MOVING AN OVERSIZE COLLECTION DURING A PANDEMIC

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For historic museums like the Harvard Museum of Comparative Zoology (MCZ), certain building repairs and maintenance are expected. In January 2021, an inspection and replacement of the fire suppression sprinkler heads was expected; a failure of ceiling plaster was not, specifically the failure of a portion of plaster which fell onto oversize vertebrate fossils. Due to Harvard University's pandemic policy, assessing the scene and developing a plan to resolve the damage required communication, quick thinking, and flexible redeployment of person-power.

In response to the pandemic policy, MCZ staff adopted a work-from-home model that transitioned to a hybrid model, where the VP collection manager worked at the museum one day per week and the curatorial assistants worked there one day per month, with no scheduled overlap. Building and room access was restricted and tracked by two university systems. All staff were required to comply with pandemic policy procedures including mask-wearing, virus testing, social distancing, and sanitation of surfaces.

Quick relay of the damage to the MCZs Director of Collections Operations (CO) and the Collections Manager (CM) of Vertebrate Paleontology (VP) allowed the two departments to formulate and execute a safe plan to evacuate the fossils. To assess the scene, the CM obtained emergency permission to enter the MCZ building, assess the condition of the room, and document the damage. The CM decided that the upcoming sprinkler maintenance and the ceiling repair validated the temporary removal of all exposed fossils to mitigate risk of further damage. Given the size of the affected fossils, the collection manager and CO staff member estimated three people may be able to complete the move in one day.

For the move, we obtained permissions for all staff, determined the equipment needed to move the fossils, and created tags to track and inventory each specimen. The specimen removal team learned valuable lessons that improved the success of the specimen return team. First, a three-person team was not sufficient for moving the specimens in one day. Second, different equipment and methods improved the ease of moving certain fossils. We learned that a team of four people working in teams of two can complete the move in one day by increasing efficiency and reducing the workload for all. Communication and trust between the CO and VP staff allowed us to care for the fossils while preventing further damage.

YET ANOTHER TECHNIQUE FOR CURATING MICROMAMMAL FOSSILS THAT EMPHASIZES COST, VISIBILITY, TIME AND STORAGE EFFECIENCY, SPECIMEN AND DATA PROTECTION

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Several techniques have been designed and used to curate and store micromammal teeth in fossil collections. Since at least the 1960s this was done with corked glass vials containing specimens glued to pinheads, with the pin sticking into the cork. Problems with this include that the glue used was often not archival, and more importantly that users often complain that it is too easy to break or lose the specimen as it is being pulled out of the vial for study. More recently developed techniques include storage in gel capsules and in centrifuge cuvettes with a foam lining. Each technique has its advantages, limitations and shortcomings. A new method described here does not claim to be the end-all curation solution for these small fossils, but simply another way to balance the pros and cons. Things to consider when choosing a curation system include but are not limited to costs, physical and visual specimen availability, specimen protection, storage efficiency, time efficiency and avoiding loss of data, and use of archival materials.

This system involves mounting the specimens on trimmed bamboo toothpicks, which are then mounted on a simple foam core board. The specimens are adhered to the toothpick using polyethylene glycol 3350, (PEG), which is water soluble and, arguably, leaves little residue. A water-soluble glue like Aquazol 50 could be used as well; the advantage of PEG is its almost instantaneous set time at this scale. The specimen numbers can be written directly on the toothpick preventing the number and the specimen from getting separated. Multiple toothpicks can be mounted onto a small square of foam core and the specimen number written on this as well. The foam core and specimens are inserted into a small lidded polystyrene box. The PEG is the weak point; if the specimen and support bamboo are stressed, the PEG will fail before the specimen.

The fact that there are 16 specimens in a box may invite confusion, especially if the PEG should fail for whatever reason. To lessen the risk of loss of data, each specimen is photographed in the unlikely case there is a mass failure of PEG and specimens need to be re-mounted.

There are advantages and disadvantages to this system. Advantages of this system include easy visibility and access, time efficiency when mounting and studying, cost, storage efficiency, specimen protection, avoiding loss of data. The big disadvantage: is it archival?

