Reconstructing Ancient Lives Using 3D Technology: A Case Study of Pork and Doughboy Point, Belize

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Reconstructing Ancient Lives Using 3D Technology: A Case Study of Pork and Doughboy Point, Belize

by

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Undergraduate honors thesis under the direction of

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Louisiana State University & Agricultural and Mechanical College
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Abstract

3D technology can preserve cultural heritage resources and enhance museum collections and exhibits. Through 3D scanning, an exact digital replica of an artifact is created, which can be printed out or used to create a digital display. For this project, 3D scanning was used to reconstruct ancient Maya lives at Pork and Doughboy Point, Belize. By studying and classifying an inventory of selected artifacts, we were able to determine what activities occurred at the site. The goal of this project was to showcase the growing importance of 3D technology in cultural preservation and the variety of ways in which it can be used. Additionally, this project sought to explore the negative and positive aspects of digitization in museum collections, and the feasibility of the implementation of this technology.
Introduction

Overview

The use of three-dimensional (3D) technology in archaeology has been a relatively contemporary development, but the advantages of this new field have quickly manifested themselves. In Louisiana State University’s Digital Imaging and Visualization in Archaeology (DIVA) Lab, Dr. Heather McKillop and a multitude of undergraduate, graduate, and doctoral students have all gained firsthand experience with 3D technology. As a student worker in the DIVA Lab, I was given the opportunity to learn various 3D scanning techniques and witness how beneficial this technology can be when it comes to managing collections and exhibiting information.

This project combines 3D scanning with the traditional study of artifacts to reconstruct an ancient site. The site used here is Pork and Doughboy Point, Belize, an ancient Maya site that yielded thousands of artifacts for study (Hammond 1975; Brandehoff-Pracht 1995; McKillop 2002: 160-161, Fig. 5.7, Map 5.9; Pemberton 2005). The purpose of this project was to scan a select of these artifacts, identify the form and function of these artifacts, and recreate a narrative of what occurred at Pork and Doughboy Point. The primary concern however is placed on the 3D aspects of this project, as this is a rapidly evolving and constantly growing field. I set out to discern the feasibility of creating a collection of artifacts via 3D scanning, and how 3D technology affects museum collection and display.

NextEngine

I conducted the 3D scanning using a NextEngine Desktop 3D Scanner HD from the DIVA Lab. This is a contact free, surface scanner, meaning the NextEngine records the surface
of an object using light or laser reflections to create a point cloud (Weber and Bookstein 2011:95). A point cloud recreates the object’s surface by gathering a collection of data points that are plotted on a 3D coordinate system (Beebe 2014). These point clouds are then converted into digital models made of polygon or triangular mesh. The NextEngine employs a triangulation method of scanning, where, as Weber and Bookstein (2011:95) describes it, a “laser light is emitted by the transmitter and simultaneously the receiver (camera) measures where the laser dot is actually located on the object. The laser source, the projected laser dot on the object, and the sensor element of the camera form a triangle, hence the name of the technique”.

The NextEngine itself is comprised of a vertically-oriented laser scanner that is attached to a turntable via a cable (Figure 1.1). The turntable can rotate up to 360°, depending on what scan mode it is placed. The turntable comes equipped with an adjustable, stainless-steel ‘PartGripper’ that allows you to secure your object while scanning it. The PartGripper allows you to securely angle and position your object in any number of ways, which gives you the ability to more accurately capture complex areas of the object. The height of the PartGripper’s platform can be adjusted, as can the stylus. The stylus can be turned 360°, and it can also be completely removed if need be. The NextEngine’s website also offers additional add-ons for the scanner, such as an extension cable for the AutoDrive or a black base for the platforms, which shows up as “nearly invisible” to the scanner, reducing trim time (“http://www.nextengine.com/products”). A NextEngine additionally come supplied with ScanStudio software, which is the 3D scanning and modelling software used to manipulate, edit, and fuse the 3D models that are captured with the scanner.
Port Honduras

Pork and Doughboy Point is located on the southern coast of Belize, in the Port Honduras area. Port Honduras’s parameters are defined by the modern-day towns of Punta Gorda and Punta and Punta Negra (McKillop 2002). The area is home to a variety of ancient Maya sites, such as Wild Cane Cay, Frenchman's Cay, and Punta Ycacos (McKillop 2002, 2005); Pork and Doughboy Point is the southernmost site of the aforementioned areas. The coasts and cays of Port Honduras were active locations in the Classic Period (250-900 AD), and were engaged in coastal and inland trade (McKillop 1980; McKillop 1989; McKillop 2002). These sites in Port Honduras all experienced sea-level rise, an environmental change that may have influenced the habitation of these sites (McKillop 2002).
**Pork and Doughboy Point**

Pork and Doughboy Point is found 11 km northeast of Punta Gorda, and can only be reached by boat (Pemberton 2005). The site is on a point, with mangroves landward (McKillop 2002: 160-161). The western area of the point is populated by low-lying mangrove swamps, while the eastern portion is slightly more elevated and features plants typically found in Southern Belize, such as coconoboy palms (Brandehoff-Pracht 1995; Pemberton 2005). Additionally, Pork and Doughboy Point is east of the Maya Mountains, southeast of the Seven Hills, and in-between the Rio Grande and the Middle River (Brandehoff-Pracht 1995; Pemberton 2005).

Sea-level rise is evident at Pork and Doughboy Point (McKillop 2002:160-161). Brandehoff-Pracht (1995) conducted an excavation 22m off the eastern point, and through a simulated wave experiment, found that the artifacts there were in situ (their original location). This suggests that the artifacts were buried underneath the sand and kept securely in place, as wave erosion would have widely dispersed them.

Excavations were conducted on the surface of both the land and the sea floor, with large amounts of artifacts obtained from each location (Brandehoff-Pracht 1995; McKillop 1995, 2005; Pemberton 2005). The artifacts found from these excavations indicate that the sites were located in middens (garbage heaps). The type and variety of artifacts found at the aforementioned excavations all suggest that Pork and Doughboy Point was the site of a small village or community.
Literature Review

Benefits of 3D Technology and Digitization

Overall, employing the use of 3D technology in collections management offers an alternative form of preservation and display. Imaging an artifact with a 3D scanner creates a digital replica of the object; this 3D image can be stored indefinitely and manipulated in a variety of ways for posterity. The 3D image can be used in the curation of online exhibits or displays, and it can also be shared online as an Open Access file for the public to view and use. Additionally, this image can be printed out using a 3D printer, expanding the original artifact’s potential to be used for educational and display purposes.

A 3D scan or print preserves an artifact in a number of ways. It first creates a copy of the artifact that can be added to an existing or newly created digital collection. While this does not physically preserve the original artifact, it does create a backup of it in case something damaging happens to the original. Just as a photograph does not physically preserve an object, it still creates a replication of it that can be used and studied if the original is lost or damaged. Additionally, creating a 3D scan or print saves the original artifact from further deterioration or loss, as the 3D copy can be handled and studied instead, preventing damages the artifact may incur from being physically handled or moved. A 3D scan also constructs a controlled, artificial environment for the artifact, which allows for manipulations and uses that may have been difficult or dangerous if performed in its actual environment.

Conservation via 3D Technology

3D technology offers a variety of conservation benefits. Missing parts of an artifact can be restored using 3D printing, and 3D scanning and fabrication can recreate missing parts as well
(Wachowiak and Karas 2009). 3D printing allows for custom-made packing materials for the transportation of artifacts, reducing the possibility of breakages, and custom-made mounts can be produced for greater stability in displays (Wachiowak and Karas 2009). Moreover, 3D scanning can be employed as a form of condition monitoring; a 3D creates an exact record of an object's form at that current time, so future scans can reveal deterioration and loss (Arnold and Kaminski 2014).

