Tlingit-Smithsonian Collaborations with 3D Digitization of Cultural Objects*

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Abstract: The Smithsonian Institution and the Tlingit community of southeast Alaska have collaborated on several initiatives to 3D digitize important cultural objects for preservation and educational purposes. For some projects, the Smithsonian created 3D replicas of objects repatriated by the National Museum of Natural History to the Tlingit community as sacred objects, objects of cultural patrimony and funerary objects. The Tlingit and Smithsonian recognize that 3D digitization provides a form of security against the loss of cultural objects and allows for reproduction and restoration in various forms. The production of physical replicas also creates the opportunity to further educational goals while the original objects remain in use for ceremony or in seclusion as restricted items. The collaborations between the Smithsonian and the Tlingit illustrate the potential for responsible applications of digital technology to transform museum-indigenous relations in a wide range of areas.

[Keywords: *Repatriation*, *Scanning (digitization)*, Tlingit, Smithsonian Institution. Keywords in italics are derived from the American Folklore Society Ethnographic Thesaurus, a standard nomenclature for the ethnographic disciplines.]

The Repatriation

On January 2, 2005, clan leaders from the Raven moiety placed a Killer Whale clan crest hat (*Kéet S'aax̲w*) on the head of the *Dakl'aweidí* (Killer Whale) clan leader or *Shaadeihani*, Mark Jacobs, Jr., in a highly emotional Tlingit ceremony held at a Sitka, Alaska, hospital (Figure 1). For the first time in more than 100 years the hat was worn in Tlingit ceremony. Beautifully carved from alder wood, the hat represents a killer whale emerging from the ocean (Figure 2). Red, black, and turquoise paint accentuate the important features of the whale, and inlaid abalone shells represent the eyes, teeth, and water cascading over the body. Hair attached to the dorsal fin symbolizes water falling from the fin.

Eric Hollinger, from the Smithsonian's National Museum of Natural History (NMNH) rushed the *Kéet S'aax̲w* to Sitka on New Year's Day 2005. Just hours before the ceremony, the NMNH repatriated the hat to its *Dakl'aweidí* relatives, presenting it to Jacobs as he lay in his hospital bed. The repatriation of the crest hat was a culmination of Mark Jacobs' long history of advocacy for cultural preservation and the rights of Native Alaskans. While the repatriation was a legal

transfer of property under Western law, the public transfer of the crest hat to Jacobs by his opposites, the Raven moiety clan leaders, in front of gathered witnesses legitimized it under Tlingit law and tradition (Figure 3). Jacobs 'walked into the forest' (passed away) eleven days later with the *Kéet S'aax̲w* and other *Dakl'aweidí* property at his side. A Killer Whale had come home.

The repatriation of the crest hat to the *Dakl'aweidí* clan began years earlier and was one of many returns completed by the NMNH over the last three decades. The NMNH voluntarily repatriated Native American human remains and sacred objects during the 1980s (Ousley et al. 2005:3). With passage of the National Museum of the American Indian (NMAI) Act in 1989 (NMAIA; 20 United States Code (U.S.C.) 80q et seq.), the repatriation process became a legal mandate for certain human remains and funerary objects in the Smithsonian's collections. Culturally affiliated tribes and Alaska Natives can request return of remains and objects that meet the definitions under the NMAI Act (Ousley et al. 2005). Congress extended the repatriation mandate to other federal agencies and museums receiving federal funds with the passage of the Native American Graves Protection and Repatriation Act (NAGPRA; 25 United States Code (U.S.C.) 3001-3013) in 1990. The NAGPRA expanded categories of items that can be requested by tribes (Echo-Hawk 2002) and integrated concepts, particularly the object of cultural patrimony concept, first adopted by the Smithsonian in its pre-legislation consultations with tribes (Merrill et al. 1993). An amendment to the NMAI Act in 1996 expanded the scope of the act and aligned it with the NAGPRA by adding certain sacred objects and objects of cultural patrimony to the items that can be claimed for repatriation by culturally affiliated tribes and Alaska Natives.

The Tlingit have successfully used both the NAGPRA and the NMAI Act to reclaim hundreds of cultural items from museums and federal agencies throughout the country. For most of the Tlingit, the focus has been on the recovery of clan crest objects, which meet the definition of sacred objects and/or objects of cultural patrimony. Clan crest objects have historical, cultural, and religious significance to the clans as they embody *Haa Shagóon*, clan ancestors, the present generation, and future generations. They are known as *at.óow,* 'an owned or purchased thing' (Dauenhauer and Dauenhauer 1987:25) and a high price was paid in past times by the clan for the rights to the crest.[1]

Today the Tlingit "kill money" on *at.óow*. To become *at.óow*, an object must be brought out formally as a crest object, and its unveiling must be witnessed by the opposite moiety (Fred 1969:7; Jonaitis 1986:68; Kan 1989:175). *At.óow* are owned communally by the clan and cared for by clan and house leaders, who wear them during ceremonies and potlatches and display them at memorials and funerals of clan leaders. As sacred objects the crest objects are needed to spiritually balance the crest objects of clans of the opposite moiety. Hats depicting the clan's crests, often spirit animals, are among the most important of the clan's property (Dauenhauer 1995; de Laguna 1972, 1990; Hollinger et al. 2005). The tangible property of the crest objects as well as the intangible property of the stories and songs associated with the crests depicted on the objects are fiercely defended by the Tlingit as the intellectual property of the clans. For the *Dakl'aweidí* clan, of the Wolf/Eagle moiety, their primary crest is the Killer Whale and it is depicted on their clan hats, daggers, tunics, and robes as well as the personal regalia of clan members.

Mark Jacobs Jr., inherited the role of *Shaadeihani* of the *Dakl'aweidí* clan after the previous clan leader died and with that role came responsibility for the care of his clan's *at.óow*. After the passage of the repatriation laws, he energetically pursued repatriation of clan items that had been lost to the clan over the previous century. He worked through the Kootznoowoo Cultural and Educational Foundation and the Central Council Tlingit and Haida Indian Tribes of Alaska (CCTHITA) to submit claims to museums from Juneau to New York City. Mark's son Harold first saw the Smithsonian's Killer Whale Hat illustrated (Figure 4) in a 1908 publication by Smithsonian ethnologist John Swanton (1908: Plate LVIII).[2] Intrigued by the photo, Mark and Harold visited the NMNH for a repatriation consultation, to see the hat in person, and to examine the museum's records relating to its acquisition. They learned that the hat had been made in 1900 for the *Dakl'aweidí* clan leader known by the name *Gusht'eiheen* (Spray Behind the Dorsal Fin) and it had been illegally sold to Swanton by one of the clan leader's sons. Harold believed that *Yéilnaawú*, brother-in-law of *Gusht'eiheen*, likely made the hat, and Harold told his father of this belief. *Yéilnaawú* was a well-known *Deisheetaan* clan (Raven moiety) artist who made a number of other clan crest hats, including a Killer Whale Hat already in Mark's care. Mark inherited the name *Gusht'eiheen* from his predecessor as well as his title as housemaster of the Killer Whale House of the Native Village of Angoon. The NMNH's research in response to the repatriation request confirmed the information about the origins of the hat (Hollinger et al. 2005) and recognized Mark Jacobs, Jr., as the appropriate caretaker for the hat.

While the repatriation request was in its last stages of review by the Smithsonian, Mark fell seriously ill and was hospitalized. When the NMNH learned of his condition, Director Cristián Samper expedited approvals of the recommendation to return the hat and sent Hollinger to Sitka to deliver the hat to Mark and his clan. Mark passed away only days after the repatriation, but the hat was securely in the hands of the *Dakl'aweidí* clan. At his funeral service an astonishing 31 crest hats were displayed, including the Killer Whale Hat from the Smithsonian. The memorial *koo.éex'* for Mark, held two and a half years later, was the ceremony at which the hat and the other clan property was transferred to the new caretaker. Edwell John, Jr., leader of the Killer Whale Chasing the Seal House of Angoon, was recognized as the new *Shaadeihani* of the *Dakl'aweidí* clan and he assumed the responsibility for the clan's *at.óow* (Figure 5) . The Killer Whale Hat was danced (Figure 6) and served as a dish for the "killing of the money" portion of the ceremony, a function of honor and importance. The hat was finally serving the role of a Tlingit ceremonial object as it was intended and it will remain there for generations to come.

Initiation of the Killer Whale Hat Project

Edwell John, Jr., a computer trainer for the State of Alaska, is familiar with emerging technology and recognizes the potential for cultural preservation that digital technology offers. John, Harold Jacobs, and Smithsonian staff recognized that the return of the Killer Whale Hat was a significant event for the *Dakl'aweidí* clan and the NMNH. Everyone agreed that the story of the return is a poignant demonstration of the importance of clan crest objects to the Tlingit and the unique opportunity repatriation offers for clans to strengthen their heritage by reclaiming clan property. Telling stories of repatriations in exhibits can be difficult since the objects are not usually available for viewing after they have been returned. Nationally, repatriated items are

often reburied, destroyed, or secluded, and video or other recordings may be restricted. There is often little that can physically aid in the telling of a repatriation-related story.

Jacobs and John have visited the NMNH on several occasions over the last 20 years for consultations and had seen some of the technological capabilities of the Smithsonian (Figure 7). After learning of the Smithsonian's increasing interest in expanding digital documentation of collections, they realized that laser and Ct scanning had the potential to serve as a tool for education and preservation. After consultations with the NMNH Repatriation Office, John, authorized the museum to laser scan the original *Kéet S'aax̲w* repatriated by the Smithsonian and to have a replica made for an exhibit that would educate the public about the importance of Tlingit crest objects and tell the story of the repatriation.

