*Human Rights*
*continued from page 11*

an imagined community of rights work across otherwise disconnected social realities. The localization of rights work in these cases necessitates relinquishing of purity in condemnation for the messy compromise of engagement. The result can be a kind of moral syncretism in which fears that lead to witchcraft accusations and incapacity assessment are accepted without accepting the camps or full guardianship as the best or sole solution. Rights are then not something to demand as much as to negotiate within limitations and opportunities of local realities.

***Alexandra Crampton** is an assistant professor in the department of social and cultural sciences at Marquette University. Her research interests are in social intervention work in the US and Ghana. Current research focuses on mediation as intervention for parents in dispute over children in a large, urban US family court.* AN

**Published March 7, 2013 on anthropology-news.org**

TOOLS AND TECHNOLOGY

# Sustainable Archaeological Tourism of the Underwater Maya Project by 3D Technology

Heather McKillop
Louisiana State U

E Cory Sills
Louisiana State U

What if archaeologists could make exact replicas of artifacts, make them bigger or smaller, and make whole vessels from potsherds? We can do this and more, with 3D imaging and 3D printing. But why should we bother, when we have the actual artifacts? Unless you are a museum curator studying material in the collections, most archaeologists are temporary custodians of artifacts to be curated elsewhere after initial study is completed. Archaeologists can keep 3D digital images of artifacts for further study, even enlarging the digital artifact for closer examination. We can share the image with colleagues, students, or even make digital museums, or incorporate the 3D digital artifacts into a GIS. For that "gee-whiz" impact, we printed 3D replicas of artifacts for showing colleagues at conferences, granting agencies, and visitors to our lab, the LSU Digital Imaging and Visualization in Archaeology (DIVA) lab.

Most of our imaging focuses on making accurate 3D images of fragile waterlogged artifacts from the Underwater Maya research project, where we have wooden buildings preserved in a peat bog below the seafloor.

Where we have made a big impact is creating exhibits using 3D replicas of artifacts from our 3D printer. In 2012 we opened two permanent exhibits in Belize with 3D artifact replicas. This makes archaeology tangibly accessible to the public, especially in areas without widespread access to the Internet or museums. While a picture of an artifact may be worth a thousand words, a 3D replica is priceless. We discuss the equipment and software we use in the LSU DIVA lab and our current and future exhibits featuring 3D replicas from the Underwater Maya project, including the only ancient Maya wooden canoe paddle.

## Underwater Maya Project

The 2004 discovery of ancient Maya wooden buildings and the only known ancient Maya wooden canoe paddle, preserved in a peat bog below the seafloor in a shallow coastal lagoon, led to the development of the ongoing Underwater Maya project. Discovery and mapping of some 4,000 wooden posts defining the outlines of buildings at 105 underwater sites was carried out between 2005 and 2009. The sites were salt works, where brine was evaporated in pots over fires inside buildings—to help meet the inland Maya demand for salt. The salt works were submerged by sea-level rise and protected by peat developed from red mangroves that kept pace with sea-level rise. Excavations of selected underwater salt works, ongoing since 2010, have yielded enormous quantities of salt-water saturated wood and pottery that deteriorate on exposure to air, underscoring our research interests in 3D imaging of perishable materials. All material recovered on survey or from excavations is placed in plastic bags full of fresh water to maintain the integrity of the artifacts. Selected artifacts, notably the K'ak' Naab' wooden canoe paddle, were exported for conservation in the US, under temporary export permit from the Belize government Institute of Archaeology. Excavations of the salt works produce large quantities of briquetage (salt-making artifacts), which we study at our Lagoon Lab, set up with plastic tables under a tent in shallow water near the excavations. Selected material is taken for 3D scanning at our base camp or for temporary export for specialist analyses or conservation.

## Digital Imaging and Visualization in Archaeology Lab

The Digital Imaging and Visualization in Archaeology (DIVA) Lab was established with funding from the Louisiana Board of Regents (BoR) in 2009 and has expanded to include various imaging, educational, outreach, and exhibit projects. Equipment purchased with the BoR grant includes three NextEngine 3D portable scanners operated using laptops with "hot video" cards and a lot of RAM; a Kreon hand-held 3D scanner attached to a Microscribe arm and operated from a workstation in the DIVA lab; a microscope for imaging thin-sections; and a Dimension Elite 3D printer. In addition to the HD Pro ScanStudio and Scantools software specific to the 3D scanners, other software for manipulating 3D images includes Avizo, Rhinoceros, SolidWorks, and Rapidform. All 3D scanners are used in the DIVA lab, but we also take a NextEngine scanner to Belize to image fragile and salt-waterlogged artifacts and wooden posts, which allows us to preserve the artifacts by returning them to protective underwater locations (which we mark by GPS) to study in successive years. Curating the salt-waterlogged artifacts in the sea allows us to select a small quantity of material for conservation in the US under temporary export permits from the Belize Institute of Archaeology. The 3D printer weighs 300 lbs, so all printing is carried out in the DIVA lab at LSU, using the printer software to set up the specifications of the replica


**Artifact replicas from 3D images printed in the 3D printer in the LSU Digital Imaging and Visualization in Archaeology (DIVA) lab, as well as the original artifact.** Photo courtesy H McKillop from an STL file, created in the lab, downloaded from a FTP site, or stored on a portable hard drive.