Collaboration and Research

3D technology also possesses valuable research benefits. High resolution scans can reveal intimate details of an artifact; fine tool marks or the weave of a fabric can be enhanced and studied to a previously unknown degree (Arnold and Kaminski 2014). Removing the texture of a scan better displays the object’s structure and surface texture, making it easier to view its core condition. 3D scans are also very easy to share electronically, and there are a variety of websites that host 3D scans that are available for free downloads, such as Sketchfab and Thingiverse.

There are also innumerable collaborative benefits that are created through widespread use of 3D technology. Researchers no longer need to travel to see an object in person to study it. While obviously contact with the original artifact is always preferred, physical travel is not always possible or time/cost effective. Shared 3D scans broaden the parameters of accessibility to the scientific community, opening up more avenues for research. One example of this is the effort of North and South American physical anthropologists to create a “virtual osteological library” containing prehistoric skeletons (Kuzminsky and Gardiner 2012:2749). This collaboration will increase data sets and expand sample sizes, creating a cohesive database of
prehistoric skeletal materials that will allow researchers to access a large swath of data that was previously unconnected (Kuzminsky and Gardiner 2012).

**Economic Advantages**

Digitization offers new methods of display and conservation for cultural heritage institutions. Many museums and similar institutions are falling victim to increasing budget cuts and have to find new ways of staying afloat. The preliminary budget plan of the United States’ government for the 2019 fiscal year proposes the end of federal funding for agencies such as the National Endowment for the Arts and the National Endowment for Humanities, and goes as far as to propose the complete elimination of agencies such as the Institute of Museum and Library Services (U.S. Office of Management and Budget 2018). With these potential cuts looming in the future, digitization can provide museums and other institutions with more cost-effective options for operation.

Battle et al (2016) discusses such benefits. One major advantage of digitization is the fact that creating a virtual exhibit comes “without requiring the costs of a new physical exhibition or museum building” (42). The cost to construct an entirely new physical space is far greater than the cost to build and host a digitally-based exhibit. Additionally, digital exhibits and displays can increase interest and demand for the original objects (Cloonan 2001), which brings more attention to the hosting institutions and has the potential to attract more physical visitors. Existing exhibits can also benefit from digitization, as they can be enhanced and augmented online with additions such as “archival images, oral history recordings, interactive maps and timelines, or video clips” (Battle et al 2016:42). Through digitization, museums and cultural
heritage institutions can produce new content at minimal cost, as well as updating existing content to increase their visibility.

**Limitations of 3D Technology**

While there are clear advantages to utilizing digitization, this practice has its inevitable drawbacks. A replica can never replace the inherent value and meaning an original possesses; a digital copy of an object cannot capture or re-create its authenticity. According to a Getty Conservation Institute report in 2000(7), “[t]he ultimate aim of conservation is not to conserve material for its own sake but, rather, to maintain (and shape) the values embodied by the heritage—with physical intervention or treatment being one of many means toward that end”. Contemporary collection dilemmas now include the question of how far digital preservation should go. Should digitization be prioritized over physical conservation? Some institutions, in an attempt to survive their shrinking or stagnant budgets, have completely eliminated their preservation departments in favor of focusing on fully digital initiatives (Cloonan 2001).

**Technological Drawbacks**

3D technology itself has its limitations. Other digitization techniques, such as photography, radiography, and computed tomography (CT scans) all offer their own unique benefits that 3D scanners cannot completely replicate. 3D scanning can only capture the external surface and features of an object; it cannot scan any internal facets or characteristics, as radiography and CT scan can do (Wachowiak and Karas 2009). Additionally, some commercial 3D printers have difficulty turning high-resolution scans into high-resolution objects, so not
every 3D print has the potential to be a perfect replica of the original artifact; exact replicas can be difficult and expensive to produce (Wachowiak and Karas 2009). Another challenge posed by 3D technology is that not all materials can be scanned equally (Arnold and Kaminski 2014). Arnold and Kaminski (2014) explain that materials such as cloth and feather “have complex surfaces and a degree of flexibility” which make them difficult to accurately scan; artifacts with reflective surfaces are also difficult to capture with 3D scanning, given their surface interactions with lasers and light.

Furthermore, actually using and operating this 3D technology can impose restraints. The learning curve associated with 3D software can be daunting for many institutions (Metallo and Rossi 2011). Depending on the size and complexity of the object, a full scan of an object could take many hours to complete. Human error can also add onto the length of a project, further complicating the process of scanning. As Metallo and Rossi (2011) state, there is no all-encompassing “how-to” manual for scanning artifacts. Furthermore, “[t]he time investment required in learning how to operate the hardware and software applicable to one set of objects or collections may not work for the next (Metallo and Rossi 2011:65). There are a discouraging amount variables when it comes to operating 3D scanners, and this comes at a high cost of labor.

Sensitive Materials

While increased access to artifacts is generally a positive benefit of digitization initiatives, it also can create problems with culturally sensitive material. Once artifacts are placed in an online, digital landscape, they are removed from the context museums put them in via exhibits (Arnold and Kaminski 2014). With greater accessibility comes greater probability that these artifacts can be misused and misappropriated by digital users. Many indigenous and source
Communities have been concerned “about the activities of museums and other cultural institutions that can sometimes undermine their interests and rights” (Arnold and Kaminski 2014: 82), and digitization has the potential to open up another problematic avenue surrounding indigenous cultural and intellectual property rights.

**Current Applications of 3D Technology by Museums**

While 3D technology is a relatively new approach to collections management, many museums have already utilized these techniques to engage with the public in new, modernized ways. A number of museums have taken advantage of 3D technology and used it to share their artifacts with the digital world. Museums have used 3D scanning and imaging to create online, virtual mini “tours” of select artifacts, making these objects accessible to millions online when they have previously only been accessible by attending these museums in person. Additionally, a variety of museums have uploaded open access files of their scanned artifacts to websites for the public to view, manipulate, and in many cases, download and print themselves.

The Metropolitan Museum of Art is one museum that has adopted the use of 3D technology for public outreach. Using the website Thingiverse as a host, the Met has uploaded 75 3D models available for public use. Thingiverse allows for files that have been created a variety of ways; tinkercad was used to create a model of “Albar Curcan” (https://www.thingiverse.com/thing:3616254), a Sense 3D Scanner was used for “Fragilinga” (https://www.thingiverse.com/thing:226394), and an Autodesk 123D Catch was used for “Memory” (https://www.thingiverse.com/thing:24125). These are just some of the 3D methods employed by the Met to capture objects in their collections. All 75 models are free for public download, which means they are also free to print. Additionally, some of the models, such as
“Memory” and “Fragilina” are accompanied by short descriptions of the original artifacts which include information such as dimensions, medium, and classification. A link to the object in the Met’s online collection is included at the bottom of these descriptions, which gives visitors a more in-depth look at the object. These descriptions are not uniform throughout the models, however, as some, such as “Albar Curan”, only feature the name of the person who scanned the object and what platform they used.

The British National Museum employs the same strategy, but takes it a step further. The British Museum has uploaded hundreds of 3D scans to Sketchfab, a website that hosts thousands of 3D models. Like Thingiverse, Sketchfab supports scans created through a variety of methods. The British Museum’s uploaded models are free to download and free to print, and they are accompanied by descriptions of various length and detail. Some of these models are augmented by the addition of an audio tour or description of the object; the Hoa Hakananai’a and the Rosetta Stone models both possess this supplementary feature. It is no surprise that these objects are two of the British Museum’s most popular models on Sketchfab (https://sketchfab.com/britishmuseum), as the audio descriptions provide for a more immersive experience. Much like an audio tour at an actual museum, this feature creates another level of engagement for the audience, and can provide them with additional information that may not be included text-based descriptions. The audio tours turn these models into virtual displays, developing a new digital cultural heritage landscape that expands the scope of how the public can connect with the past.