From the start, John wanted to be involved in the reproduction process and asked to be consulted on each stage to ensure that the 3D images and the completed replica are used in a responsible and culturally appropriate way. Because only clan members have the intellectual property rights to the clan's crest, the depiction of crest objects must be respectful to its cultural significance. In the past, images of crest objects have sometimes been misappropriated for commercial purposes. To protect the crest and the clan, he made certain that no images or films of the hat or the replication process appeared on the web without his approval and that no major steps were taken in the reproduction process without consultation. The replica did not have to be an exact copy of the original, such that they were indistinguishable; instead the copy should have some attributes that were unique since it was not intended to be an exact replacement. The original *Kéet S'aax̲w* has an accidental smear of red paint that appeared sometime during its time at the NMNH but John decided the smear should not be reproduced so the replica could depict the hat as it might have looked after it was first created by *Yéilnaawú*. John signed an agreement with the Smithsonian authorizing the NMNH to proceed with the project and stipulating that the hat was not to be displayed without being accompanied by labels making it clear that this was a replica of an important *Dakl̲'aweidí* clan crest object and was not true *at.óow* since no money would be killed on it and it would not be brought out formally as a crest object. It was important that any Tlingit who saw it realize that they were not viewing one of their true crest objects on exhibit, something they might consider inappropriate or offensive, but that it was a very good facsimile.

3D Digitization Technology

3D digitization technology is most commonly utilized in the movie industry and in architecture and design, but it is becoming more widely used in other fields as computing capabilities increase. Three types of 3D documentation were used for the projects described here: laser scanning, Computer Tomography (CT) scanning, and Photogrammetry/Computer Vision. Each of these techniques has unique advantages and limitations; and they are often used in combination to overcome the deficits of any one technique. In general, 3D documentation yields a series of xyz coordinates known as a point cloud. A 3D digital model will often consist of thousands, millions, or even billions of points that can be used to accurately depict or even replicate an object (Figure 8). Since a xyz point cloud is a simple text file, the data are more durable and archiving is simpler than other forms of digitization.

Laser scanning allows for extremely accurate and high-resolution measurement of an object's visible surfaces. Laser scanners are portable and can scan small objects such as insects or large objects such as ships, buildings, and even landscapes. CT scanning offers an ability to measure the density of objects inside and out. CT scanning yields a series of cross-sections that can be processed into a 3D digital model with interior geometry that would otherwise be obscured. For instance, the skeleton of a mummy can be digitally recorded with enough detail to facilitate facial reconstructions without ever unwrapping the mummy or even opening the sarcophagus in which it rests. Photogrammetry/Computer Vision is a method of reconstructing a series of images, often hundreds or thousands, of the same object or environment into a 3D digital model. This method yields excellent color information and is often used to add color to higher resolution 3D digital models. Photogrammetry offers the promise of democratization, which is particularly exciting given the low cost of hardware (digital camera).

3D documentation offers one of the most comprehensive records of an object in lieu of the object itself. Access to original objects is often difficult and sometimes impossible. A digital 3D surrogate can be used to pull precise measurements, volume calculations, cross section visualizations, and more. Post-processing of the digital data also allows the digital repair of objects where the original has damaged or missing sections. For instance, if a symmetrical object is missing a piece, like a plane missing a wing, the existing wing can be flipped in the computer to make the digital model of the plane whole again.

Point cloud models can be processed further to create photorealistic image and video renderings (Figure 9). Once an object is “digitized” it can be shared easily while also maintaining varying degrees of security. Although 3D digital surrogates can never replace an original object, they offer a number of interactive experiences, some of which would not be possible with the actual object. Imagine, for example, a rare and fragile object in secure climate controlled storage in the Smithsonian becoming accessible to school children in Indonesia via a web site that allows them to zoom in and rotate an object or even hold it in their hands through a virtual interface.

3D Reproductions

3D digital models can also be made physical again via an array of rapid manufacturing techniques. These techniques include the reductive process of CNC (Computer Numerical Control) carving or milling and the additive manufacturing process, also known as 3D printing, that can produce objects in a variety of sizes, resolutions and material types.

3D printing is a process of building up very fine layers of material inside a 3D printer. Digital files, whether captured by a laser scanner, CT scanner, photogrammetry, or other technologies, are divided into very thin layers of data. Similar to the way a printer lays down ink on a piece of paper, droplets of binder are applied to an unconsolidated medium according to the data in each layer. When all the layers are stacked via the 3D printer, a 3D replica is produced. There are many types of 3D printers that use a variety of output of materials, from a silica-based material, ABS, nylon, metal, to ceramic, and glass. 3D print replicas usually need to be hand painted to match the originals. Currently, only the ZCorp 650 printer is able to print in full color; the ZCorp

650 was used to produce some of the objects in the collaborative projects described here using a silica-based medium.

A CNC milling machine, CNC router, or a robotic arm produces replicas in the opposite manner. These machines, guided by digital files in the computer, begin with a block or sheet of material and cut the material away (Figure 10). Depending on the type of machine, materials such as foam, plastic, wood, or metal can be used as the raw material from which the replica will be carved.

With these replication technologies it is possible to reproduce objects at different scales. Very large objects or enlarged reproductions can be printed or carved in sections and joined together. Alternately, much smaller scale replicas can be produced with less expense and effort and increasing the portability of items. Another useful feature is the option to carve only a section of a digital file, perhaps to repair an original, or to print a cross section of an object with complex interior structure. For instance, a CT scan can be converted into a printed cut away of a fossil dinosaur skull showing the structure of the sinus cavities or the shape of the brain.

Delaware Replication Pilot

The first project in which the Smithsonian created a replica of a repatriation object for a tribe was an outgrowth of a collaboration between the NMNH, the Stockbridge-Munsee Tribe of Wisconsin, the Delaware Nation, and the Delaware Tribe of Oklahoma. In 2007, the three tribes requested repatriation of culturally affiliated human remains and funerary objects from the Minisink site, an important protohistoric and historic village of the Delaware-speaking people that was located along a trade route in northern New Jersey. While the NMNH assessed the claim, Sherry White, repatriation representative for the Stockbridge-Munsee Tribe visited the NMNH to receive training in identification of human remains from the NMNH Repatriation Office's Osteological Identification Laboratory and observed various research technologies, including CT-scanning, X-rays, and laser scanning, that were used in collections research and documentation. She also saw 3D prints of fossils made for exhibits by the Office of Exhibits Central and recognized the potential for such technology for cultural preservation. In 2008, the NMNH completed its assessment of the request and agreed to the repatriation (Hollinger et al. 2008). White envisioned the 3D replication project after her visit to the NMNH.

Prior to the repatriation, White contacted Hollinger and asked if the NMNH Repatriation Office could laser scan and 3D print a replica of a 17th century pewter pipe that had been found with a burial near the Minisink site. The pipe is beautifully cast with two owls perched on the pipe bowl. It is unique in Munsee material culture and illustrates the wealth and trade relations enjoyed by the people of Minisink. White felt that a replica of the pipe would allow her to teach others about early historic Munsee material culture and about the repatriation, but they would still be able to address the spiritual concerns associated with the original by ultimately reburying it. The Office of Exhibits Central completed a laser scan of the pipe and made a 3D print but due to time limitations, could not paint the print to resemble the original pipe. On September 16, 2009, the 3D printed replica was presented by the NMNH Repatriation Office to the tribes jointly during the repatriation of human remains and funerary objects, including the pewter pipe, from

the NMNH, NMAI, and the National Park Service. More than 40 representatives of the three tribes examined the printed replica and compared it to the original. Later, at the feast celebrating the repatriation, White told Hollinger that the representatives were very impressed with the replica and they wanted to loan the original pipe back to the museum to enable the OEC Model Shop to use it as a model in painting the copy. The tribes also wanted the Smithsonian to make additional copies so that all three tribes could have one (Figure 11). The replicas would enable each tribe to create displays in their communities to educate tribal members about their past material culture and the repatriation process. As requested, replicas were made for all three tribes as well as one for the museum to replace the original in the collections. The enthusiasm of these tribes for the replication of their objects demonstrated the potential for technology in education and cultural preservation; now some of the tribes are considering making replicas of Delaware objects that are not subject to the repatriation laws but that would be important educational items in the tribe's cultural centers. The collaboration with the Delaware/Munsee tribes and the resulting 3D printed replica was one of the projects that inspired Edwell John, Jr., to consider working with the Smithsonian on a Tlingit project. Hollinger told John the story of the collaboration and showed him the completed replica.

Execution of the Killer Whale Hat Project

In April of 2010, Edwell John, Jr., Harold Jacobs and Bob Sam traveled to the Smithsonian to consult on issues relating to exhibits, Tlingit spirituality, and repatriation. John brought the Killer Whale Hat back with him and allowed it to be laser scanned by the Office of Exhibits Central. Jacobs, John, and Sam observed and assisted with the scanning process and advised on the handling of the hat explaining details of its construction (Figure 12). Photogrammetry was also done on the hat as well as close up photography of details (Figure 13). The group saw how the data were collected in real time and appeared in digital form on the computer screen (Figure 14). Once the documentation was completed, the hat returned to Alaska with the delegation, having never left the control of the clan.

Jacobs observed that the technology could enable Tlingit clans to digitally archive their important crest objects in case of loss to fire or other disaster. During the visit, he told the story of the Tlingit Village of Hoonah, which had burned in 1944 (Dauenhauer and Dauenhauer 1990:88, 102, 371, 387, 392; Swann 2004:598) and from which only two crest hats had survived. He noted that if the technology had existed at that time, the lost objects could have been replaced using the digital data as a model for carvers or to guide computer assisted carving machines.