PALEONTOLOGICAL RADIATION AND RADON MONITORING: A CASE STUDY FROM THE UTAH FIELD HOUSE OF NATURAL HISTORY

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The Utah Field House of Natural History State Park Museum was founded in 1948 and has a collection of geological and paleontological specimens totaling more than 17,000 items. The museum has particular strengths in Eocene and Jurassic fossil material, with specimens from the Uinta, Washakie, and Morrison formations often having elevated radiation output. Following preliminary radon monitoring over five days in November 2019, we tested two fossil-containing spaces (lab and collections) in the collections wing and one control space (classroom/meeting) in the main office wing for one year (Dec 2019–Dec 2020), taking 200 readings semi-daily for 24-hour, 7-day, and long-term averages in pCi/L. We also tested collections spaces for increased radiation and took 0-m and 1-m readings for radioactivity of 50 individual specimens for mRem/hr. Results indicated that six mineral and ore specimens had readings of 1.6 up to 16.0 mRem/hr and up to 36,000 CPM at 0 m. The highest three fossil specimens were two brontotheres from the Washakie and Uinta and a Morrison sauropod humerus, ranging from 0.36 to 1.23 mRem/hr and up to 1860 CPM. The mineral and ore specimens were deaccessioned, as their levels were considered higher than the museum could properly store, and risk of possible contribution to radon levels was considered to outweigh scientific value. The fossil specimens were retained, labeled as radiation sources, and will be mitigated along with other slightly elevated specimens. Results of radon monitoring indicated a long-term average of 2.00 pCi/L in the control space in the main wing, 4.16 pCi/L in the paleo lab, and 2.83 pCi/L in the collections room; all three spaces collectively had a 7-day average range between 0.85 pCi/L (main wing, Aug 2020) and 6.0 pCi/L (lab, Feb 2020). Short-term (24-hour) average radon levels varied greatly and could only be correlated inversely with local barometric pressure; response to pressure changes appeared to lag somewhat in rough proportion to room volume. Smaller spaces demonstrated more immediate raising or lowering of pCi/L readings with lower or higher barometric pressure, respectively. While degree of response seemed proportionately similar in the large collections space, response time to pressure changes appeared to lag. Other variation in daily averages appeared to be present, but triggers could not be reliably determined. Ventilation of spaces with elevated levels is in the engineering design phase.

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MOUNTING FOSSIL SPECIMENS FOR MICROCT SCANNING

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MicroCT scanning is an important tool in paleontological research. A basic understanding of the mechanism of scanning is vital to understanding how to mount specimens for the most informative scan. X-ray beams travel from the source, through a specimen and are captured by the detector. The specimen, sitting on a rotating platform, moves a fraction of a degree and another image is taken. This is repeated for a complete 360°; these images, when rendered, create a 3D volume. A mount for scanning must hold the specimen securely and safely while it spins slowly on the scanner platform. The mount should be created so that the specimen is centered within the scanning frame and must not move while the scan takes place. The mount affects the quality of the scan in other ways, such as whether the beam can be as close to a small specimen as it needs to be. The mounting materials must be invisible to the x-ray beam, having low density and low x-ray absorption: for example polystyrene, polypropylene, gel caps, styrofoam, and florist foam. Floral foams, one of the easiest materials to use, can be carcinogenic with prolonged exposure and other foams can spread particles widely. When even a small particle can damage the detector, every attempt must be made to maintain a clean, dust-free working area. Gloves and N95 respirators should be worn when handling these foam mounting materials. Thin plastic films, like 1-mil plastic wrap can be used to protect the specimen from the mounting materials. Metals, though, should be avoided as they cause scan artifacts. In concept similar to a cavity mount, mounts for CT scanning are created with sculpture tools: serrated knives, X-Acto knives, and wire end modeling tools. The Yale Peabody Museum's procedure for mounting includes documentation, photographing the current condition of the specimen prior to scanning, labeling the mounted specimen with catalog number and element, and tracking possession and travel of specimens from collections, to lab, to scanner and back safely in the collections.