The Smithsonian has also embarked on a mission to share their collections digitally with the world. The Smithsonian has a very specific mission in regards to their use of 3D technology. The Digitization Program Office’s objective is to digitally scan 10% of the Smithsonian’s
various collections (Waibel 2013). Some of the current scan can be found on their website
dedicated to their 3D digitization process, Smithsonian X 3D. As of now, there are 65 models
present on their site, most of which are available to download and print with the appropriate
software. In addition to the 65 models, there are 31 virtual “tours”, all which vary depending on
the object. The tours feature the 3D model of the object along with an accompanying text box.
The text box can change with each progressive “step” the viewer takes, revealing new
information about the object, such as the discovery of the object or the scanning and
conservations methods employed on the object. These tours effectively create virtual museum
exhibits that viewers can navigate without ever leaving their home. The Smithsonian by far
possesses the most immersive digital experience of the three aforementioned museums, as it not
only provides the public with downloadable 3D models, but it also takes them on richly-
descriptive tours that construct a deeply encompassing narrative around the object being viewed.
Materials

Pottery Materials

The materials used in this project were taken from the 199 numbered artifacts that were excavated from Pork and Doughboy Point, Belize, and multiple artifacts that were not numbered. However, this number is not representative of the full selection of artifacts recovered from the site. The artifacts used in this project are the artifacts that were currently on-hand in the Pork and Doughboy Point collection of LSU’s Archaeology Lab.

Both terrestrial and underwater excavations were conducted to obtain these artifacts. For the terrestrial excavations, 109 pieces of pottery were recovered, eight pieces of chert, three pieces of ground stone, and one piece of obsidian, bringing the total number of terrestrial-based artifacts in this inventory to 122. For the underwater excavations, 72 pieces of pottery were recovered along with five pieces of chert, for a total of 77 underwater-based artifacts.

Additionally, an Excel-based spreadsheet was used to create a cohesive inventory of the artifacts, which had not been previously done. The artifacts were catalogued based on the numbers assigned to them, which correlated to the artifact’s Universal Transverse Mercator (UTM) grid number, site number, location, material, and item number.

For example, one artifact’s unique number sequence is 31/178-1-2-1-20. All artifacts in this collection begin with 31/178-1, as this is the UTM grid number and site number. The next ‘2’ in the number denotes that the artifact was found during an underwater excavation (a ‘1’ would mean it was terrestrially-based). The next digit is representative of the artifacts material, and a ‘1’ here means it is pottery. The final digit in the number sequence, which is a ‘20’ here, represents the artifact’s specific number in the grouping it belongs to. Artifact 31/178-1-2-1-20 is
therefore the 20th pottery-based artifact from Pork and Doughboy Point from an underwater excavation.

From the 199 numbered artifacts and the unnumbered artifacts, 25 were chosen to be scanned using a NextEngine 3D Laser Scanner from the DIVA Lab. Since the ultimate purpose of scanning these artifacts was to create a digital and physical display, I chose artifacts I believed would be the most useful in reconstructing what occurred at Pork and Doughboy Point. A variety of artifacts differing in shape, size, and function were chosen for this purpose. I also wanted to showcase the NextEngine’s ability to accurately scan detailed and complex items, so I chose additional artifacts that would be more challenging to scan, such as artifacts with holes or layered surfaces. The 25 scanned artifacts are listed in the table below on the next page.

For the three currently unnumbered artifacts, the names ‘Temporary #1’, ‘Temporary #3’, and ‘Temporary #4’ have been assigned to them for the purpose of this project. Other than their UTM grid number and site, which is Pork and Doughboy Point, nothing else is definitively known about these three artifacts. Two artifacts were numbered as ‘31/178-1/1-6’, which obviously caused an issue. For the purpose of this project, the artifacts have been renamed ‘31/178-1-1/6-1’ and ‘31/178-1-1/6-2’.

Of the scanned artifacts, 10 were from terrestrial excavations, 12 were from underwater excavations, and three are of unknown provenance. As previously stated, the ‘1’ in the materials column means it is a piece of pottery. Pottery made up the majority of my selection with 16 pieces. Two pieces of ground stone, meaning a stone ground from other materials, are included in my selection, which is denoted by the number ‘6’. There are two additional pieces of chert, denoted by ‘2’, and one sample of other stone, denoted by ‘10’. The specific types and functions
of these artifacts will be discussed in a later section, along with the concepts and methods used to determine their classifications.

Table 3.1 Scanned Artifacts from Pork and Doughboy Point

<table>
<thead>
<tr>
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<th>Site Number</th>
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<tr>
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<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>31/178</td>
<td>1</td>
<td>2</td>
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</tr>
<tr>
<td>31/178</td>
<td>1</td>
<td>2</td>
<td>10</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 3.1 Scanned Artifacts from Pork and Doughboy Point (Continued)

<table>
<thead>
<tr>
<th>UTM Grid</th>
<th>Site</th>
<th>Location</th>
<th>Material</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>*</td>
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<td>Temporary #1</td>
</tr>
<tr>
<td>*</td>
<td></td>
<td></td>
<td>*</td>
<td>Temporary #3</td>
</tr>
<tr>
<td>*</td>
<td></td>
<td></td>
<td>*</td>
<td>Temporary #4</td>
</tr>
</tbody>
</table>
Methodology

Scan Settings

Before the actual scanning begins, a number of parameters need to be set. An overview of these can be seen below in Figure 4.1. First, the scan mode, or the positioning, must be chosen. There are three options: 360°, Bracket, and Single. A 360° scan will rotate the AutoDrive 360° and take however many scans the division is set to. A Bracket scan will turn the AutoDrive three times, taking a scan of the object’s center, left, and right side. A Single scan will take just one scan of the object, and will not cause the AutoDrive to rotate. Divisions need to be set next and the number of divisions set determines the number of single scans that will be taken during a 360° scan. For example, choosing ‘7’ for the number of divisions means that the scanner will take seven different single scans of an object as it is rotated 360°. These seven single scans will then be grouped into a scan family. Bracket and Single scans are not affected by this setting, as they have a predetermined division setting. The mode and the divisions both affect the amount of time the scan will take, as well as the amount of memory the program will use in creating this scan. Bracket scans take 16.5 minutes and single scans take approximately 5 minutes to complete; these times are not affected by division changes, as these two modes do not change their division settings. 360° scans, however, are affected by the division settings. The length of scan time is extended with each increasing division. A 360° scan with 6 divisions would take 32 minutes, for example, while a 360° with 7 divisions would take 38 minutes.
Figure 4.1. Overview of scanning parameters in ScanStudio.

The resolution of the scan is chosen next, and the user is given the option to choose Quick, SD, or HD; within these settings the user also chooses if they want a low, medium, or high points per inches\(^2\). The approximate color of the object must be chosen as well, either from Dark, Neutral, or Light. These five aforementioned settings all affect the duration, quality, and memory storage of the scan.

The range of the scan needs to be set next. The range simply refers to the distance between the scanner and the object being scanned. Each range has a minimum, maximum, and ideal distance for the object to rest. Macro is the shortest range, and offers the highest resolution options. The ideal distance for macro is 9.5 inches, while the minimum and maximum distance is 7.5” and 11.5” respectively. Wide is the mid-range, with its ideal distance being 25”, and its minimum and maximum being 22” and 28” respectively. Extended provides the longest range, but this setting is used for much larger objects than the ones featured in this project, and was therefore not used during any of the scans.
Scanning

In total, 25 artifacts from Pork and Doughboy Point were scanned. Since each artifact has unique shapes and sizes, a standardized setting parameter could not be created. Each artifact required personalized settings that were curated based on complexity of the artifact. That being said, my scanning preferences did fall somewhat into a pattern.