The Office of Exhibits Central (OEC) Model Shop then post-processed the digital data. This can be a time-consuming process, given that the laser does not always distinguish the different materials that it comes into contact with. For instance, the abalone shell inlays appeared to the laser the same as the surrounding wood, so if the shell and wood were flush at the surface the laser could not detect where one left off and the other began. Similarly, black paint on the hat might absorb more of the laser light than lighter colors and give the false appearance that there was relief on the surface where in fact there was none. If there were any gaps in the digital data, it was necessary to digitally fill them during the post-processing to make sure the digital rendition of the hat was as uniform and complete as it could be and was as true to the form and

details of the original as possible. With the permission of the clan, the NMNH Education Department filmed the entire replication process (Figure 15) so footage could be used along with the replica to help show how the project was accomplished. The final replica will be exhibited in the NMNH's new Education Center.

Once the digital data were ready, Jonathan Zastrow of the OEC Model Shop fed the information into a Haas CNC milling machine, which carved the hat out of a block of wood. Tlingit carver Steve Brown generously supplied a piece of seasoned alder of the appropriate size for the replica hat, so that the replica could be made from the same wood as the original. Zastrow and Danny Price, also of the OEC, had the privilege to briefly examine the original hat only once (Figure 16) when it was brought back to the Smithsonian in March of 2011 to be present at the repatriation of a headdress from the Virginia Museum of Fine Arts.[3]

The work of the mill is delicate; one slight miscalculation in the programming can result in the bit cutting too deep and seriously damaging the piece. Therefore, Zastrow utilized test pieces of maple and cherry woods before running the alder piece through the mill. This allowed opportunities for fine corrections to the milling without risking the final piece. Milling of the roughed-out piece progressed from using large bit tools to smaller and finer bits (Video 1). In November of 2011, during the milling sequence, Hollinger traveled to a Tlingit *k̲oo.éex'* in Angoon, Alaska, with Edwell John, Jr., and John had an opportunity to personally inspect one of the test pieces and advise the Smithsonian on the next steps of the reproduction process. After the main body of the hat was milled, the dorsal fin was made from a separate piece of wood plank.

Where the shell inlays had been on the original hat, it was necessary for the sockets to be hollowed out to receive shell pieces. Made from abalone shells that Edwell John, Jr., personally selected from Juneau shops, each of the new inlays had to be carefully cut and fitted by hand. Although four of the inlayed shell teeth of the original whale had been lost between the time of the repatriation and the time it was laser scanned, the replica hat was made with all the teeth in place. The replacement of the teeth restored it to the state it was in when it was repatriated from the museum.[4]

Some differences in the paints were necessary because the original vermillion red paint used on the Smithsonian hat contained mercury. Chewed salmon eggs were commonly used by the Tlingit to mix with materials to make the original paints. Lora Collins, Model Shop supervisor, used commercial paints instead, but color matching proved to be a challenge (Figure 17). Without the original hat in hand, it was difficult to accurately judge the color from photographs. The light greenish-blue color was the most difficult as it varied greatly across the hat and in some sections was so lightly applied that the color of the wood showed through, making it seem like a wash. Collins examined the other Tlingit objects in the NMNH's collection to get a sense of the colors and how they appeared on the woods of various objects. Hollinger and Collins were also permitted to examine a hat (NMAI #154319.000) among the collections of the NMAI (Figure 18) that Jacobs believed to be the work of *Yéilnaawú* in order to match the color of the greenish paint using color chip samples.

The hat also has leather straps and ties attaching the dorsal fin and hair plugs attached to the back of the dorsal fin representing water falling from the fin as it emerges from the sea. Records from the collector indicated that the hair was human (Swanton 1904). It was difficult to find a clan member who had the right color and length of hair and was also willing to donate it for the fin, but a non-native donor was found in Washington, DC. The hair had to be cut to length and affixed to the fin with an adhesive. A shop owner from the village of Hoonah supplied the deer hide for the leather straps and ties.

During the reproduction work with the original hat, Zastrow noticed that there were a series of small holes along the base of the back of the hat and one hole still has a small piece of string hanging from it. A comparison to the hat believed to have been made by *Yéilnaawú* at the NMAI showed the same series of holes. Strings through the holes attached a cloth, which had a series of white ermine skins hanging from it. Based on this comparison, we now believe that the original hat once had a trailer of ermine skins to drape the wearer's neck and represent the froth of the sea kicked up by the whale. The trailer of skins was not present on the original NMNH hat at the time it was collected; it is possible they were removed before the hat was sold to Swanton. However, since the hat probably originally had a trailer when it was first brought out, Edwell John, Jr., agreed that the replica should be made with a trailer. Ten beautiful white ermine skins were supplied by a vendor in Hoonah and attached by Collins to a cloth trailer modeled on the one attached to the hat in the collections in the NMAI (Figure 19). With that final piece, the physical replica of the Killer Whale Hat was complete and ready to be revealed to the Tlingit community for their consideration (Figure 20).[5]

The Hoonah Object Project

When the Killer Whale Hat reproduction was nearing completion, the Repatriation Office was in the process of responding to a separate repatriation request from the Tlingit village of Hoonah. The Hoonah Indian Association (HIA) asked for repatriation of 53 objects listed in museum records as coming from the graves of shamans in the Hoonah area. The objects were collected in 1884 by U.S. Navy Lt. T. Dix Bolles from at least two grave houses near Hoonah, Alaska (Hollinger 2012). The objects have a wide range of forms and include carved bone and ivory charms, wooden masks, wands, clubs, figurines, leather aprons and shirts, woven spruce root hats, and elaborately carved wooden rattles. The NMNH Repatriation Office described the Killer Whale Hat project and the Delaware pipe project to Robert Starbard, Tribal Administrator for the HIA, and asked if the HIA would be interested in exploring opportunities for the application of digital technology to HIA's interests. Starbard felt that it might be useful for educational and security purposes to have 3D replicas of many of the objects in the request, whether or not they were found to fit all of the legal criteria necessary to complete a repatriation. The objects are very fragile and as shamans objects they are considered to have spirits in them called *yéik*. Displaying original objects would put the objects at risk and potentially endanger any Tlingit coming into contact with the spirits. An accurate replica of such an object would allow the original to be safely stored away while the reproduction could be displayed without the same concerns for climate control or security. In theory, if the replica were damaged or destroyed another one could be produced by the same process but the original would remain safe.

The HIA authorized the NMNH Repatriation Office to proceed with digitizing and replicating a rattle as an example of what could be done so the village could consider whether to seek funding for a larger scale project with the rest of the objects. The NMNH Repatriation Office selected one of the more complex rattles for replication (NMNH E073856) and then CT-scanned the rattle using a medical scanner in the Anthropology Department of the NMNH (Figure 21). The scans of the rattle were able to distinguish some of the painted portions because mercury was in the red pigment and the different density of the metal was revealed in the images (Figure 22). The scan was able to detect the internal structure of the rattle and showed that the objects in the cavity of the rattle were not pebbles, as might be assumed, but were instead stone beads with holes drilled through them (Figure 23). Without the CT-scan, it would have been impossible to tell exactly what kinds of objects were making the sound in the rattle.

Carolyn Thome of the OEC Model Shop processed the digital data to prepare it for printing. First, she had to filter the data to remove the digital presence of packaging that protected the rattle during the scanning. The original rattle also has leather wrapped around its handle that had to be removed digitally removed in order to print the wood portions of the handle (Video 2). Similarly, ermine skins had been attached to the sides of the original rattle and those too were removed in the digital data to enable the printer to reproduce the wooden portions only (Figure 24). As was done on the Killer Whale Hat, the leather and skin portions would be replaced on the replica with actual leather and skins.

The processed digital data were then sent to the 3D printer to produce the physical replica. The printer reproduced the intricate structure of the rattle, with its finely carved figures on the back of the oystercatcher figure as well as the hollow interior of the rattle. Thome isolated the digital data for the beads from the rest of the rattle, then printed the beads. Before the print, Thome digitally created a small hole in the bottom of the bird in order to place the beads into the hollow of the rattle. The hole was then filled and it was now a fully functional, noise-making rattle.

Because the rattle is wood and the primary color of the rattle is the brown of the exposed wood, Thome was able to tell the printer to add a brown color to the surface of the print so that it looked like a wooden object rather than the stark white of the plaster. The next step was to paint the print to look like the original rattle, using the actual rattle for a model (Figure 25). This enabled a closer matching of the paint colors and details of the painted designs. Rather than have the replica look brand new, Thome roughed the surface by hand to make it look more like the original rattle, which showed signs of wear and weathering (Figure 26).

Reactions of Tlingit at Sharing Our Knowledge Clan Conference

With the completion of the replica of the Killer Whale Hat and the first 3D print of a rattle from the Hoonah object project, it was time to present the work to date to the larger Tlingit community for their feedback on the collaborations and to give them the opportunity to see the digital technology first hand. Organizers of the Sharing Our Knowledge Clan Conference invited the Smithsonian to present on the work at the conference held in Sitka, Alaska (March 29-April 1, 2012). Held intermittently since 1993, this unique conference brings Tlingit clan leaders and scholars together with non-Tlingit academics from around the world. Cultural traditions,

protocols, and ceremonies are blended with common conference formats so that there might be an academic presentation on Tlingit naming ceremonies, after which Tlingit clan leaders would then rise to offer corrections and clarifications and conduct an actual naming ceremony on the spot.

