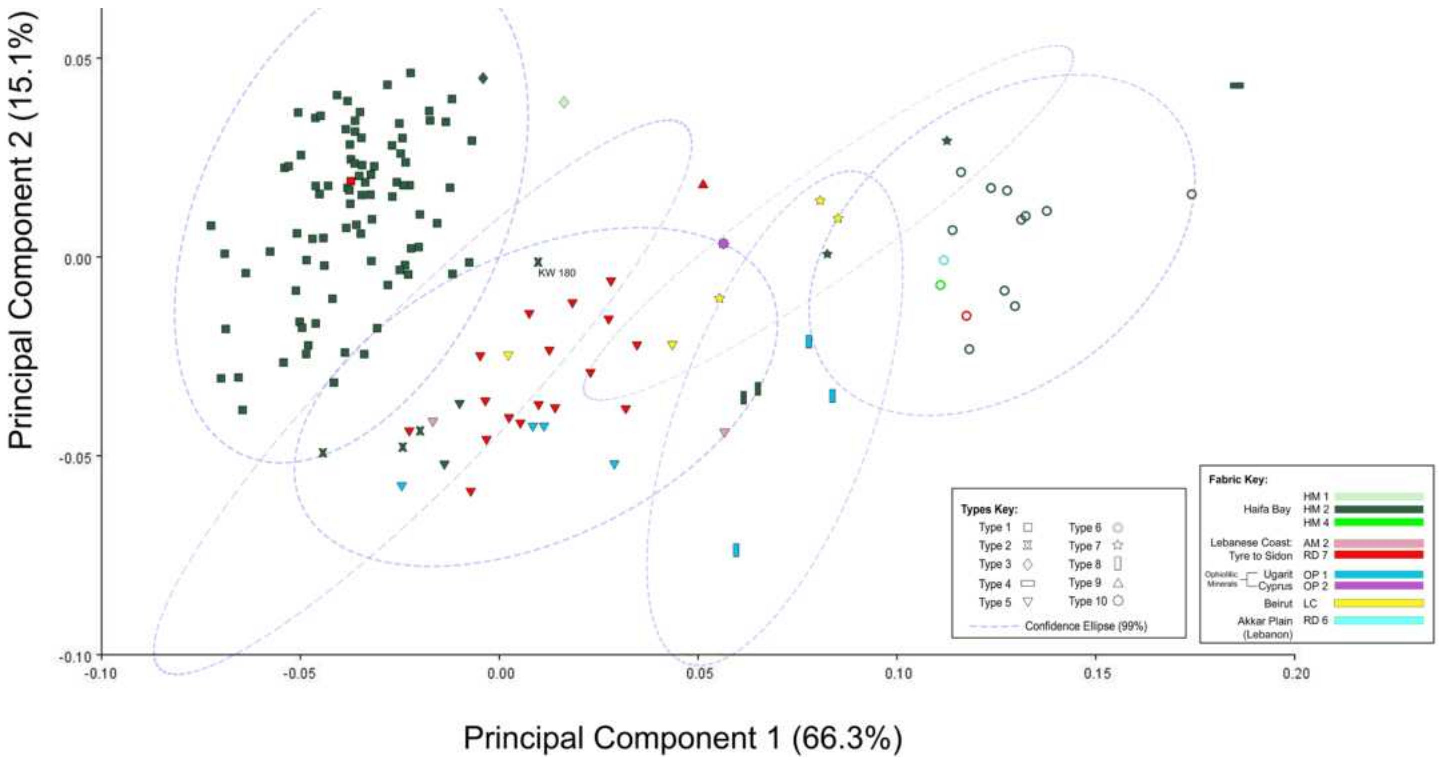

Figure 4: PCA graph classified by type (shape) and fabric (color). There are confidence ellipses (95%) around the types (blue dashed line); the smaller the ellipsis the more homogenous the type. Image by the author.

ery artifact. I then moved these coordinates into a program called MorphoJ, a program package for geometric morphometric analysis. I used this program to perform a Procrustes analysis, a type of statistical shape analysis used to compare multiple sets of configurations. Using the Procrustes coordinates, I performed a principal component analysis (PCA) and graphed the results (Fig. 4). The resulting scatterplot shows discrete groupings of jar types, which not only helps refine the typology, but also indicats that, mathematically, there are significantly different shapes within the assemblage.