For the majority of the artifacts, the setting ‘360/6/HD/29k/Macro/32M/26%’ was the first setting used. This setting gave a me a good base to start off with, at the 360° scan captured most of the artifact. The second scan family typically followed this setting as well, as I would turn the artifact on its side to capture the top and bottom areas that were not visible in the first scan. A third scan family set to ‘Bracket/HD/29k/Neutral/Macro/16.5M/13%’ would be performed next to pick up any angles or sides that might have been missed. When everything went perfectly, these would be the only three scans needed. However, this did not often happen, and more than three scans would be needed to capture the entirety of the object.

Figure 4.2. NextEngine scanning an artifact
When I first began scanning artifacts, I would use one 360° scan to start out with, and then I would use two Bracket scans instead of another 360° scan to capture the top and bottom of the artifact. I began to experiment using two 360° scans as opposed to one 360° and two brackets, and found that the results were about the same. I switched over to using two 360° scans after this as this left less room for alignment errors.

After all the scan families are taken, the next steps are to trim, align, and fuse them. Trimming can be performed at any point in this process, including when a scan is running. Trimming entails selecting and deleting unnecessary and unwanted surfaces the scanner picked up (Figure 4.4). The AutoDrive platform and the PartGripper are typically captured in the scan, so those need to be trimmed out as well.
Once the scan families have been trimmed, they need to be aligned. Only two scan families can be aligned at a time. During this process, a minimum of three points need to be selected on each scan; these need to be the same points on both of the scans, so that the software can align them correctly. This has great potential for user-error, as placing identical points on different scans can be difficult and time-consuming. Scanning artifact Temporary #1 incurred many alignment errors, as it was a complex, curved object with three different openings. This added a great deal of time to the production process of this artifact, as adjustments to the scans continuously had to be made.

Fusing is the last step, where all the aligned scan families are fused together to create one final product. Any holes present in the scan are filled in, and a surface texture (color) map is created. Most discoloration is fixed during fusing via the surface texture map. This occurred, for example, with artifact 31/178-1-2/1-69. The scan was oddly shiny in some parts, most likely due to the reflection of the scanner’s light of its surface, but once this artifact was fused the shiny sections disappeared, and much more even surface texture was created. Occasionally, the opposite will occur, and fusing will create a texture that was not present in the original scans.
This happened with artifact 31/178-1-1/10-1. The top and bottom right corners were given a shiny texture post-fuse that can be seen in Figure 4.5. 

![Discolored fused artifact](image)

Figure 4.5. Discolored fused artifact

This discoloration made me mark it for a possible rescan. The surface geometry of the scan was in good shape however, and looked fine when the scan was displayed in a non-texture view, so a rescan of this artifact was not a top priority. Figures 4.6 and 4.7 show two fused artifacts first in Color view and then in Mesh view.
Pottery Vessel Identification

The identification of pottery vessels is obviously much easier when the full, unbroken artifact is uncovered at a site. Most excavated vessels are broken into various pieces, and only random sherds are able to be recovered. Accurately classifying an artifact based solely on small,
scattered sherds is understandably difficult, as you have to reconstruct a full artifact with only a fraction of the whole present. It is possible, however, and can be done based off a variety of factors.

Rice (1987:212) describes a vessel as having “three essential components: orifice, body, and base”. The orifice, or opening, of a vessel, has a great deal of significance when it comes to identification. Often times a rim sherd still has a portion of the body attached, and this can be used to determine a variety of things. A body of a vessel is described by Rice (1987:212) as being the portion of the pottery vessel that is between the orifice and the base, and either contains the vessel’s area of maximum diameter or just the greatest enclosed space. Jars that are thicker in the rim and thinner in the body would typically have different functions than jars that are thinner in the rim and thicker in the body. The third component of a vessel is the base, which is the vessel’s underside “that touches the surface it rests on during normal use” (Rice:1987:213). In determining function and form, body sherds and base sherds are more difficult to work with.

The size and shape of the jar’s orifice is one of the best identifiers of form and function. If the opening is equal or greater to the maximum diameter of the body, it is classified as an unrestricted jar (Rice 1987:212). If the opening is less than the maximum diameter of the body, it is a restricted jar (Rice 1987:212). Jars with restricted rims are better suited for the long-term storing and pouring liquids, while jars with unrestricted rims are better suited for cooking or holding frequently used goods as they give wider access to the contents inside (Rice 1987:236; Rice 1987: 241).

Moreover, the orifice or rim diameter can be determined by using a standard diameter-measurement template. The diameter is calculated by fitting the curve of the rim flush against one of the template’s units. This was performed for artifact 31/178-1-2/1-1, and a rim diameter
of 8.5 centimeters was given. Wall orientation can also be determined by hold the rim sherd at eye-level and tilting it “until three points along the uppermost edge- one at each end of the sherd and one in the middle- are aligned horizontally” (Rice 1987:222-3). Problems can arise with this method, as rims have the potential to be uneven, which makes diameter and orientation difficult (Rice 1987).

**Pottery Classification Systems**

Pottery analysis is an effective way determine cultural history and site activities (Smith et al 1960). The type of pottery found at a site provides clues as to what exactly occurred there. Determining type and function can be difficult however, as pottery is typically found in random, fragmented pieces that have experienced weathering and wear. Establishing a formalized widely-accepted classification system is therefore crucial in the legitimacy of pottery analysis.

There are multiple classification systems for Maya pottery. A commonly used system is the type-variety concept, which is popularly used to determine ceramic chronologies correlating types and varieties of pottery to specific time periods (Smith et al 1960). Smith et al (1960:333) states that “a type represents an aggregate of visually distinct ceramic attributes already objectified within one or (generally) several varieties that, when taken as a whole, are indicative of particular class of pottery produced during a specific time interval within a specific region”; a variety is a subset of a type, and accounts for the variations of attributes within a type. The type-variety concept relies heavily on decorations and surface finishes, which leads to problems and dead ends if the artifacts being analyzed are eroded and worn.

Formal analysis is another classification system that can be used to identity Maya pottery (Brandehoff-Pracht 1995). This system, unlike type-variety, defines type as an issue of
morphology, rather than of surface appearance. Therefore, items with similar vessel, rim, and lip shapes are considered to fall under specific types (Brandehoff-Pracht 1995). This system is typically the more appropriate choice when your collection of artifacts has experienced heavy erosion and wear, and lack definitive visual characteristics.

However, the exact employment of these classification systems fall outside the preliminary scope of this project. For this reason, my advisor was the one who identified the forms of my artifacts, and additionally supplied their types and varieties when that analysis was applicable. A formal analysis/attribute system was the primary identification method for these items. Most of the artifacts used in this project have been discolored through wear, erosion, and salt water; a type-variety classification system would have been difficult and ineffective due to these reasons. A small number of artifacts, however, retained somewhat of their surface color and slip, and in the case of these artifacts a type-variety classification was included.
Results

Artifact Discussion

The 25 scanned artifacts from my selection have a variety of shapes, sizes, and forms. This section will include a brief overview of the materials and forms of the artifacts; a later discussion will be centered on the functions of the artifacts and the roles they likely played at the site, which will also include pictures of the artifacts. The focus of this section will be to provide tables and metadata on my 25 selected artifacts from Pork and Doughboy Point.