The forum of the Clan Conference was an ideal context for the Smithsonian, *Dakl'aweidí* clan and HIA to share the progress and results of the digitization projects to date. The Smithsonian sent Hollinger from the NMNH Repatriation Office, Metallo of the Digitization Program Office, and Thome of the Office of Exhibits Central to Sitka with the finished replicas. They planned to show the replica hat and video of its story to the conference attendees in presentations jointly with John and Jacobs, then keep it on display throughout the four days of the conference.

When John first saw the finished replica of the hat in person in a side room at the conference, following cultural protocol, he asked a Raven carver, Ben Schliefman, to unveil it for him. John was very moved (Figure 27). For those present and particularly for his opposites, he gave a speech thanking the Smithsonian team for their hard work and noting how pleased he was with the results. He described the project and why he thought it was important to explore the use of this new technology to try to educate others about the importance of clan crest objects to the Tlingit (Video 3). "This is not meant to replace our *at.óow*," he said. He explained to those present how the Killer Whale crest represents his clan and that when he looks upon the replica, although he knows it is not a true *at.óow*, he still sees all the other Killer Whale ancestors that have gone before him. He also remarked that when he is wearing the *Kéet S'aaxw* at a party (a *koo.éex'*) and other Killer Whales approach and hug him, they are hugging the hat and the generations of their own Killer Whale relatives that the hat represents. In referring to the replica hat John noted, "When I look at this hat I see Mark Jacobs. I see my Uncle Dan Brown. I see my mom, Alice. And it's just amazing that I could be a part of this."

John said he was honored to have been able to support the project and that the replica would be on display at the Smithsonian so it might help others understand its importance to the Tlingit. John said he had heard Hollinger comment that "a picture is worth a thousand words but a 3-dimensional object can be worth a million words" and that he believed that was true.

The original *Kéet S'aaxw* repatriated from the Smithsonian was then brought in and placed next to the replica. For the first time the reproduction, made entirely from digital data and from reference to digital photographs was side by side with its archetype (Figure 28). Close comparisons of color, surface textures and edge details were possible for the first time. Of course, differences were noted, the original, after having been relatively untouched for 100 years in the Smithsonian, was now darker and more worn from frequent handling over the seven years since its repatriation. Many Tlingit elders had passed away over this period and the hat was regularly "brought out" to honor them at funerals and memorials. Several teeth were now missing and the leather straps had all been replaced. Some very fine details of *Yéilnaawú's* knife work were not duplicated by the CNC's larger bit in the replica, although if the original were in hand at the time the Office of Exhibits Central could have reproduced that as well with hand tools. Overall, as Edwell pointed out, the similarities of the replica to the original were amazing and everyone seeing them could not help but be impressed.

Edwell John, Jr., Harold Jacobs, and the Smithsonian team then took to the main stage of the conference where they told the story of the repatriation and the replication project and showed video of the process. John and Harold displayed the original hat and the replica together for all to see and invited everyone to come see them together in a side room throughout the conference (Figure 29). They explained why they thought the technology was important to explore as an educational tool and how Tlingit clan objects might be digitally scanned and archived as security against fire or other loss. The Killer Whale Hat project had shown how, if well-documented digital data were all that remained of a crest object, the technology could produce a very accurate likeness that could replace the original or at least be used as a digital or physical model by Tlingit carvers to replace the original. The hats were then made available over the ensuing days for examination by clan leaders and other conference attendees. The team made another in depth presentation in which they explained both the Killer Whale Hat and Hoonah collaborative projects.

The 3D print of the rattle from Hoonah was also displayed along with a smaller 1/3 scale print (Figure 30). A partially printed version of the rattle, created accidentally when the printer stopped part of the way through the process, was also displayed to show the interior of the print and better demonstrate how it was laid down in layers. Although Robert Starbard was unable to attend the conference himself, several HIA representatives were on hand to view the rattle and discuss it. Those who saw it were amazed that it had moving, noise making beads inside it. The brown coloration of the print medium gave it the appearance of real wood and the painted details were impressive. Several people viewing it on a table did not realize that it was not a carved and painted wooden rattle. Although the printed rattle could not be directly compared to the original rattle at the conference because the original was still at the National Museum of Natural History, photographs showing the two side by side and CT scan images of the original were shown to all interested.

On the last night of the conference, a number of Tlingit dancers performed in the Sitka Indian Tribe clan house to celebrate the event and the gathering of the Tlingit of both the Raven and Wolf/Eagle sides. Three brothers, Armando DeAsis (*Naalkh*), Antonio DeAsis (*Daanaawú*, 'Death All Around', from Killerwhales slaughtering their prey) and Joshua DeAsis (*Stuteix* [Baby Killerwhale] 'Asleep in the Ribbon Kelp'), direct descendants of Dick *Yéilnaawú* who are named for his son Archie Bell, danced together wearing the Killer Whale hats of the *Dakl'aweidí* clan (Figure 31).[6] Antonio wore the original hat returned from the NMNH while Joshua danced while wearing the replica hat made by the Smithsonian (Figure 32). Harold Jacobs announced that the replica hat would be going back to the Smithsonian for exhibit and they thought it would be appropriate to put life into the hat by dancing it at least once before it went back to the museum. The replica was danced by Joshua following his older brothers who wore the older original hats (Figure 33). For the first time, a museum-made object was danced at a Tlingit cultural event, and although Jacobs jokingly threatened to kill money on the hat (Figure 34), use of the hat as regalia for the dance fell short of it being brought out formally as a crest object.

The replica and original hats were danced together again in the rotunda of the NMNH on January 18, 2013 by the Tlingit dance group *Yaaw Tei Yi* and the group visited the museum's new education center where the replica will be exhibited. Over the next two days the two hats were also danced by the group at the American Indian Society's Inaugural Powwow and Inaugural

Ball in Crystal City, VA. In the future, the replica hat will be available to be checked out from exhibition when the clan leader authorizes it to be danced by clan members for such important occasions.

Scanning of Clan Crest Objects

In addition to the finished replicas, the team brought a laser scanner and photogrammetry equipment to the Clan Conference to demonstrate the technology in a workshop-like setting over the entire four days of the conference. The conference organizers generously allowed the team to take over an entire room to set up the digitization equipment and replica displays (Video 4). Rather than simply give one presentation and leave, the Smithsonian team, in consultation with John and Jacobs, determined that the new technology would be easier to understand if it could be available so it could be seen in action. This approach would enable clan leaders and members to come view the technology in use when they were ready.

The Smithsonian team had invited clan leaders to bring forward clan crest objects they wished to have digitally documented. A number of clan leaders were attending the conference, each accompanied with their clan's important crest objects. The clan leaders had seen the presentations on the collaborations and had heard from Edwell and Harold about how the Smithsonian team had consulted on every step of the project and had not taken any action without clan approvals. Clan leaders recognized the potential benefits and security for their clans if there were digital models of their clan crest objects that could be called upon should anything happen to their *at.óow*. The Smithsonian team would only digitally document objects with the written consent of the clan leaders and agreed that no replicas would be made and there would be no public displays of the digital models or images without permission of the clan leader. Honoring that agreement, permissions from the clan leaders was obtained even to reproduce the photos in this article.

Eighty-nine year old Cyril George, Sr., (*Deisheetaan* clan Angoon) (Figure 35) the oldest clan leader at the Clan Conference and a conference keynote speaker, was the first to come forward and have his clan's Basket Bay Beaver Hat (*S'igeidí S'aax̲w*) digitally recorded. The wooden hat is a large and elaborately carved beaver with a stack of woven spruce root baskets or 'potlatch rings' on top (Figure 36). The beaver depicted is the crest of his clan and represents "The Beaver that Overturned the Town." George was able to watch as a laser danced across sections of his clan hat and images of the sections instantly appeared on a computer screen. The process, although capturing millions of points of data in only a few minutes, took hours to scan the intricate surfaces and angles (Figure 37). Once scanned, the hat was then photographed on a special turntable to record accurate color images that could be mapped onto the digital model in the computer. For scanning and photographing the hat had to be repositioned to access the underside and all angles and the baskets were detached and documented separately. In an interesting blending of new practical technology with traditional knowledge, George pointed out to the team that his clan hat, said to be hundreds of years old, had a plastic headband from a hardhat attached to the interior allowing a more comfortable fit. After the digital recording was complete, George wanted to tell the Smithsonian team more of the story of the hat and his clan's crest so he was interviewed by the team on video telling the story of "The Beaver that

Overturned the Town" (Video 5). The video will be archived with the other digital images and digital data recorded during the project. Other clan leaders followed his lead and were interviewed on video talking about their crest hats and the potentials and concerns about the digital technology.

Two more crest objects were scanned at the request of Edwell John; another Killer Whale Hat, called the Big Hat (Figure 38), and a large Killer Whale dagger (*Keet gwálaa*), said to have been made hundreds of years ago from meteoric iron. The hat had been repatriated from the Denver Museum of Nature and Science to Mark Jacobs, Jr., and had also been created by *Yéilnaawú* for the first *Gusht'eiheen* who was caretaker of the dagger that had been repatriated to Mark Jacobs, Jr., by the Seattle Art Museum.

Andrew Gamble, *Anaaxoots*, *Shaadeihani* of the *Kaagwaantaan* brought forward the Sea Monster Hat (Figures 39 and 40), which was repatriated from the Field Museum of Natural History in Chicago. As one of the main Eagle/Wolf moiety clans of Sitka, it was appropriate that at the same time the Smithsonian team was also scanning a hat of the main Raven moiety clan (*Kiks ádi*) of Sitka, as it is important that crests of the opposite side always be present to provide balance.