PREPARATION AND RECONSTRUCTION OF *FALCATAKELY FORSTERAE*, AN ENANTIORNITHINE BIRD FROM THE UPPER CRETACEOUS MAEVARANO FORMATION OF MADAGASCAR

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We describe the mechanical and digital preparation of *Falcatakely forsterae* (UA 10015), a high- and narrowbeaked enantiornithine bird from the Upper Cretaceous Maevarano Formation of Madagascar. The preserved rostral and palatal portions of the cranium were remarkably complete given the exceptionally thin bone (<1 mm maxilla thickness), and relatively coarse-grained depositional setting (sandstone). Both of these factors made mechanical preparation especially challenging. Medical-scale computed tomography conducted prior to preparation provided inconclusive resolution as to the anatomical nature of the flattened specimen. Mechanical preparation of the specimen's surface with insect pins and carbide needles under magnification occurred in two phases. A subsequent micro-CT scan at Ohio University served as the basis for digital preparation of morphology inaccessible via mechanical preparation, and also for a digital reconstruction. Segmentation was performed in a taphonomic (rather than strictly anatomical) context, isolating 167 distinctive volumes (elements and/or fragments) from three blocks of collected matrix. Selected materials were enlarged three times and prototyped in polymer for research and initial 3D morphological reconstruction. These results were combined into a single volume in an effort to model the in situ context of the specimen prior to its collection. The in situ model in turn served to create a Beauchene-style anatomical reconstruction; both of these models were ultimately included as 3D pdfs in the supplemental materials associated with publication. All fragment position changes were recorded and reported for model repeatability. Changes between in situ and in-life position were animated in "rocker" style videos to qualitatively depict the relative displacement of fragments relative to the left maxilla. These processes were essential for allowing the research and data dissemination processes on this remarkable specimen, and will also feature prominently as part of both digital and physical exhibitions related to various outreach efforts.

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MARINE FOSSILS FROM THE COALEDO FORMATION: A CASE STUDY ILLUSTRATING THE WORKFLOW TO PREPARE AND SHIP AN UNCURATED COLLECTION

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As stewards of paleontological materials at the Natural History Museum of Los Angeles County, collections staff are relied upon to preserve collections and their associated data. A lack of resources, however, contributes to specimens remaining in various curation states after being collected in the field. We present one such example in the marine vertebrate fossils from the Coaledo Formation, collected many decades prior by a former paleoicthyology curator. This former curator, now retired, wanted to complete the study of the Coaledo Formation material that consists of teeth, vertebrae, spines, and scales of sharks, rays, and teleosts. Using the Coaledo Formation collection as a case study, the following workflow establishes the materials and methods employed to inventory, track, pack, and ship an uncurated marine collection to its original collector for identification, research, publication, and completion of curation. Photographs of the material were taken with a DSLR camera to document their original condition and location. Over 100 specimen trays containing 249 glass vials and 279 elements were inventoried with associated field numbers and tags. Once all trays were assigned a unique number for tracking, each was photographed alongside a printed label using an iPhone or a Nikon point and shoot camera. Custom specimen housings, similar to cavity mounts, were created using a combination of Ethafoam planking, tri-rod, and 1/4" and 1/8" liners affixed using a hot glue gun inside polystyrene containers and pre-made cardboard boxes. Using a Dremel tool, cylindrical holes were drilled into Ethafoam planking to house vials. The specimen housings were packed inside cardboard shipping boxes internally lined with 1/4" Ethafoam with Styrofoam peanuts or air-filled bags to fill empty space. A copy of the images and inventory were sent in the packages and electronically to the collector to aid in the unpacking, identification, and cataloging of the material. This method allowed for over 500 trackable yet uncataloged elements to be shipped to the original collector with approval from the Museum Registrar, resulting in diminished museum backlog and material identification which aids in the completion of curation and publication of research.