The table on the next page lays out the material, form, and, if applicable, the artifact’s ceramic type, all arranged by artifact number. There are two subsequent smaller tables: one table for the data on pottery-based artifacts, and another for the artifacts made from ground stone, chert, or other non-clay materials. This section also contains pictures of all 25 artifacts, grouped and labeled by form, to provide a cohesive look at the selection in an easy to follow format.

The table on the following page shows that of my selected artifacts, five were jar rims, four with vertical wall basins with rims, three were stone tools, two were large fragments of incense burners, and two more were candeleros (small incense burners). My selection also possessed two manos and one metate, a fragment of a bowl, a clay cylinder support vessel, one possible notched fishing weight and one possible jar handle. Of the 25 artifacts, nine of them were able to be assigned a ceramic type. Of these nine, only one was identified as Warrie Red; the other eight were identified as Punta Ycacos Unslipped. These two type-varieties will be discussed later on in this section.
<table>
<thead>
<tr>
<th>Artifact Number</th>
<th>Material</th>
<th>Form</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>31/178-1-1/1-1</td>
<td>Pottery</td>
<td>Incense burner</td>
<td>Punta Ycacos Unslipped</td>
</tr>
<tr>
<td>31/178-1-1/1-3</td>
<td>Pottery</td>
<td>Clay cylinder vessel support</td>
<td>*</td>
</tr>
<tr>
<td>31/178-1-1/1-6</td>
<td>Pottery</td>
<td>Vertical wall basin of jar with rim</td>
<td>Punta Ycacos Unslipped</td>
</tr>
<tr>
<td>31/178-1-1/1-8</td>
<td>Pottery</td>
<td>Vertical wall basin of jar with rim</td>
<td>Punta Ycacos Unslipped</td>
</tr>
<tr>
<td>31/178-1-1/1-12</td>
<td>Pottery</td>
<td>Jar rim</td>
<td>*</td>
</tr>
<tr>
<td>31/178-1-1/1-14</td>
<td>Pottery</td>
<td>Vertical wall basin of jar with rim</td>
<td>Punta Ycacos Unslipped</td>
</tr>
<tr>
<td>31/178-1-1/1-18</td>
<td>Pottery</td>
<td>Vertical wall basin of jar with rim</td>
<td>Punta Ycacos Unslipped</td>
</tr>
<tr>
<td>31/178-1-1/1-61</td>
<td>Celt</td>
<td>Tool</td>
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<td>Pumice</td>
<td>Possible fishing weight</td>
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</tr>
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<td>31/178-1-1/6-2</td>
<td>Ground stone</td>
<td>Metate</td>
<td>*</td>
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<td>Pottery</td>
<td>Jar rim</td>
<td>Warrie Red</td>
</tr>
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<td>Jar rim</td>
<td>*</td>
</tr>
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<td>Pottery</td>
<td>Jar rim</td>
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</tr>
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<td>Candelero</td>
<td>Punta Ycacos Unslipped</td>
</tr>
<tr>
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<td>Incense burner</td>
<td>Punta Ycacos Unslipped</td>
</tr>
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<tr>
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<td>Jar rim</td>
<td>*</td>
</tr>
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<td>Perforated spindle whorl</td>
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<tr>
<td>31/178-1-2/1-69</td>
<td>Pottery</td>
<td>Possible jar handle</td>
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<tr>
<td>31/178-1-2/2-1</td>
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<td>Tool</td>
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</tr>
<tr>
<td>31/178-1-2/2-2</td>
<td>Chert</td>
<td>Tool</td>
<td>*</td>
</tr>
<tr>
<td>31/178-1-2/10-1</td>
<td>Ground stone</td>
<td>mano</td>
<td>*</td>
</tr>
<tr>
<td>Temporary #1</td>
<td>Pottery</td>
<td>Candelero</td>
<td>Punta Ycacos Unslipped</td>
</tr>
<tr>
<td>Temporary #3</td>
<td>Pottery</td>
<td>Bowl</td>
<td>*</td>
</tr>
<tr>
<td>Temporary #4</td>
<td>Other stone</td>
<td>Mano</td>
<td>*</td>
</tr>
</tbody>
</table>
**Pottery**

To break the artifacts further down into groups, the table below lists those artifacts that possessed pottery material. This table grouped artifacts by form as opposed to artifact number, in order to provide a better visual display of the data for the various pottery forms. The pottery forms encompassed nine different models: incense burner, candelero (though these two possess the same function, their sizes and shapes are vastly different), vertical wall basin of jar with rim, bowl, un/perforated spindle whorl, clay cylinder vessel support, and a possible jar handle.

Table 5.2 Pottery Form and Type

<table>
<thead>
<tr>
<th>Artifact Number</th>
<th>Form</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>31/178-1-1/1-1</td>
<td>Incense burner</td>
<td>Punta Ycacos Unslipped</td>
</tr>
<tr>
<td>31/178-1-1/1-6</td>
<td>Vertical wall basin of jar with rim</td>
<td>Punta Ycacos Unslipped</td>
</tr>
<tr>
<td>31/178-1-2/1-20</td>
<td>Incense burner</td>
<td>Punta Ycacos Unslipped</td>
</tr>
<tr>
<td>31/178-1-2/1-6</td>
<td>candelero</td>
<td>Punta Ycacos Unslipped</td>
</tr>
<tr>
<td>Temporary #1</td>
<td>candelero</td>
<td>Punta Ycacos Unslipped</td>
</tr>
<tr>
<td>31/178-1-1/1-6</td>
<td>Vertical wall basin of jar with rim</td>
<td>Punta Ycacos Unslipped</td>
</tr>
<tr>
<td>31/178-1-1/1-8</td>
<td>Vertical wall basin of jar with rim</td>
<td>Punta Ycacos Unslipped</td>
</tr>
<tr>
<td>31/178-1-1/1-14</td>
<td>Vertical wall basin of jar with rim</td>
<td>Punta Ycacos Unslipped</td>
</tr>
<tr>
<td>31/178-1-1/1-18</td>
<td>Vertical wall basin of jar with rim</td>
<td>Punta Ycacos Unslipped</td>
</tr>
<tr>
<td>31/178-1-2/1-1</td>
<td>Jar rim</td>
<td>Warrie Red</td>
</tr>
<tr>
<td>31/178-1-2/1-48</td>
<td>Jar rim</td>
<td>*</td>
</tr>
<tr>
<td>31/178-1-2/1-2</td>
<td>Jar rim</td>
<td>*</td>
</tr>
<tr>
<td>31/78-1-2/1-4</td>
<td>Jar rim</td>
<td>*</td>
</tr>
<tr>
<td>31/178-1-1/1-12</td>
<td>Jar rim</td>
<td>*</td>
</tr>
<tr>
<td>Temporary #3</td>
<td>Bowl</td>
<td>*</td>
</tr>
<tr>
<td>31/178-1-2/1-29</td>
<td>Unperforated spindle whorl</td>
<td>*</td>
</tr>
<tr>
<td>31/178-1-2/1-54</td>
<td>Perforated spindle whorl</td>
<td>*</td>
</tr>
<tr>
<td>31/178-1-1/1-3</td>
<td>Clay cylinder vessel support</td>
<td>*</td>
</tr>
</tbody>
</table>
Table 5.2 Pottery Form and Type (Continued)

<table>
<thead>
<tr>
<th>Artifact Number</th>
<th>Form</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>31/178-1-2/1-69</td>
<td>Possible jar handle</td>
<td>*</td>
</tr>
</tbody>
</table>

Since the type-variety system only applies to ceramics, only the 18 pieces of pottery in my selection were eligible for this kind of analysis, and only half of these pieces had enough surface preservation to be assigned a specific type. Punta Ycacos Unslipped made up the overwhelming majority of this pottery with eight pieces, while the Warrie Red type only made up one piece. The specifics of these two ceramic types are discussed below.