Kiks ádi clan leader Ray Wilson asked the Smithsonian team to scan the *Kiks ádi* Frog Hat (Figures 41 and 42), which represents the primary crest of his clan. Wilson also asked that *Katlian*'s Hammer, one of the most important *Kiks ádi* clan objects be scanned. The iron hammer is a Russian blacksmith's hammer, which was captured by the *Kiks ádi* war leader *Kaltian* in an attack on the Russian fort at Old Sitka in 1802 and was used again in an 1804 battle (Dauenhauer et al. 2008). The hammer was on loan by the clan to the Sitka National Historical Park in Sitka and at Wilson's request Sue Thorsen, Museum Curator for the park, acted quickly to remove it from exhibit and bring it to the conference for scanning (Figure 43). Another important crest object of the *Kiks ádi* clan, the helmet worn by *Katlian* (Figure 44), a Raven war helmet worn by him in the battles with the Russians over 200 years ago (Dauenhauer et al. 2008), was brought to the Conference by the Sheldon Jackson Museum so that it too could be scanned. The hammer and helmet had only been in the same room together a few times so it was a great honor for the Smithsonian team to be able to digitize these two great *Kiks ádi* crest objects (Figure 45).

How do I Pay a Machine?

The Smithsonian team digitally documented a total of seven clan crest objects over the four days of the conference; three from the Eagle side (not including the original Killer Whale Hat) and four from the Raven side. A number of other clan leaders expressed interest in having their clan's objects scanned as well but were prevented from doing so by a lack of time or immediate availability of the crest object. Several clan leaders said their primary interest was the potential for the technology to provide a certain security or back-up in case something happened to the original. They felt a sense of responsibility to utilize the new, although unfamiliar, technologies to preserve and perpetuate their clan's objects for future generations.

Some clan leaders also felt apprehensive about the new technology. They had seen Asian "tourists" with sophisticated cameras come into local shops and photograph Tlingit arts and crafts in detail and had then seen the resulting cheap knock-offs mass produced in China flooding the market. They feared that this technology might make it easier for the unscrupulous to exploit Tlingit culture and they might see replicas of their crest objects mass-produced for sale in gift shops. The intellectual property rights they so valued could be easily undermined by technology that makes reproductions easier. The Smithsonian team acknowledged the legitimacy of those concerns and noted that while the Smithsonian could do little to prevent the irresponsible use of ever increasing personal technologies, it could demonstrate the responsible applications of digitization of Tlingit cultural property as had been attempted in the collaborations with the *Dakl'aweidí* clan and the HIA. This approach has been founded in an utmost respect for Tlingit property law and the clan's intellectual property rights.

An initial concern, especially among the Tlingit carvers at the conference, was that the digital scanning and replication technology would put traditional carvers out of business. Traditionally, Tlingit clan crest objects were made when clan leaders commissioned an artist from their opposite moiety to make the hat or other object and it was not legitimately *at.óow* until the artist was paid publicly for his work and opposites were also paid to witness it being brought out at a *koo.éex*. Only if the opposite moiety witnesses and acknowledges the new crest object by bringing forward their own *at.oow* for balance is the new object validated as *at.oow*. Unless and until that happens, an object, no matter how good a representation of the clan's crests, is "just a piece of wood." Balance must always be maintained between the two moieties. At one point while watching the laser scanning in progress, *L'uknax.adi* clan leader Herman Davis (Figure 46) commented to Hollinger "I have to pay my opposites for my crest hat.[7] How do I pay a machine?" However, as more was learned about the technology, clan leaders and carvers somewhat relaxed their concerns, realizing that the technology was just a new tool like the chain saw and the steel curved knife before it. A tool can be used or abused, but it can serve the carvers and the clan leaders. The technology will become increasingly accessible and members of an opposite moiety will be able to entirely produce objects with it or finish objects started using the technology if they feel it would be appropriate for their particular situation. The digitization technology can create 3D digital models for carvers just as they use 2D photographs as models today. CNC routers could rough out a piece to be finished by the hands of the artist. Carvers wishing to reproduce a large memorial pole or canoe could have the original scanned and 3D printed at a smaller scale to serve as a guide for their carving. The technology may give the impression that it is simply push-button and walk away, rather like a replicator from Star Trek, but it becomes clear that there is always a role for the artist in guiding and exceeding the limits of the technology. In cultural contexts like that of the production of Tlingit crest objects, the role of the artist, even coupled with 3D technology, may also be crucial in fulfilling traditional requirements for reproduction. For true crest objects, the name and clan of the artist can be an important part of its origins and history. Prestige of the artist may add to the significance and prestige of the object. Yet, even made by a renowned artist of the opposite moiety, the object, such as a clan hat, is still "just a piece of wood" until it is brought out and validated in a *koo.éex'* in accordance with Tlingit law.

Potential for Future Collaborations

There is great potential for future collaborations with Tlingit and other communities on digital documentation and reproduction of important objects. Clans that have had their objects digitally scanned and archived can call upon the digital files for whatever purpose they deem appropriate. Different clans may be comfortable with different applications. Some may be interested in displaying their 3D digital images of their crest objects on a web site to teach clan members about the history of their crests and crest objects. Others may wish to have replicas made for educational purposes. At the very least the digital files serve as a back-up should anything happen to the originals.

Some clans have expressed interest in using the technology to make replacements for their original but aging and badly worn crest hats. Tlingit have a long tradition of reproducing crest hats such as those cremated with clan leaders or lost in disasters such as the burning of the village of Hoonah. The reproductions, once validated in a *k̲oo.éex'*, are considered even more prestigious than the originals. Although reproduced using the digital technology, money could be killed on the object and witnessed by the clan's opposites legitimizing it as *at.óow* under Tlingit law. In at least one case, a clan has asked to have a broken hat in the NMNH's collections scanned and digitally repaired so the digital files could guide the carving of a newly restored hat and the clan would bring it out as *at.óow*. Such an application of the technology would not be production of a replica, but would be the actual reproduction of the original in every sense.

The examples described here are not "digital repatriations" or "virtual repatriations" as is often misstated when digital documentation is involved. These are real repatriations in every sense of the term now carrying clear legal meanings under the federal repatriation legislation. But these cases show how the repatriation process does not have to be about extremes of either keeping collections locked away from source community access or the removal of collections from the museum and a complete "loss" to science or the public. The digital technology provides means for more dynamic relations between museums and native communities to explore those common interests they both share; the perpetuation of culture and cultural education of future generations. Digital technology allows museums and tribes to go beyond legal and/or physical returns of objects and remains and engage in discussions of what more can be done to restore, renew, and reinvigorate collections in museums and in the cultures from which they originated.

The Killer Whale Hat reproduction project serves as use case for how 3D technology can be applied to fulfill the mission of the Smithsonian Institution. The Smithsonian OCIO's Digitization Program Office has started compiling further use cases to document the versatility of 3D technology, and promote a dialog among curators, scientists, educators, conservators and technologists about how these new techniques can support their day-to-day efforts and ambitions. The story of the Killer Whale Hat, and the role 3D digital images played in its repatriation, serve as a poignant example of how the digital technology can transform the relationship between museums and Native communities (Video 6).

Acknowledgements

This article is a tribute to the memory of Mark Jacobs, Jr. whose Tlingit names were *Gusht'eihéen* ('Spray Behind the Dorsal Fin'), *Saa.aat'* ('Cold', from the migration of the clan and the clan being stuck behind a glacier), *Keetwú* ('Pale Killerwhale'), and *Oodéishkádúneek* ('Everyone Wants to Claim Killerwhale History'), in honor of his dedication to the perpetuation of Tlingit culture. We would also like to thank the organizers of the 2012 Sharing our Knowledge Clan Conference for inviting us to present on this work. We also thank the many Tlingit clan leaders who have allowed these collaborations to develop and for their ongoing input on the right ways to do it. Thanks to *Deisheetaan* clan leader Cyril George, Sr., *Kaagwaantaan* clan *Shaadeihani* Andrew Gamble (*Anaaxoots)*, *Kiks ádi* clan *Shaadeihani* Ray Wilson, *L'uknax.adi* clan leader Herman Davis, *T'akdeintaan* clan *Shaadeihani* Kenneth Grant, and *Lúkaaxh.ádi* clan leader Ray Dennis for their review and comments on drafts of this article and their permissions for use of photos of clan crest objects for which they are responsible. In particular, thanks go to Robert Starbard, Tribal Administrator for the Hoonah Indian Association, for his support and interest in exploring the technology for preserving Hoonah's heritage. Bill Billeck, Program Manager of the NMNH Repatriation Office for supporting the reproduction of the Killer Whale Hat and the 3D printing of the Munsee/Delaware and Hoonah objects as well as continuing support for collaborations with the Tlingit community. We also want to thank former NMNH Director Cristían Samper for his efforts to expedite the repatriation of the Killer Whale Hat to Mark Jacobs, Jr., and the *Dakl'aweidí* clan, and for his sensitivity and understanding of the hats' importance to the Tlingit community.

Notes

1. Human life, whether taken or given, was often the price for *at.óow*. Although a sensitive subject to some today, according to early accounts, slaves were sometimes killed to dedicate *at. óow* (e.g. Kamenskii 1985:35). For example, Father Anatolii Kamenskii recorded the history of the *Keet Aanyádi S'aaxw* ('Noble Killerwhale Hat') belonging to the Sitka *Kaagwaantaan* clan and noted that the lives of four slaves were taken when it was dedicated to pay for displaying the hat (Kamenskii 1985). Later, when the hat was transferred to successive caretakers, slaves were given their freedom by the Sitka *Kaagwaantaan* to commemorate "bringing it out" for transfer ceremonies.

2. John Reed Swanton was an ethnologist and linguist who worked with Native Americans across the country and made collections for the Smithsonian's Bureau of American Ethnology.