### Tips for 3D Imaging and 3D Printing

Having imaged over 400 artifacts and printed over 600 plastic replicas, we have discovered there are several important criteria for imaging and printing of archaeological material: We aim for high-accuracy in 3D scanning, since our images will be a permanent digital record of the objects for archival and research purposes. Although you can clean up a 3D scan in "post-processing," the image accuracy is better if you begin with a good scan. This goal results in large image files, typically over 700 MB for a stone tool, for example. We use Avizo software to reduce the image file size to print exact replicas on the 3D printer, which has a maximum file size of about 250 MB. We also reduce the file size for sharing digital images, including attaching to the Underwater Maya GIS. To image artifacts, especially large or detailed objects, and manipulate the images, we need computers with good processors (such as I-7, over 2.5 MHZ), hot-video cards with dedicated video memory (1GB or more), and lots of RAM (at least 12 GB, but more is better). In the field in Belize, we scan artifacts but post-process the images (removing extraneous data, joining images to create the object) and manipulate images using other software in the LSU DIVA lab. Limiting field imaging to basic scanning maximizes our use of time in the field since all of our electricity is from a small generator.

When we print 3D images, we set up the orientation, size, and density of the plastic replica and the support on the computer screen. The replica is created from cartridges of ABS+ plastic in long strands that are heated in the printer and extruded as fine filaments of plastic. The replica is built, first by the support material, and then the model material, so the orientation of the object is important: If a stone point is oriented vertically the replica will be more accurate along the side edges than if the object is oriented sideways. In order to keep track of scanned artifacts and the 3D prints—including the amount of plastic used, time to print, and techniques—we maintain detailed spreadsheet records.


**Opening of permanent exhibit in the Tourism Information Building in Punta Gorda, Belize featuring 3D replicas of artifacts and wooden posts from the Underwater Maya project.** Time release photo courtesy H McKillop

**LSU student Roberto Rosado using the Kreon Scanner to make a 3D image of the K'ak' Naab' canoe paddle.** Photo courtesy H McKillop

### Collaboration in 3D Imaging

Collaboration with other labs at LSU, as well as the private sector, broadens our access to expensive, high-tech equipment and expertise. In the DIVA lab we focus on 3D scanning and printing which is time-consuming and requires expertise, especially for post-processing and manipulating of images. Both in terms of the costs of equipment and the requisite expertise, we have found valuable collaborations with others: The K'ak' Naab' canoe paddle was conserved by C Wayne Smith at Texas A&M. James Ruz carried out a CT scan of the canoe paddle in the radiology department at Woman's Hospital in Baton Rouge which we manipulated using Avizo software and collaboration with the LSU Visualization Technology Center. Miguel Ocana from Nikon Metrology imaged skeletal material with a micro-CT scanner, providing a better exterior surface than we were able to do with our 3D equipment, as well as imaging the interior of the bone and teeth. In order to make 3D replicas of large objects beyond the printing capabilities of our 3D printer (20 x 20 x 30 cm), we turned to CNC technology, which is a subtractive process of cutting objects from a block of solid material using XYZ coordinates from our 3D scan "STL" files: The K'ak' Naab' canoe paddle, which measures 1.43 m in length, is being milled in wood in the LSU Mechanical Engineering lab using CNC technology.

### Beyond 3D Imaging: Printing Replicas for Exhibits

The potential for sharing the past using displays of 3D artifact replicas is tremendous for schools, communities lacking museums or widespread access to the Internet for "digital museums," and for engaging people with archaeological sites. To further communicate to the public, we digitally reconstruct complete vessels from pottery rim sherds, and print the complete vessels for exhibits: Only archaeologists can visualize in our minds a rim sherd as a complete vessel!

In March 2012, with funding from a "Site Preservation Grant" from the Archaeological Institute of America, we opened two permanent exhibits, including one in Punta Gorda and another in remote Paynes Creek National Park, accessible only by boat. The exhibits include plastic replicas and text inside wooden display cases, accompanied by laminated posters. The artifact replicas were printed using a 3D printer, from 3D scans of artifacts made both in our remote jungle camp in Belize and in the LSU DIVA Lab. Exhibits using 3D replicas of artifacts integrate the Underwater Maya Archaeology project with local tourism in southern Belize and inform descendant Maya communities about their heritage, thereby helping to protect the ancient sites by "sustainable archaeological tourism." Our success of creating displays with 3D replicas underscores the potential for exhibiting 3D replicas that do not require loans of actual artifacts, or security for actual artifacts.

Our next exhibit, also funded by the AIA grant, features a replica of the ancient Maya wooden canoe paddle from the K'ak'Naab' underwater Maya site. Even though the paddle was conserved, it continues to deteriorate from cracks it received in antiquity, so our 3D digital image will be the enduring record of this scientifically valuable artifact. While the original paddle will be returned to the Belize Institute of Archaeology, a full-sized replica in wood will be available in a public exhibit in Belize.

***Heather McKillop*** *(Louisiana State U) has ongoing research on the ancient coastal and underwater Maya in southern Belize. Her books include* In Search of Maya Sea Traders *and* Salt: White Gold of the Ancient Maya. *She received grants for the Underwater Maya project from LSU, Foundation for the Advancement of Mesoamerican Studies, National Geographic Society, and the National Science Foundation.*

***E Cory Sills*** *is a PhD candidate in anthropology at Louisiana State University. Her MA thesis was on mapping wooden architecture at one of the underwater sites. NSF awarded her a dissertation grant to support her work on underwater excavations. She is manager of the LSU DIVA lab.* AN

**Published February 6, 2013 on anthropology-news.org**