Punta Ycacos Unslipped was first established as a ceramic type during excavations and studies performed in the Port Honduras region (McKillop 2002). Its defining characteristics are an “unslipped surface”, a “coarse paste with sand temper showing throughout the surface”; for jars of this type they have “out-curved necks and direct or exterior folded rims”, and bowls have “out-curved sides with direct rim” (McKillop 2002: 55-6). This type-variety included many artifacts associated with the process of salt production, and was found at sites specifically geared towards salt-making as well as sites that most likely made salt on a “sporadic, household basis” (McKillop 2002:72).

The other type-variety identified from my selection of artifacts was Warrie Red. McKillop (2002) first established Warrie Red as a ceramic type during the same excavations and studies mentioned before in Port Honduras. McKillop (2002:77) gives four identifying characteristics of Warrie Red:

1. red slip, often weathered or discolored gray or black
2. jar with neck and out-curving to out-flaring rim and direct lip, or bowl or dish with out-curving to out-flaring sides and basal break or ridge
3. medium to fine paste without notable visible inclusions, except on eroded sherds
4. on some vessels, unit-stamped or other impressed or incised decorations on the shoulder of jars or exterior incised decoration on some bowls

Like Punta Ycacos Unslipped, artifacts of the Warrie Red type-variety are also believed to have been associated with salt production. Warrie Red jars may have been used to store brine, and they also may have been used in certain salt rituals (McKillop 2002).

**Lithics**

The remaining seven artifacts are all comprised of a stone material. There are three tools: two of them are made of chert, and one is made of celt. Artifact 31/178-1-2/2-1 is a large stem blade, while 31/178-1-2/2-2 is a much small chert flake that was mostly likely part of a large stem blade but broke and was repurposed. Artifact 31/178-1-1/6-1 is a very small, cylindrical tool made of celt. There are also two manos, which are cylindrical tools used in food production. 31/178-1-2/10-1 has been broken in half vertically down the middle, giving it one flat side and one curved side, and is made of an unidentified stone. Temporary #4, on the other hand, is a fully cylindrical mono, though it is broken off horizontally in the middle, but also made of an unidentified stone. The metate is similarly used as a stone tool, but serves as a surface for grinding. Artifact 31/178-1-6/1-1 is a small pumice stone, whose size and shape may suggest that it was used as a weight to hold down fishing nets.

<table>
<thead>
<tr>
<th>Artifact Number</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>31/178-1-1/1-61</td>
<td>tool</td>
</tr>
<tr>
<td>31/178-1-2/2-1</td>
<td>tool</td>
</tr>
<tr>
<td>31/178-1-2/2-2</td>
<td>tool</td>
</tr>
<tr>
<td>31/178-1-2/10-1</td>
<td>mano</td>
</tr>
<tr>
<td>Artifact Number</td>
<td>Form</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>Temporary #4</td>
<td>mano</td>
</tr>
<tr>
<td>31/178-1-1/6-2</td>
<td>metate</td>
</tr>
<tr>
<td>31/178-1-1/6-1</td>
<td>Possible fishing weight</td>
</tr>
</tbody>
</table>
Discussion

Site Discussion

The artifacts from this selection suggest that Pork and Doughboy Point was a small village site. Previous excavations have also reached the same conclusion (Hammond 1975; Brandehoff-Pracht 1995; Pemberton 2005). Based off of ceramic analysis, Hammond (1975) and Brandehoff-Pracht (1995) both date the occupation of the site to be from the Late Classic to Terminal Classic periods (A.D. 600-900). Furthermore, a radiocarbon date from wood charcoal found at the site places Pork and Doughboy from A.D. 665-885 (McKillop 2002).

The diversity in pottery form and function suggest that a range of activities occurred at Pork and Doughboy Point, most of them being of the settled and domestic variety. The rim sherd pieces (Figures 6.1 and 6.2) and the vertical wall basins (Figure 6.3) are from jars, which could be used for storing liquids or food, or used for cooking or boiling (Rice 1987). Most vessels, however, could have a variety of functions, so one jar could have been used for multiple purposes (Rice 1987). The amount of jar rim sherds recovered imply intense, prolonged settled activity.

Figure 6.1. Artifacts 31/178-1-1/1-12, 31/178-1-2/1-1, and 31/178-1-2/1-48 (jar rim fragments)
Figure 6.2. 31/178-1-2/1-4 and 31/178-1-2/1-2 (jar rim fragments)

Figure 6.3. Artifacts 31/178-1-1/1-18, 31/178-1-1/1-18, 31/178-1-1/1-14, and 31/178-1-1/1-6 (vertical wall basins with rims)

The bowl sherd (Figure 6.4) is likely from a serving bowl (based on McKillop 2002 findings), which is another domestic-based activity. Pottery vessels used for eating and serving are widest at their rims, as a large opening makes it easier to access the inner contents of the
vessel (Rice 1987). The outward-flaring orientation of Temporary #3 suggests that its diameter would be greatest at its rim, meaning it would have been a likely candidate for a serving bowl.

![Artifacts](image)

Figure 6.4. Artifact Temporary #3 (bowl fragment)

Artifact 31/178-1-2/1-69 (Fig. 6.5) is incredibly eroded by sand, saltwater, and just time in general, so its exact function cannot confidentially be guessed. Analysis of the shape of it suggests that it may have been part of a jar handle, attached to a jar used for pouring purposes.

![Artifact 31/178-1-2/1-69](image)

Figure 6.5. Artifact 31/178-1-2/1-69
The metate and manos (Figures 6.6 and Fig. 6.7) found are used in the production of food. Corn is grinded on to the surface of the metate by rolling the handheld cylindrical mano (McKillop 2004). Artifact 31/178-1-1/6-2, the metate, is slightly concave and curling up at its three corners. The manos, artifacts 31/178-1-2/10-1 and Temporary #4, would have been rolled back and forth on their sides to grind the corn into the center of the metate. This points to sustainable food production at Pork and Doughboy, where a staple food in the Mayan diet was created and consumed.

Figure 6.6. Artifacts 31/178-1-2/10-1 and Temporary #4 (manos)

Figure 6.7. Artifact 31/178-1-1/6-2 (metate)
The small pumice stone (Figure 6.8) may have possibly been used as a weight for fishing nets, which was a common usage for notched stones and potsherds (McKillop 1984). The pumice stone in my collection is not as notched as most of the artifacts used for this purpose are, so this is only a possible interpretation, not a definitive one. This interpretation does suggest that exploitation of marine life occurred at Pork and Doughboy, which further supports the argument that this was a village site.

Figure 6.8. Artifact 31/178-1-1/6-1 (pumice stone, possible fishing weight)

Other artifacts in my selection point to daily village activities outside of food-based ones. Two large incense burner fragments (Figure 4.9) were found, as well one miniature rounded candelero and one rounded candelero with three openings (Figure 4.10). Incense burners and candeleros are linked to ritual and ceremonial activities (McKillop 2002). Their presence suggests that a variety of activities took place, as Maya performed rituals on both a daily and ceremonial basis (McKillop 2002).
A perforated spindle whorl (Figure 6.11) was included in my selection, which is a small circular disk with a smaller circular hole in the middle. Spindle whorls were used in the production of cloth, which would then be used as a household material. An unperforated spindle
whorl (Figure 6.11) was also included, most likely meaning that this disc had been thrown away or repurposed when it was discovered to be inadequate for cloth making.