3. The Virginia Museum of Fine Arts repatriated a headdress to the *Lúkaaxh.ádi* clan and at the request of the Tlingit the transfer took place at the NMAI's Cultural Resource Center. For such significant events it is important that crest objects be present from the opposite moiety and the Killer Whale Hat was brought from Alaska to provide that balance.

4. The OEC also produced a second set of shell inlay teeth to enable the clan to repair the original hat.

5. The Tlingit have since added an ermine skin trailer to the original hat and restored the missing teeth.

6. Archie Bell was also named *Gusht'eihéen* after the first *Gusht'eihéen*'s sons asked him to take his name.

7. Mr. Davis' use of the term "my" in this context is meant to refer to the hat for which he is responsible for as caretaker and does not indicate personal ownership since such objects are clan property.

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Figures

Unless otherwise noted, the Smithsonian staff members contributing to this article took the photographs presented here. Crest objects and clan leaders are depicted with permission from the respective individual clans.

Figure 1. Mark Jacobs Jr., wearing the *Kéet S'aax̲w*. Photograph by Dave Dapcevich. Used with permission from the photographer.

Figure 2. The *Kéet S'aax̲w* in the Smithsonian's collections.

Figure 3. The *Kéet S'aax̲w* being placed on Mark Jacobs, Jr., during repatriation ceremony January 2, 2005.

Figure 4. Painting of the *Kéet S'aax̲w* from Swanton (1908 Plate LVIII).

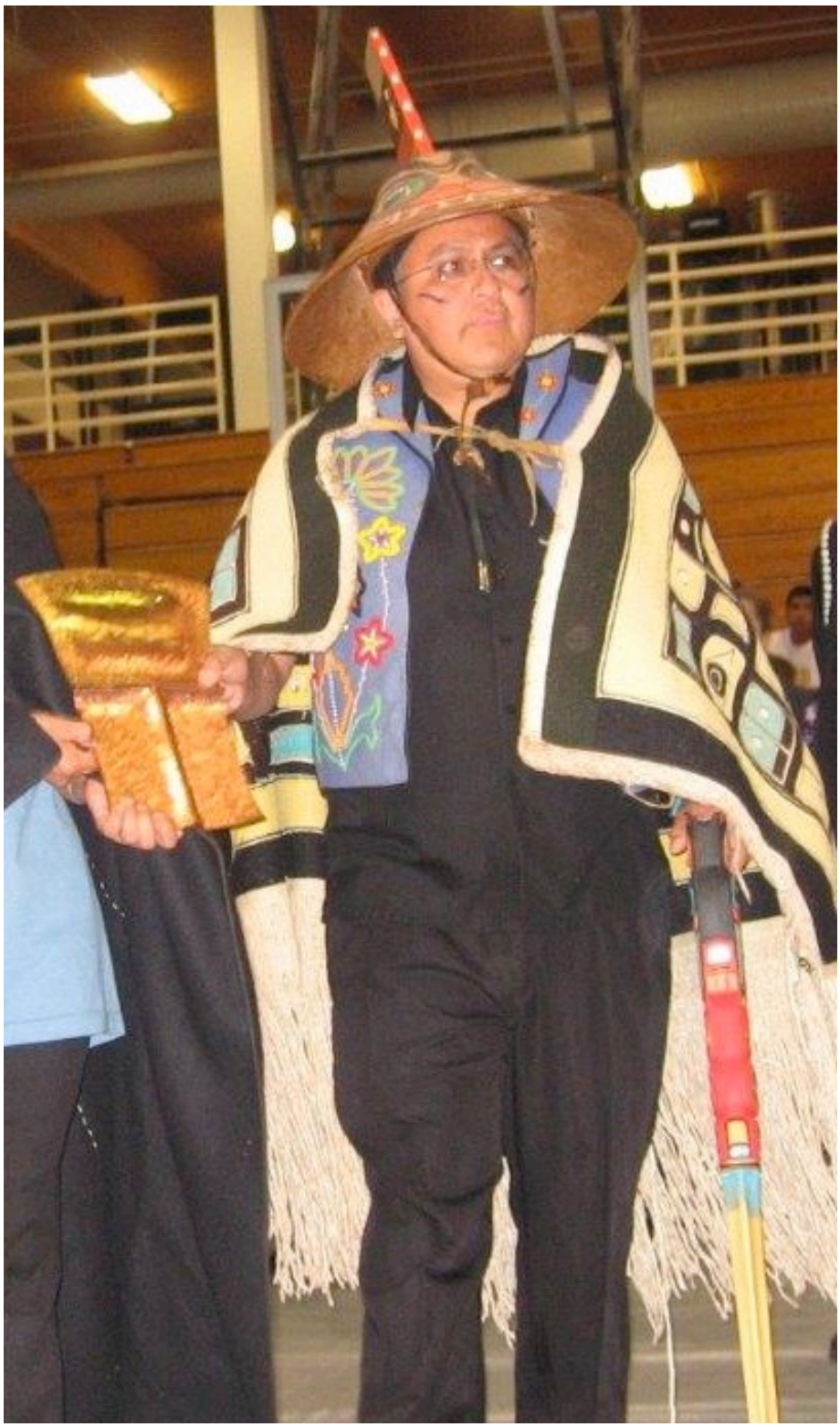

Figure 5. Edwell John, Jr., installed as *Shaadeihani* of the *Dakl'aweidí* clan, 2007. Photograph by Brooke John. Used with permission.

Figure 6. Repatriated *Kéet S'aaxw* being danced at a *koo.éex'* for the first time in 100 years by Armando DeAsis *(Naalk* - "Medicine Man") (center).

Figure 7. Adam Metallo demonstrating laser scanning on a Tlingit helmet for Harold Jacobs during a consultation visit in 2010.

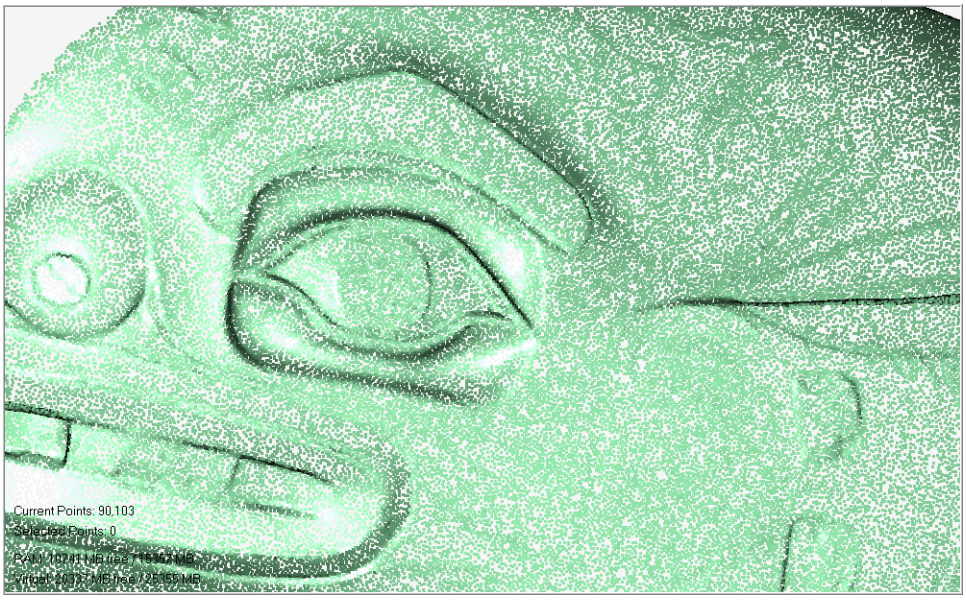

Figure 8. Point cloud showing the face of the killer whale.

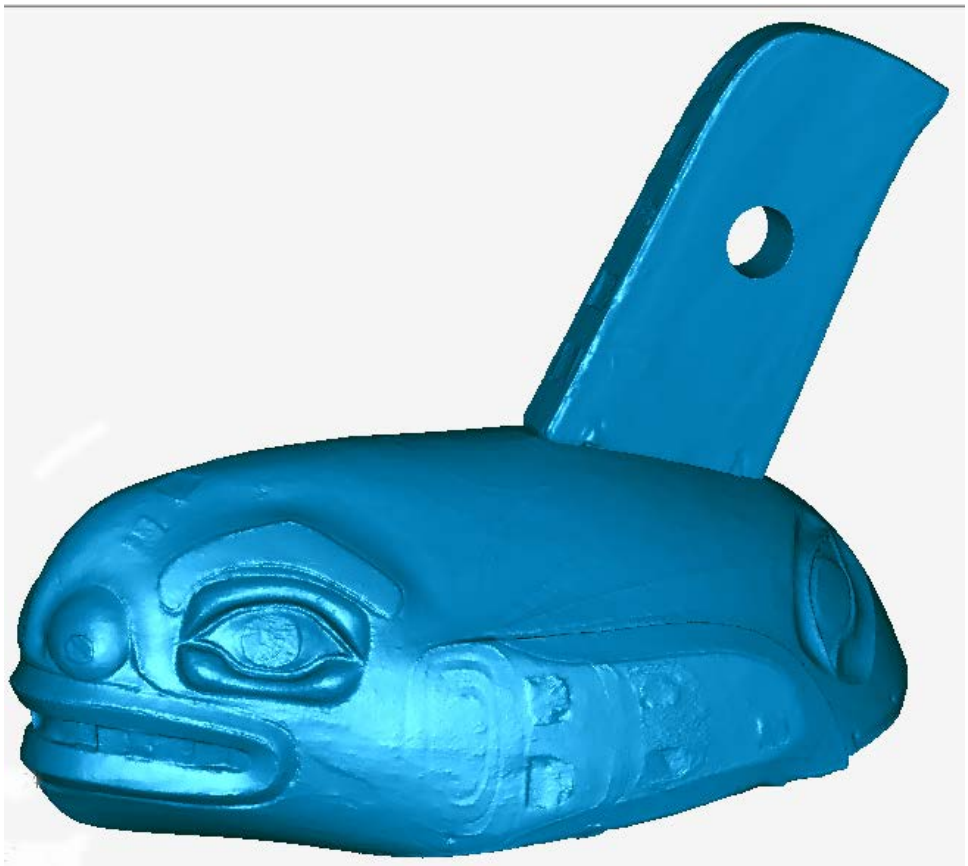

Figure 9. Polygon model of the killer whale hat.