HARNESSING THE POWER OF COMMUNITY SCIENCE TO DIGITIZE, TRANSCRIBE, AND IMPORT PREPARATION INFORMATION INTO A COLLECTIONS MANAGEMENT DATABASE SYSTEM

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Museums with active fossil preparation labs historically have handwritten, sometimes barely legible, fossil preparation sheets (prep sheets). The digitization initiative at the Natural History Museum of Utah (UMNH), as well as the "Stay at Home" orders of the pandemic, allowed UMNH to scan the handwritten prep sheets, put these scans onto DIGIVOL, a platform created by the Atlas of Living Australia, and have citizen scientists from all over the world transcribe these data. Since September 2019, UMNH has digitized 12,000 pages of documents, including 3,140 pages of prep sheets. These prep sheets were transcribed by citizen scientists and validated by UMNH volunteer preparators. DIGIVOL generated an Excel spreadsheet with the transcribed prep sheet data. This spreadsheet was then analyzed, massaged, and coded in a way that could be imported into EMu, our Collection Management System (CMS). When UMNH bought EMu, our Paleontology Department knew that customizing our Conservation Module in order to best record fossil preparation data was essential. In collaboration with our Preparation Lab Manager, we determined essential data to be recorded, then created customized tabs and fields for these data. These fields included drop down menus for consolidants, adhesives, solvents, and techniques used, as well as open notes fields for comments such as preparator's remarks, specimen's condition upon receipt, handling concerns, among others. A conservation number is assigned to each Preparation Record. Each record is linked to the Catalog Record of the specimen to which it is referring, the Party Record of the preparator, as well as any Multimedia Record (i.e. scanned prep sheet, preparation photos, etc.). In moving forward with our current and future

preparation records, we are creating a digital prep sheet using Sapphire, a browser-based tool for EMu. By formatting the form in Sapphire, we can add only the fields we need to create accurate preparation records. Photos can also be added directly into the form and annotated with notes. All this can happen via a mobile device. This information feeds directly into Emu and, if needed, can feed into a report to be printed. Bringing preparation records into the 21st century will create fewer human errors, more relevant details recorded, and make for easier importation into EMu.

COLLECTION AND PREPARATION OF A *TRICERATOPS PRORSUS* SKULL PROVIDES UNIQUE OPPORTUNITIES FOR SCIENCE COMMUNICATION AND EDUCATION IN MATERIALS AND METHODS IN PALEONTOLOGY

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Science education and communication highlighting the multifaceted processes of preparing a fossil specimen for study and museum exhibition infrequently transpires in tandem with the project. However, the initial discovery (2016), excavation (2017–2018), extraction (2018) and preparation (2019–current) of a nearly complete, articulated skull of *Triceratops prorsus* from the Upper Cretaceous Hell Creek Formation of Montana presented such an opportunity. Field expeditions conducted by the North Carolina Museum of Natural Sciences (NCMNS) paleontology unit, are showcased, tweeted, and uploaded on NCMNS social media platforms, throughout the expedition, directly from the field. Additionally, livestream interviews by field team members are broadcast directly into the Daily Planet theater in the museum's research wing and are free and open to the public. Once back at the museum, the skull was prominently placed within the publicly viewable Paleontology Research Lab allowing museum visitors to watch the progression of the preparation process. Opening of the field jacket was live streamed by NCMNS to local news agencies and was free and open to the public. Once open, K–12 students at the event were provided the opportunity to help sweep down the newly exposed matrix. Furthermore, NCMNS set up information tables where museum visitors could engage with paleontology staff and volunteers during the event. Additionally, in collaboration with the museum's Exhibits and Digital Media team, Paleontology staff set up a timelapse camera system set to capture a still photo every five minutes to record the progress of preparation. Current preparation status is regularly reported via Twitter and other museum social media platforms and aimed at highlighting preparation progress of the skull and the discovery of secondary fossil specimens (e.g., paleobotanical specimens and other taxa) in the entombing matrix. Preparation is ongoing and projected to continue for several years. This project and the discovery of such an iconic dinosaur species has allowed NCMNS to engage with the public in effective science education and communication more broadly regarding the materials and methods of paleontology generally and fossil preparation and conservation specifically.