![Image of artifacts](image)

Figure 6.11. Artifacts 31/178-1-2/1-54 (perforated spindle whorl) and 31/178-1-2/1-29 (unperforated spindle whorl)

My collection also contained stone tools, which further points to Pork and Doughboy Point being the site of a small village with a variety of activities. One lithic is a large complete stem blade (Figure 6.12), and there is another smaller chert tool (Figure 6.12), its size and shape suggesting that it once belonged to a larger lithic tool, but was broken off and repurposed.
These are stone working materials, which mean inhabitants were likely producing some of their own lithic tools as opposed to relying wholly on an outside source (Brandehoff-Pracht 1995). There is also a small piece of ground stone celt (Figure 6.13) in a cylindrical shape that originally belonged to a larger tool, which is another tool used in stone- and tool-making.

There is also one item in my selection that has a unique intrasite reference. The small clay cylinder (Figure 6.14) found at Pork and Doughboy Point is similar to the vessel support
fragments found at other salt-making sites in Port Honduras, such as Punta Ycacos Lagoon (McKillop 2002).

These support vessels were used to hold up brine-boiling jars over fires (McKillop 2002; see figure 3.1). Salt was an important resource to communities on the coast of Belize, and some sites were solely dedicated to the production of salt, such as Punta Ycacos Lagoon (McKillop 1995; McKillop 2002). It is quite possible that salt making occurred at Pork and Doughboy Point, but the scale of production was not specialized and instead occurred on a “sporadic, household basis” (McKillop 2002:72), as some of the Punta Ycacos jar fragments may have also been used in small-scale salt production.

**Petrographic Analysis**

In archaeology, petrographic analysis is conducted to examine mineralogical composition of a ceramic artifact. This is done by taking a thin section of the artifact and mounting it “on a glass microscope slide”, where it is then viewed in polarized light so that “distinguishing optical
properties can be observed” (Josephs 2005:111; Kerr 1997; Phillips 1971). The origin of the material used to make the artifact can then be traced, which greatly aids in the research of tracking trade routes and systems of exchange.

I received a Tiger Athletic Fund (TAF) Honors Thesis Research Scholarship in the Fall of 2017, which allowed me the funds to send two thin sections of ceramic materials to Dr. Linda Howe at HD Analytical Solutions. Dr. Howe will be performing petrographic analysis on these two thin sections so that material provenance can be determined and exchange routes can be analyzed. Pork and Doughboy’s role in coastal Maya trade may be greater than previously thought, depending on the results of the analysis. At the present time, the results are still in progress and therefore cannot be discussed. This section will be expanded once the sections have been fully analyzed.

Site Summary

The analysis of pottery and lithic artifacts from my collection support the theory of Pork and Doughboy Point being a village site. The variety of artifact forms and functions point to the varied activities that would be common in the everyday life of a small community of people. The jar fragments show that there was store of food and liquid, an indicator of subsistence, and the bowl fragment is also a sign that regular food-based activities occurred at the site. The metate and manos are definitive evidence of food production at Pork and Doughboy Point, and the clay cylinder vessel support is another possible piece of evidence for long-term food subsistence at this site. Candeleros and incense burner fragments are indicative of regular, repeated ritualistic behavior, and the presence of spindle whorls mean that household materials such as cloth were being produced. The two chert tools and the piece of ground stone celt are possible signs that
stone tool production took place at the site, which means the inhabitants of Pork and Doughboy Point were not solely dependent on outside sources for common, everyday items and had the capabilities of producing their own.

These are all utilitarian items, meaning items that are used in basic common household functions. The Maya household is considered to be the foundational unit of production in their society, and these utilitarian items are manufactured in the home (McKillop 2004). There is some debate, however, over whether all households created their own tools, or if only certain household were responsible for this craft (McKillop 2004). Household workshops did exist, meaning only some areas of a community would be engaged in tool production.

The site of Colha in northern Belize is an interesting example, as chert-based tools produced at this site were used both in Colha and in other northern Belize communities; these outside communities, however, also used tools crafted from their local chert sources (McKillop 2004). This means that subsistence-related tools could come from any number of sources, and did not necessarily have to come from resources in close proximity to the site.

That being said, based on my findings and the previous findings of others (Hammond 1975; Brandehoff-Pracht 1995; Pemberton 2005), Pork and Doughboy Point was a village site that supported a wide range of basic, everyday activities.

**Scanning Results**

I was able to successfully scan a total of 25 different artifacts from Pork and Doughboy Point. One scanned artifact was left out of the final sample, and the scans of two artifacts had to be abandoned altogether. The quality of the 25 completed scans of the artifacts included in this project give them the potential to be displayed virtually online or be printed out with a 3D
printer. All of the scans accurately displayed each artifact’s surface topography and accurately captured the shapes and depths of each object. Instead of going through each individual scan and displaying comparison pictures of each artifact (as I would, inevitably, become unnecessarily repetitive), I have chosen four specific scans to discuss below. These four were chosen as they perfectly showcase what 3D imaging is capable of achieving. The scans in this section pertain to the NextEngine’s ability to accurately pick up minute surface-level details, transfer texture from physical artifact to 3D model, capture openings filled with materials, and highlight surface features that may have been looked-over on the original artifact.

Artifact 31/178-1-2/1-2 is actually four sherds glued together; the cracks where the four pieces meet are all still visible on the artifact. There is also a small hole on the lower left side of the artifact where the glued sherds left a gap. I wanted to capture these small details on my scan, so I set the scanning parameters to seven divisions for my 360° scan, and kept the point density at 29k in HD. I especially did not want the hole to be accidentally filled in, so I needed my alignments to be as close to perfect as possible. The final results of this scan were quite pleasing, as not only were the cracks and small gap picked up, but the texture of the model matched the artifact perfectly. Figure 6.15 shows artifact 31/178-1-2/1-2 in texture view on ScanStudio, with the red circle indicating the gap. The cracks are also visible in texture view, but they are even more pronounced in shaded and mesh views. Figure 6.16 shows the original artifact with a red circle pointing out the same gap present in the scan.
Artifact 31/178-1-2/1-2 is another example of scan texture appearing in high quality. Artifact 31/178-1-2/2-1 is made of chert, a material that has a slight shine to it. Shiny objects always have the potential to distort scans, as the reflection of the material interferes with the 3D
scanner’s lasers. This 3D model, however, was captured without any distortion or shine. The coloring of the artifact translated easily to the model, and the various color changes were picked up without any issues. The gray sections on the right side of the artifact did not blend in to the rest of the texture on the scan, and the various darker colorings were mapped to a high degree of accuracy. For a visual comparison of the scan and the original, figure 6.17 shows the 3D model in color view on ScanStudio on the left and the original artifact on the right.

Temporary #1 is a small candelero with three circular openings, and these openings posed an immediate challenge. Material inside of the candelero is also visible, so a good scan would have to capture the curvature of the openings as well as the inside contents. This required a series of bracket scans at various angles in addition to a great deal of experimentation in order to
achieve the best results. Bracket scans were chosen over single scans, as bracket scans include three divisions. The candelero had openings on the left and right side, and in the center, which matched trajectory the division scans would take. There was also the opportunity for more angles to be captured in a division scan as the AutoDrive rotates during it, whereas single scans only capture surfaces head on and do not cause the AutoDrive to rotate. My scans went smoothly until the fifth and final scan. There were many user-errors made during the final alignment step as it took three tries to properly align the scan families. Additionally, not all of the inside spaces were captured in my scans; the deep, inside edges of the openings were unable to be captured, despite the five different angles in which the candelero was placed. The fuse settings were set to ‘water-tight’, however, so any missing areas would be filled in by the software. The final result yielded a fully-filled inside that still showed most of the lumps, bumps, and curves that were present inside the candelero’s openings.