With the combination of direct observation, statistical analyses, and 2-D geometric morphometric analysis, I was able to create a general typology for the Canaanite jars from the Uluburun shipwreck. Deeper investigation into this typology (e.g. quantal analysis) contextualizes the assemblage within Late Bronze Age Levantine world and explores themes such as Canaanite jar standardization and usage. Considered with the petrographic results, performed by Yuval Goren, the typology can also elucidate Canaanite jar production and transportation and regional workshop variation and organization. For a more comprehensive discussion on the Canaanite jars and other Canaanite pottery from the Uluburun shipwreck see "The Canaanite Pottery Assemblage from the Uluburun Shipwreck", TINA Maritime Archaeological Periodical Issue 16, 2021, pgs. 16-61. ■

Acknowledgments: The documentation, recording, and analysis of the Canaanite jars from the Uluburun shipwreck are under the direction of and in collaboration with Dr. Cemal Pulak. This on-going work is not possible without the excellent team in Turkey: Orkan Köyağasıoğlu, Seçil Kayacık Aydar, Bilge Güneşdoğdu, Gülser Kazancıoğlu, and Edith Trnka. The Canaanite jar assemblage has also been recorded by a fleet of former and current graduate students from Texas A&M and other universities including Lilia Campana, Cydrisse Cateloy, Kevin Melia-Teevan, John Littlefield, Anya Kruger, and Ryan Theis.

Current Research

CMAC Professors Dr. Carolyn Kennedy and Dr. Christopher Dostal led a team of students to perfom work locating cultural heritage materials in Gaspe Bay, Canada. This area has witnessed a high volume of fishing, whaling, and trading for many centuries, and represents an important facet of the heritage of the area. Participating students were: Catherine Brooks, Alyssa Carpenter, Meagan Clyburn, Megan Crutcher, Brandon Lentz, and Sam Werthan.

Patrick Boyle surveyed a late 19th century oyster boat as the Assistant State Underwater Archaeologist for Virginia's Department of Historic Resources. Two trips were made to photograph, film, and measure the hull remains, which Patrick plans to re-examine as part of his future dissertation research.

Megan Crutcher received a grant to conduct archival research at the Arquivo Nacional da Torre do Tombo in Lisbon, Portugal, where she gathered data on sailors and ships logs from the port of Lisbon during the 17th and 18th centuries.

Angela Burr spent the summer at the *Queen Anne's Revenge* Project Laboratory working on the conservation of the artifacts recovered from the shipwreck.

Raul Palomino Berrocal and Megan Crutcher worked in Lugo, Spain, on the research team led by Dr. Miguel San Claudio focused on archaeological survey of the Ribadeo channel. In addition to documenting modern shipwrecks, the team also discovered timbers from a Medieval longboat.

Summer 2022

Kimberly Breyfogle worked at the Newport Medieval Ship in Wales with NAP alum Dr. Toby Jones to conduct post-conservation cleaning and re-recording of major ship timbers. Comparisons were made to the original shape of the timbers to determine how the shape has changed since they were originally excavated.

Charlotte Jarvis continued her thesis research on the history and archaeology of alcohol consumption at sea as a research fellow at the National Maritime Museum in Amsterdam.

Claire Zak and Bethany Becktell, as well as recent NAP graduates Sheri Kapahnke and Jose Casaban, participated in an excavation with CMAC professors Dr. Cemal Pulak and Dr. Debbie Carlson and the Institute of Nautical Archaeology off the coast of Turkey. This shipwreck is believed to date to the Bronze Age.

Rachel Matheny, Annaliese Dempsey, Traci Andrews, and Angela Paola worked for the Uluburun Shipwreck Project in Bodrum, Turkey. Their work focused on documenting the tin ingot assemblage from this 3,000 year old shipwreck.

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