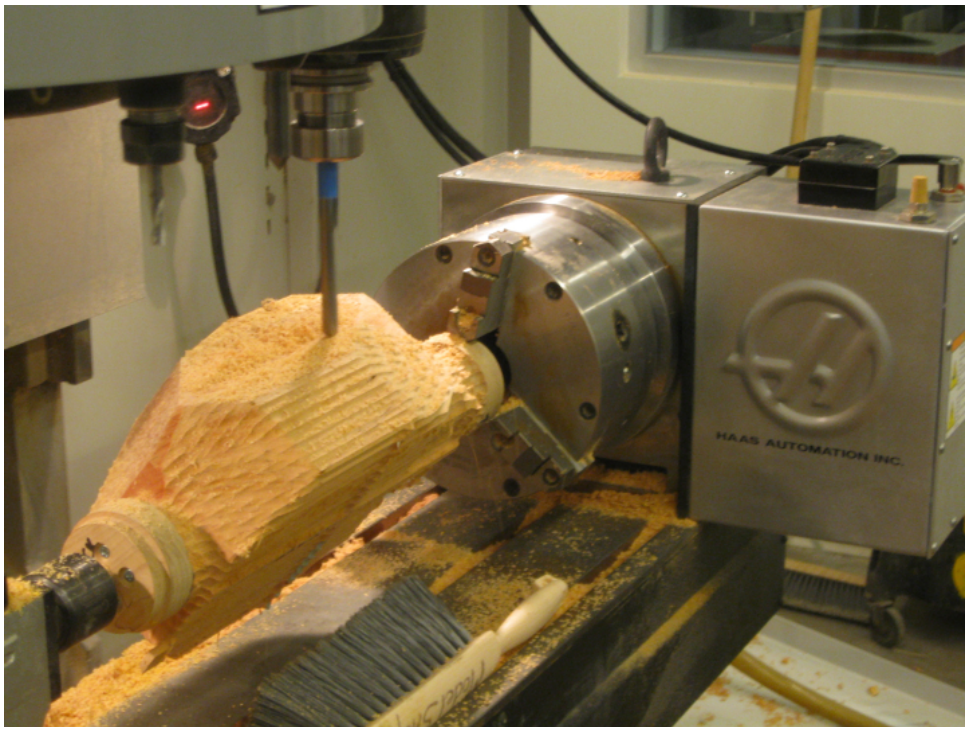

Figure 10. CNC milling machine, guided by computer, cuts away at a block of wood.

Figure 11. Pewter pipe front, painted replica middle, unpainted replica rear (photo by Chip Clark).

Figure 12. Edwell John, Jr., and Bob Sam laser scanning the *Kéet S'aaxw* at the Smithsonian. The laser can be seen on the side of the hat.

Figure 13. Adam Metallo and Natalie Gallelli using Photogrammetry to document the hat.

Figure 14. Edwell John, Jr., examining the digital data with Adam Metallo.

Figure 15. David Price of the NMNH Education Department filming Jonathan Zastrow adjusting the CNC milling machine.

Figure 16. Jonathan Zastrow and Danny Price examine the *Kéet S'aaxw* after it was 'brought out" for a repatriation ceremony.

Figure 17. Colors being tested out on the hat and test piece.

Figure 18. Lora Collins comparing paint colors on a similar Tlingit hat.

Figure 19. Positioning ermine skins for trailer.

Figure 20. The completed replica hat and the Smithsonian team that worked on the project.

Figure 21. Janine Hinton of the NMNH Repatriation Office prepares to CT scan the rattle.

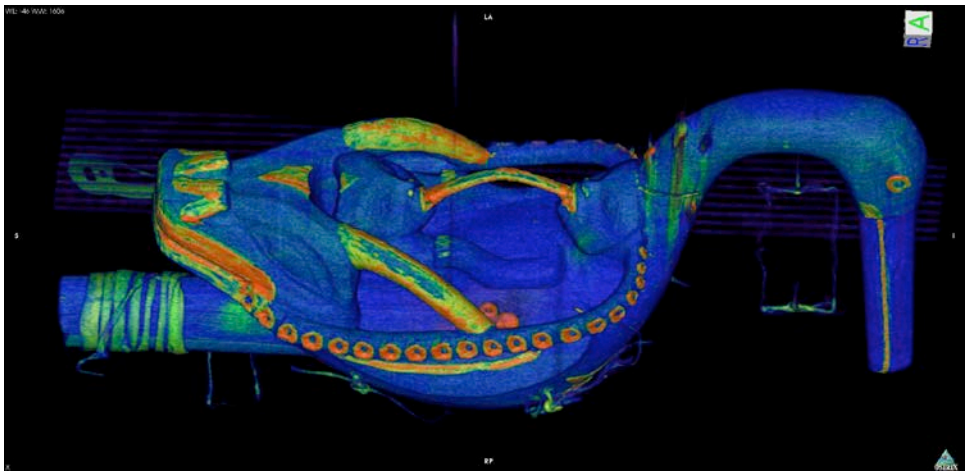

Figure 22. CT scan of Hoonah rattle showing mercury in paint showing as bright red.

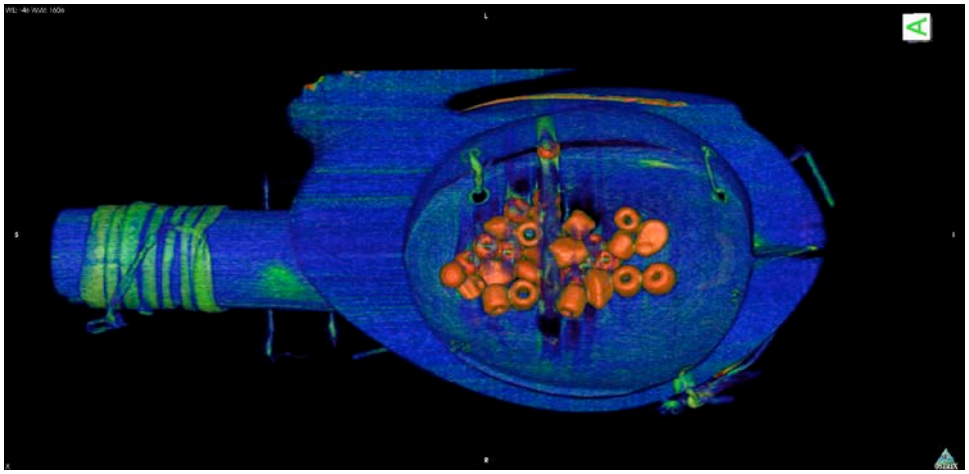

Figure 23. CT scan of Hoonah rattle showing stone beads inside the rattle.

Figure 24. Original shaman's rattle from Hoonah. Photograph by Jane Beck.

Figure 25. Carolyn Thome painting the replica rattle with the original as a model.

Figure 26. The nearly completed replica rattle.

Figure 27. Edwell John, Jr., viewing the replica hat for the first time.

Figure 28. The original *Kéet S'aaxw* and replica hat together for the first time.

Figure 29. Edwell John, Jr., and Harold Jacobs describing the repatriation and digital collaboration to the Clan Conference.

Figure 30. Hoonah rattle replica examined at the Clan Conference by Edwell John, Jr., and James Bennett.

Figure 31. Brothers Armando, Antonio and Joshua DeAsis dancing the killer whale hats.

Figure 32. Joshua DeAsis dancing with the replica hat.

Figure 33. DeAsis brothers displaying their clan crests and hats.