Figure 6.18. Temporary #1 in ScanStudio in Mesh view
The 3D model of artifact 31/178-1-2/1-48 is a good example of 3D scanning’s ability to highlight or reveal certain geometry on an artifact’s surface that would not have been as visible or pronounced if a 3D model had not been created. As a potsherd, artifact 31/178-1-2/1-48 was straightforward to scan. Though the overall shape was simple, this potsherd contained small pockmarks and grooves on its surface. Not all of these marks are equally prominent and noticeable, and some of these features would be practically indiscernible if the potsherd was behind a display glass or could only be shared in photographic form. Mesh and shaded views especially showcase the pockmarks and grooves, a fact which demonstrates 3D imaging’s ability to reveal specific features that would otherwise be unnoticeable if the object’s texture could not be stripped away. The examples of this can be seen in Figures 6.20 and 6.21.
Scanning Problems

Other problems arose while scanning apart from discoloration. A Single division scan was used during the scanning of artifact 31/178-1-1/1-1 that had to be deleted. The area being scanned was unusable; the surface morphology was unrecognizable, and it was much too
pixelated. Artifact 31/178-1-2/2-2 was first scanned on the ‘neutral’ setting, but that did not
match the artifact’s color well enough, so I immediately switched to ‘light’ to better capture it. I
began scanning artifact 31/178-1-2/1-1 on the macro range, as that was my standard. The scan
was slightly distorted, and the color was picking up too light. I tried the scan on ‘wide’, and this
change alleviated the problems. Some scans, such as Temporary #2, had to be abandoned
altogether, as repeated attempts to properly scan them on various settings all failed.

Complex artifacts, like a candelero, are much more likely to cause problems than simple
ones, such as a rim sherd. Artifact 31/178-1-2/1-6 (Figure 6.22) was one such artifact. It is a
simple candelero, but it has a deep, curved opening; the inside of the artifact, with its depth and
curves, had to be captured completely in order to create an accurate copy. My original two 360°
scans did not pick up much of the inside at all, so a series of single scans was initiated. Scan C
was the first single scan and picked up a fair amount of the inside, but Scan D did not capture a
lot of new points. I switched to using bracket scans to see if that would catch more of the inside,
but Scan E did not fare much better than the single scans, so I went back to using single divisions
in order to save time and data. The candelero was positioned in a variety of different angles in an
attempt to capture the missing data, and five more single scans were performed. After the fifth
scan, most of the inside had been filled out, but a pinkish-red discoloration was present, so I
completed one more scan to fix the texture. This scan did not improve the texture, so it was
deleted. Two more single scans were taken before I finally fused the scan families. After all this,
there was still a green discoloration on the inside of the artifact; it was otherwise fine, so it was
saved and marked for possible rescanning.
Webpage Display

One benefit that has been previously mentioned is the possibility of displaying and sharing 3D images online. One of my future goals after this project has been completed is to create a post on Dr. McKillop’s webpage, “Underwater Maya”, about what occurred at Pork and Doughboy Point and included additional information on the process of scanning the artifacts. The post will include 2D images of the scans and artifacts with accompanying text. A select number of 3D models will be uploaded online through SketchFab, and links to these models will be included in the webpage post. The post will be created with the intent to curate a virtual display of the artifacts included in this project. The purpose of a virtual display is to share cultural heritage information freely across the world, removing the barrier of access of strictly physical display would possess. A virtual display and the digitization of information would expand the potential audience reach and illustrate the usefulness and relevancy of 3D technology in archaeology.
3D Printing

The TAF Honors Thesis Research Scholarship also gave me the opportunity to reproduce a small number of my 3D scans using the DIVA Lab’s Dimension Elite 3D printer. The Dimension Elite printer uses a modeling material called ABS*plus, which is a production-grade thermoplastic. With this printer, a model is created from the “bottom up with precisely deposited layers of modeling and support material” (http://www.stratasys.com/~media/Main/Files/Machine_Spec_Sheets/PSS_FDM_DimElite.pdf?la=en). The printing cartridges I purchased were in the color ivory, so the models I print out will not have any color. The ivory-colored material does, however, serve as a great base for painting, meaning color can be added by hand to the model at a later date.

The purpose of 3D printing a small number of my scans will be to curate a physical display of select artifacts from Pork and Doughboy Point. My display will include the information discussed in previous sections to tell the story of what occurred at the site. The goal will be to educate viewers on the basic life of the Maya household, as well as to showcase the capabilities of 3D imaging and printing. At the present time, the 3D printing is still in progress, and I hope to complete it by the end of the semester, with a display in the hallway outside the DIVA lab.

Educational Outreach Potential

In September of 2015, I assisted the DIVA Lab at their booth at the Baton Rouge Maker Fair, where hundreds of people were in attendance. Our booth featured an interactive game involving 3D prints designed to engage the public. The game was comprised of five stem blades behind a Plexiglas box: four were 3D prints and one was the original artifact. The objective was
for the visitor to guess which stem blade was the original artifact and not a copy. All four prints were made using ivory cartridges, but three of them were painted to resemble the original stem blade. This game garnered quite a bit of attention from visitors, especially children and pre-teens, as it allowed them a more direct, interactive way to learn about archaeology and 3D technology. Visitors were occasionally allowed to touch and hold the different stem blades to feel the differences in texture and weight, which provided these visitors with a hands-on experience with ancient Maya artifacts.

This game showcased 3D printing’s ability to produce exact replicas of original artifacts, as well as the variety of prints that can be produced. Visitors were by far more impressed with the painted prints than the plain ivory print, as the painted prints captured the color of the original stem blade and gave the appearance of a similar texture to the original. While the ivory print may have lacked color, it still possessed the same physical features as the other, more colorful prints, including all the dips, curves, and grooves present in the original stem blade. Many visitors had trouble correctly choosing the original artifact based on looks alone, but once they were allowed to feel them the visitors were able to accurately discern the replicas from the original.

This small display has larger implications for the use of 3D technology in archaeological outreach programs. Creating 3D prints of artifacts facilitates a more direct, hands-on approach to learning. It significantly enhances public engagement with archaeological information as it removes artifacts from behind glass exhibits and places them in the hands of the audience. 3D prints allow the public to physically interact with exact replicas of artifacts, giving them an up-close look at the minute details they may have otherwise missed if the artifact was behind a display case. This interaction would obviously not be possible with original artifacts, due to the
extreme degradation that would take place from putting the artifacts in such a compromised situation. 3D prints expand the scope of public interactions with archaeological artifacts, and can redefine how the public can engage with historical materials.
Conclusion

3D technology continues to gain popularity in the various fields of anthropology, and not without good reason. 3D imaging and printing opens up a host of new avenues for museum work and researcher. It allows them an incredibly accurate way to digitize artifacts that can be shared virtually to people around the world, and it creates a near-perfect replica of an artifact. This digital 3D replica can be used for conservation purposes, including as a way to track deterioration and loss. 3D technology also allows them potentially cheaper display options, a crucial piece of information in a world where funding and budgets are continuously shrinking.

The future aims of this project include petrographic analysis, a virtual web display accompanied by digital 3D models, and a physical display with objects created through 3D printing. Once the results from the petrographic analysis come in, I will be able to identify and trace trade routes if the materials are revealed to be from a foreign site, which could have potential larger implications for Pork and Doughboy’s role in coastal trade. Additionally, the creation of both a virtual and physical display will expose this research to a wider audience, as well as showcasing the advantages 3D technology can have in the field of archaeology and anthropology.

Ultimately, the goal of this project was to highlight how 3D scanning can reconstruct the past, using Pork and Doughboy Point as a case study, and how it can aid in the curation of displays in a variety of mediums. My goal was also to demonstrate the advantages and disadvantages 3D technology can have regarding anthropological research and regarding museum collections and curation. 3D scanning and printing are not meant to replace traditional methods of research and collections management, but are meant t instead enhance the methods that already exist.
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