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UTILIZING OLD AND NEW TECHNIQUES TO BRING NEW LIFE TO OLD DISPLAYS

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Many remarkable specimens that had been on display at the Yale Peabody Museum (YPM) as much as a hundred years ago are facing a refreshed new life for the upcoming renovation. In many cases, a variety of inexplicable work had been performed on specimens showing various layers of preparation and exhibition techniques used at the time. Specimens were prepared for the YPM renovation using well-established techniques (e.g., molding and casting), as well as relatively new procedures to preparation and exhibit work like 3D printing. Specimen mount types encountered at YPM included completely prepared specimens (fossil bone), specimens in situ (fossil bone in rock), plaque mounts (fossil bone embedded in a plaster backing), and plaster body mounts (fossil bone embedded in a plaster body sculpture). Each project brought its own unique challenges due to specimens' existence through prior museum renovations; therefore, a critical eye must be given to resolve each issue on an individual basis. This case

study focuses on an assortment of specimens including *Orohippus agilis* (YPM 65700), which exemplified many of these exhibit preparation techniques. This small fossil horse is a plaque mount of a composite skeleton constructed in the early 20th century. Originally used as a display piece, this specimen was loaned to another institution where several elements were removed. It was eventually returned to YPM to be displayed but was no longer in exhibit quality. Often exhibit specimens possessed many layers of coatings and/or sculptural materials such as paint, adhesives, plaster, fabrics, putties, metal, etc. which masked real fossil material. Once the real fossil material was exposed, the specimen could then be rehabilitated and prepared for exhibit. Several of these display techniques included building stabilizing bases, creating faux matrix, molding and casting, sculpting, and painting. The traditional techniques of molding and casting are utilized whenever possible, but 3D printing has been added to YPMs skill set to add or mirror image missing portions of the specimen. Distinct methods are used to paint casts verses reconstruction; casts are painted to look like the real specimen, while sculpted reconstructions are painted a matte color to blend, but also slightly stand out from the real fossil material. The natural beauty of fossil material is brought back into view resulting in rejuvenated specimens ready for display to a modern audience.

FOSSIL PREPARATION CONTINUES AT THE SMITHSONIAN INSTITUTION NATIONAL MUSEUM OF NATURAL HISTORY DURING COVID-19 PANDEMIC

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Fossil preparation at the National Museum of Natural History (NMNH) has been impacted by workplace changes in response to the SARS-CoV-2 COVID-19 pandemic, but has continued owing to its designation as time-sensitive and a priority for continuing scientific work at NMNH.

COVID-19 response at the Smithsonian Institution (SI) is managed in a tiered system, with primary policy being set by a central task force. A phased reopening plan for SI units was developed, with phases benchmarked by public health metrics. Led by unit-level Directors, unit-specific policies affected COVID-19 response at individual facilities. At NMNH, research department Chairs and other program leads managed staff in coordination with Facilities and Security personnel.

Fossil preparation staff at NMNH were restricted to telework from the time Smithsonian buildings closed on March 13th, 2020, until limited building access was granted in early July 2020, during the first of four reopening phases. In Phase 1, three staff performed laboratory work for a combined four days per week. NMNH shifted to Phase 2 operations in September 2020, continuing through the spring of 2021. Phase 2 increased access to 6 days combined between 3 preparators per week. In addition to preparation, staff responded to concerns including the moving collections, water leaks, maintaining safety equipment, monitoring exhibits, and assisting department staff unable to access the building. When not on site, tasks done via telework included digitization of records, outreach, attending conferences, and communicating with volunteers.

Preparation staff have implemented workplace changes in response to COVID-19. Multilayered fabric masks were required to be worn on Smithsonian property. Occupancy limits were set at one person per room, with two fossil preparation 'rooms' including the laboratory in the Deep Time exhibit space, and all preparation facilities on the ground floor of the East Wing. Online training regarding COVID-19 safety was required prior to initial building access, and daily personal health checks required before leaving home. Staff were required to sanitize shared lab surfaces and to maintain a daily contact tracing log. For a time during late 2020 into early 2021, a halt was ordered for work requiring two people to be within 3 meters of one another. Field work has been restricted to Directorapproved expeditions, and fossil preparation staff did not participate in field collecting activities during 2020.