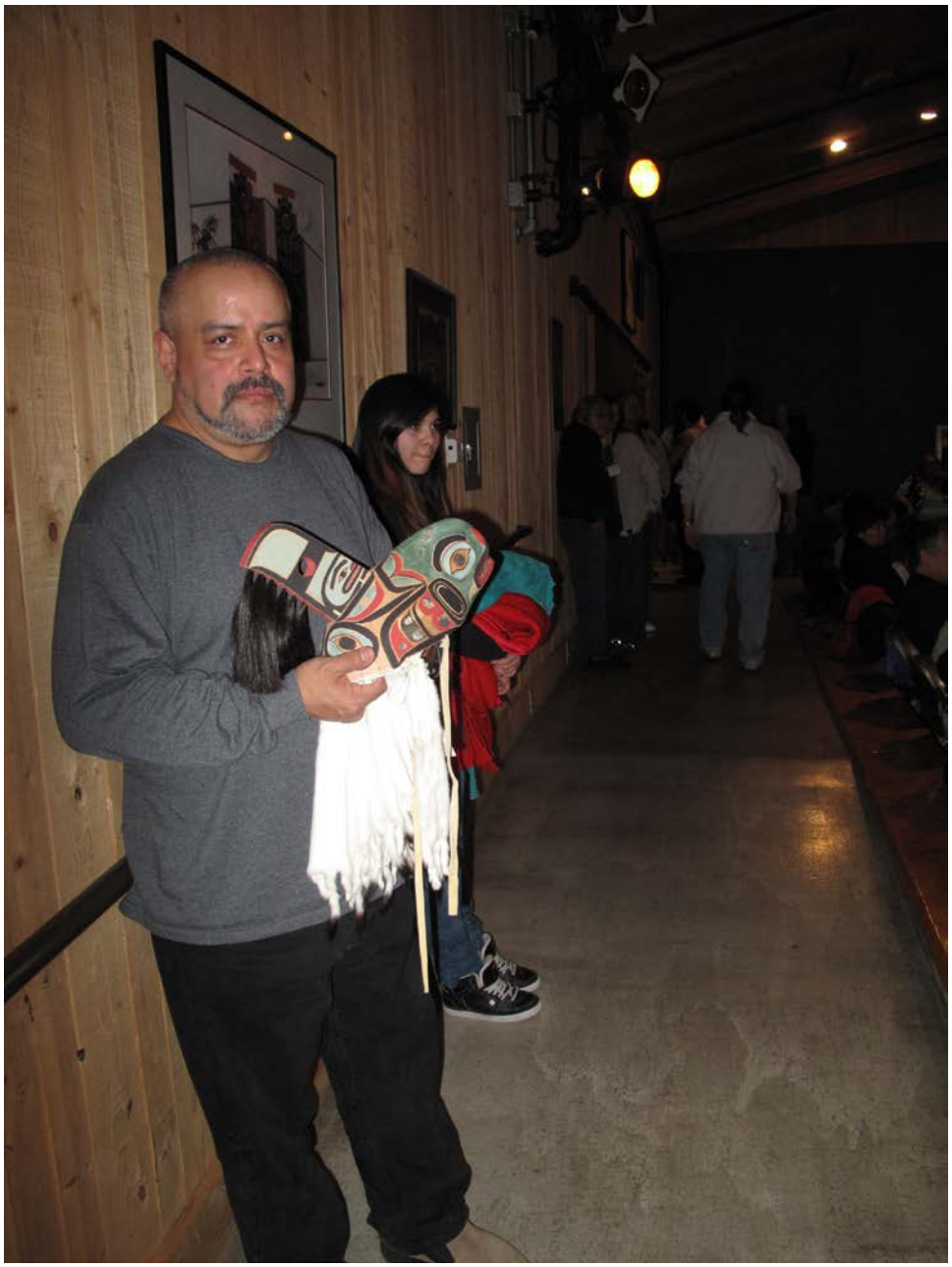

Figure 34. Harold Jacobs with replica killer whale hat.

Figure 35. Cyril George, Sr., wearing regalia at Clan Conference.

Figure 36. The Basket Bay Beaver Hat (S’igeidí S’aax̲w) being photo documented.

Figure 37. The Beaver Hat being laser scanned by Adam Metallo.

Figure 38. The *Dakl'aweidí* clan Big Hat being laser scanned by Eric Hollinger.

Figure 39. *Kaagwaantaan* clan Sea Monster Hat being photo documented.

Figure 40. Hollinger and *Kaagwaantaan* clan leader Andrew Gamble (*Anaaxoots*) watching the Sea Monster Hat being laser scanned.

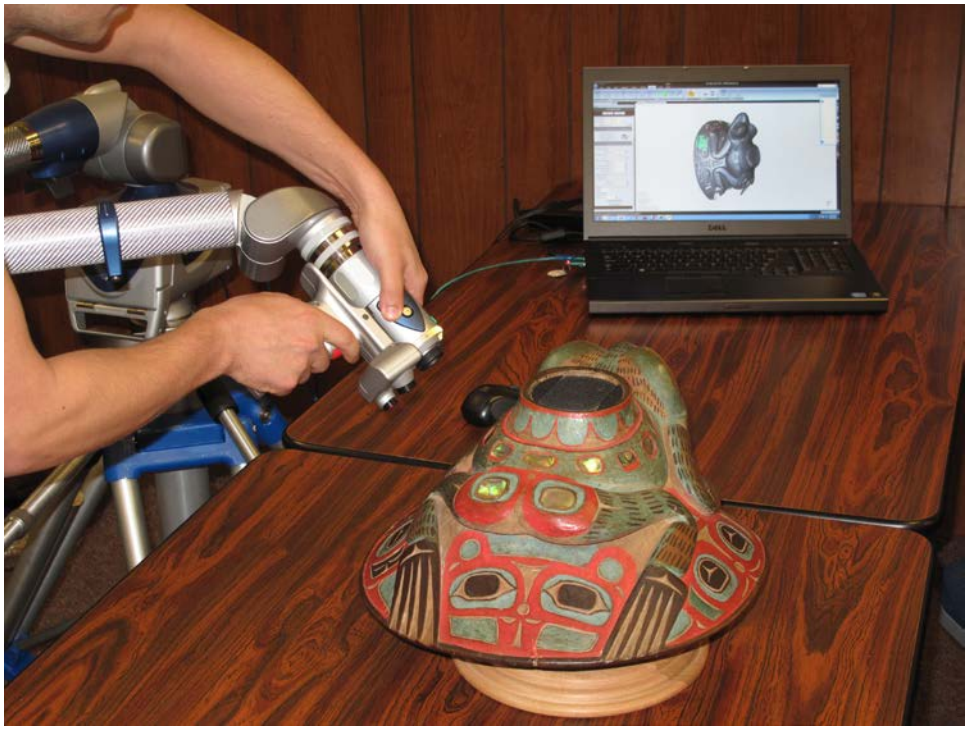

Figure 41. The *Kiks ádi* clan Frog Hat being laser scanned.

Figure 42. Clan leader Ray Wilson with Frog Hat.

Figure 43. Tlingit artist Tommy Joseph assisting with laser scanning the hammer.

Figure 44. *Kaltian's* Helmet being laser scanned.

Figure 45. *Kaltian's* Helmet and hammer together.

Figure 46. *L'uknax.adi* clan leader Herman Davis discussing the technology with Hollinger. Photograph by Peter Metcalfe. Used with permission from the photographer.

R. Eric Hollinger is a Repatriation Case Officer in the Repatriation Program of the Department of Anthropology at the Smithsonian Institution's National Museum of Natural History where he is responsible for repatriations in the Northeast, Midwest, Great Lakes, Great Basin, and California regions of the US as well as some cases in Alaska and the Southwest. He has an MA in Anthropology from the University of Missouri and a Ph.D. in Anthropology from the University of Illinois. He has published on repatriation, archaeological taxonomy, archaeogeophysics, paleoethnobotany, late prehistoric conflict, and iconography. He is an adopted member of the Dakl'aweidi *clan and has the name* Dukwú.

Edwell John, Jr., is Hit s'aati *(keeper of the house) of the Killer Whale Chasing the Seal House of Angoon, Alaska, and is* Shaadeihani *of the* Dakl'aweidí *(Killer Whale) clan. His Tlingit names are* Woochx'aduhaa, Tlei yaa keet, and Yeet'saa. *He was installed as* Hit s'aati *in 1997, following the death of his maternal uncle one year earlier. In this role, clan leaders serve as caretakers of their clan's house, history, songs, and prized possessions known as* at.oow. *Clan possessions under Edwell's care include ceremonial hats, blankets, and the prestigious Killer Whale dagger. As clan leader, he is also expected to represent the* Dakl'aweidi *at cultural gatherings.*

Harold Jacobs was born and raised in Sitka, Alaska. He is from Hít Tlein *(Big House) of the* Yanyeidí *Clan from the* Taakú Kwaan *(Taku People) and has the names* Goos'shú *and* Gooch Shaayi. *He has been the Cultural Resource Specialist for the Central Council Tlingit and Haida Indian Tribes of Alaska since 1997.*

Lora Moran-Collins came to the Smithsonian as an exhibition artist and model maker 32 years ago. She is currently the Model and Fabrication shop supervisor at the Office of Exhibits Central.

Carolyn Thome has worked as a model maker for the Smithsonian's Office of Exhibits Central for over 20 years. Her core focus is implementing the digital medium to assist in the replication and sharing of museum artifacts with the public and museum researchers.

Model maker Jonathan Zastrow has worked at the Smithsonian's Office of Exhibits Central since 1986 specializing in the prototyping and production of interactive exhibit components and the planning and production of CNC models. He is currently working in the National Museum of Natural History's Office of Exhibits.

Adam Metallo, a Smithsonian 3D Program Officer, received his B.S. in Psychology from the University of Maryland in 2004 and an MFA in painting from the University of Delaware in 2006. Working at the Smithsonian Office of Exhibits Central he developed workflows that integrate 3D technologies with traditional museum model making. In 2010 he began spending most of his time quietly sneaking up on inanimate objects to digitize them in 3D for the Smithsonian Digitization Program Office.

Günter Waibel joined the Smithsonian Institution in December 2010 as Director of the Digitization Program Office, where he oversees policy and strategy for digitizing and managing Smithsonian assets, and the implementation of the strategic plan "Creating a Digital Smithsonian." He is a past board member of the Museum Computer Network and the Association of American Museum's Media and Technology Committee. He has taught as adjunct faculty in the School of Information Studies at Syracuse University and the School of Library and Information Science at Catholic University of America. He has an M.A. in English Literature from Georgetown University.

Vincent Rossi holds a B.F.A. in sculpture from the University of the Arts in Philadelphia and has pursued graduate level fine art study at Goldsmiths College, University of London. From 2004 to 2011, he worked as a sculptor, model maker, and project manager for the Smithsonian's Office of Exhibits Central and helped produce and manage many Smithsonian exhibits. Since 2011 Rossi has worked as a 3D Program Officer for the Smithsonian's Digitization Program Office—building 3D capacity and developing 3D workflows.