ACCESSIONING A LARGE FOSSIL COLLECTION FROM THE FAIRMEAD LANDFILL LOCALITY, CITY OF CHOWCHILLA, MADERA COUNTY, CALIFORNIA

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Maintained and operated by the Madera County Public Works Department (MCPWD), the Fairmead Landfill is a well-known Irvingtonian fossil locality with thousands of specimens collected over the past 28 years from paleontological mitigation. While some specimens are on display at the Fossil Discovery Center (FDC) of Madera County adjacent to the Landfill, they do not have a collections facility on-site. The University of California Museum of Paleontology (UCMP) is the primary repository for specimens from 1993–95 whereas the remainder are stored temporarily at a decommissioned library in downtown Madera in anticipation of a future repository at the FDC. The library is in disrepair and is unsuitable as a permanent repository. As such, MCPWD officials decided to move the remaining fossils to the UCMP for curation.

While in temporary storage, the fossils have been subjected to theft by vandals, pest infestations, and water damage as a result of ceiling leaks. Specimens that sustained the worst water damage were covered in black mold and dried ceiling insulation. The MCPWD retained Applied EarthWorks, Inc. (*Æ*) to prepare and transfer the fossils of over 4,000 specimens to UCMP. To address the mold, *Æ* paleontologists used cotton swabs to apply rubbing alcohol to affected surfaces. *Æ* replaced moldy jackets of oversized specimens, using quilt batting to avoid mold regrowth. *Æ* replaced damaged specimen trays, and fossils and trays were sealed inside plastic zipclosure bags. *Æ* also transferred all microvertebrates into new screw-top vials. Lastly, *Æ* re-inventoried and relabeled the entire collection and assigned catalog numbers to over 2,000 additional uncatalogued specimens. *Æ* plans to transport the collection to the UCMP in summer 2021. For stability, *Æ* will keep specimens in their existing wooden cabinets and then will transfer them to permanent metal cabinets at the UCMP. Oversized fossils in jackets will be secured with foam sheets and plastic wrap onto wooden pallets during transport.

These efforts highlight the value of mitigation paleontology for scientific contributions from fossils that would otherwise have been lost during construction. The successful transfer of these fossils and their associated data to an accredited curation facility ensures suitable conditions for long-term preservation and scientific research. The Fairmead Landfill fossils will significantly expand the present understanding of Irvingtonian paleoecology in California's Central Valley.

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CONSERVATION OF A MOLD AND FIREDAMAGED MOSASAUR SPECIMEN

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The partial skull and associated postcranial skeleton of a mosasaur was originally collected from the Late Cretaceous Mooreville Chalk in Dallas County, Alabama by a private collector and housed in a home collection. The collector prepared the specimen using standard mechanical techniques and used an unknown thick synthetic resin (possibly a five-minute epoxy) as an adhesive. Unfortunately, the collector's residence was destroyed in a fire, but staff from the McWane Science Center were invited to salvage the fossil material from the home's basement and the specimen was donated to the museum.

The fossils were subsequently loaned to the Texas Vertebrate Paleontology Collections for research, where they were housed in polyester batting lined acid-free boxes and stored in gasketed, epoxy-coated collections cabinets. During a condition assessment prior to preparation and casting, mold growth was discovered on many of the bones. Excessive sooting of the fossils and yellowing and peeling of the adhesive was observed, especially on the upward-facing surfaces of the bones that were exposed to fire. In addition to discoloration from heat and smoke damage, bones exhibited crazing and cracking. This type of damage is discussed in conservation literature, but is rarely documented in realworld conditions. Fortunately, fires in museum conditions are now rare, and field and laboratory methods that employ fire avoid prolonged temperature and direct exposure to flame.

Conservation was undertaken to stabilize the bones for mold-making. The bones were also cleaned for photography and study. Mold was mechanically removed under exhaust ventilation using cotton swabs and neutralized with ethanol. Soot was likewise removed using swabs, non-latex makeup sponges, and ethanol. Degraded adhesive was softened using a cheesecloth poultice saturated with a 50/50 mixture of ethanol and acetone applied to the surface of the adhesive. Excess adhesive was mechanically removed where possible. In areas where peeling adhesive separated the external layers of the fossil, the bone was re-adhered. Cracked areas were consolidated with Paraloid B-72 in acetone, and broken fragments were successfully reconstructed. These conservation treatments allowed for the successful molding and casting of the bones with no further damage, and facilitated the study of the now-clean and reassembled fossils. After two further years in storage, the fossils exhibit no further mold growth or physical deterioration.