

1. Introduction

The Warren Lasch Conservation Center (WLCC) serves as the repository for the collection of the *H.L. Hunley* submarine (1864) currently undergoing conservation. Raised from the ocean in 2000, the submarine is historically significant as the first to successfully sink an enemy ship in battle. Over 3000 objects have been recovered from the submarine, including personal artifacts of the crew and submarine components in various states of degradation. Included in the collection are the leather shoes of all eight crew members.



Fig. 1: *Hunley* submarine on a barge after being raised. Fig. 2: Submarine in its conservation tank. View from the stern

2. Submarine excavation

The waterlogged shoes were excavated, documented, and partially conserved from 2002 to 2004. The shoes were part of an assemblage of composite materials that included leather, foot bones, textiles, metal, and soft tissue from the skeletal remains of the crewmembers. The excavation revealed that foot bones were still contained within the shoes some of them still articulated, and soft tissue and remnants of wool socks were also present. The shoes provided archaeological information on many levels, including the site formation process, as the shoes were filled with sediment and osteological data.



Fig. 3: Archaeologists excavating inside the submarine. Fig. 4: Shoe HL-1501 in situ before blocklifting.

3. Shoes excavation

Once lifted from the submarine, the shoes were found to be in different degrees of deterioration with the majority of them exhibiting iron staining that related to their proximity to the iron hull. In some instances, the shoes were found to be completely encapsulated in concretion and required different mechanical and chemical techniques to free them.



Fig. 5: Block lift containing leather shoe HL-1531, fibula, tibia, ankle, and foot bones in a semi-articulated state.
Fig. 6: Conservator excavating foot bones from inside the shoe.

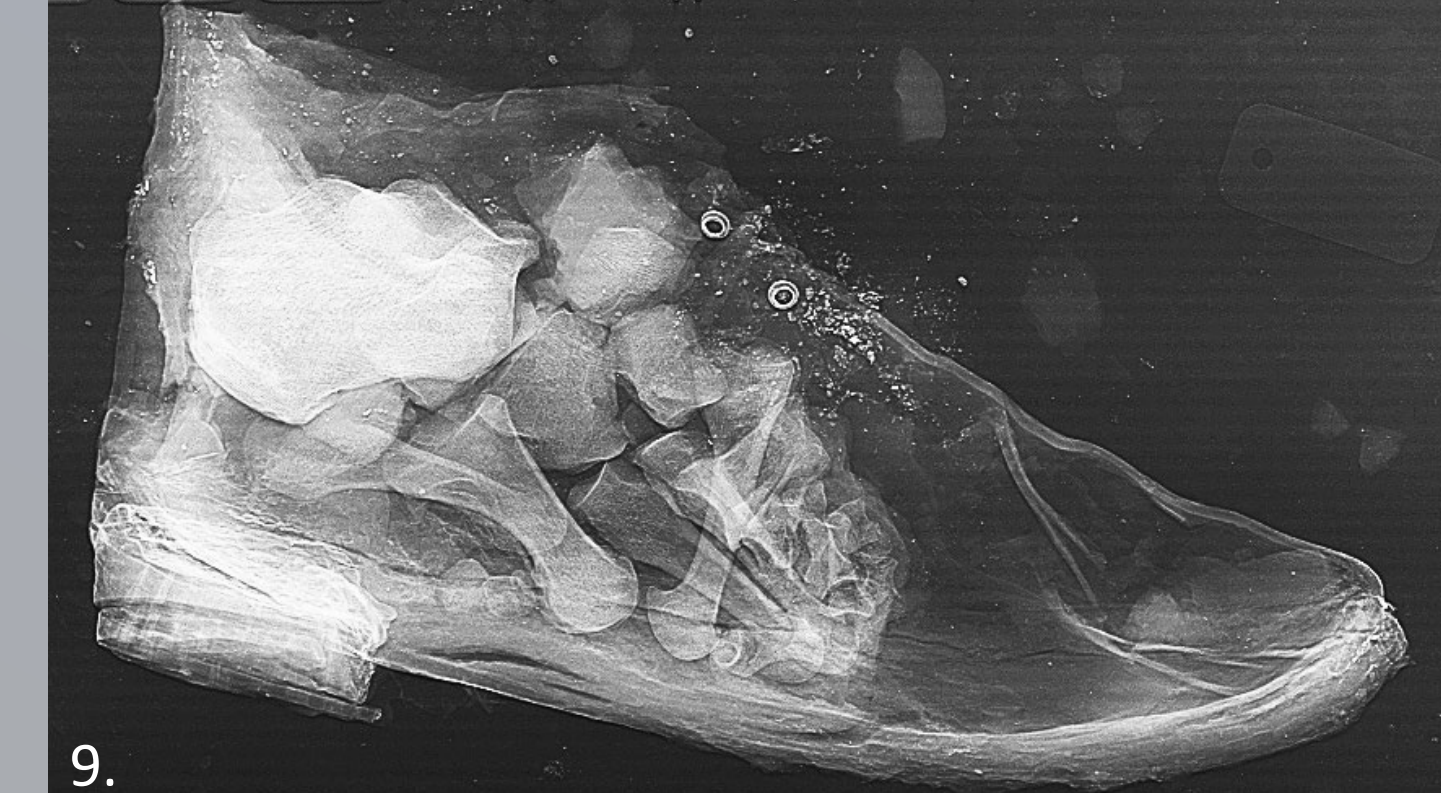
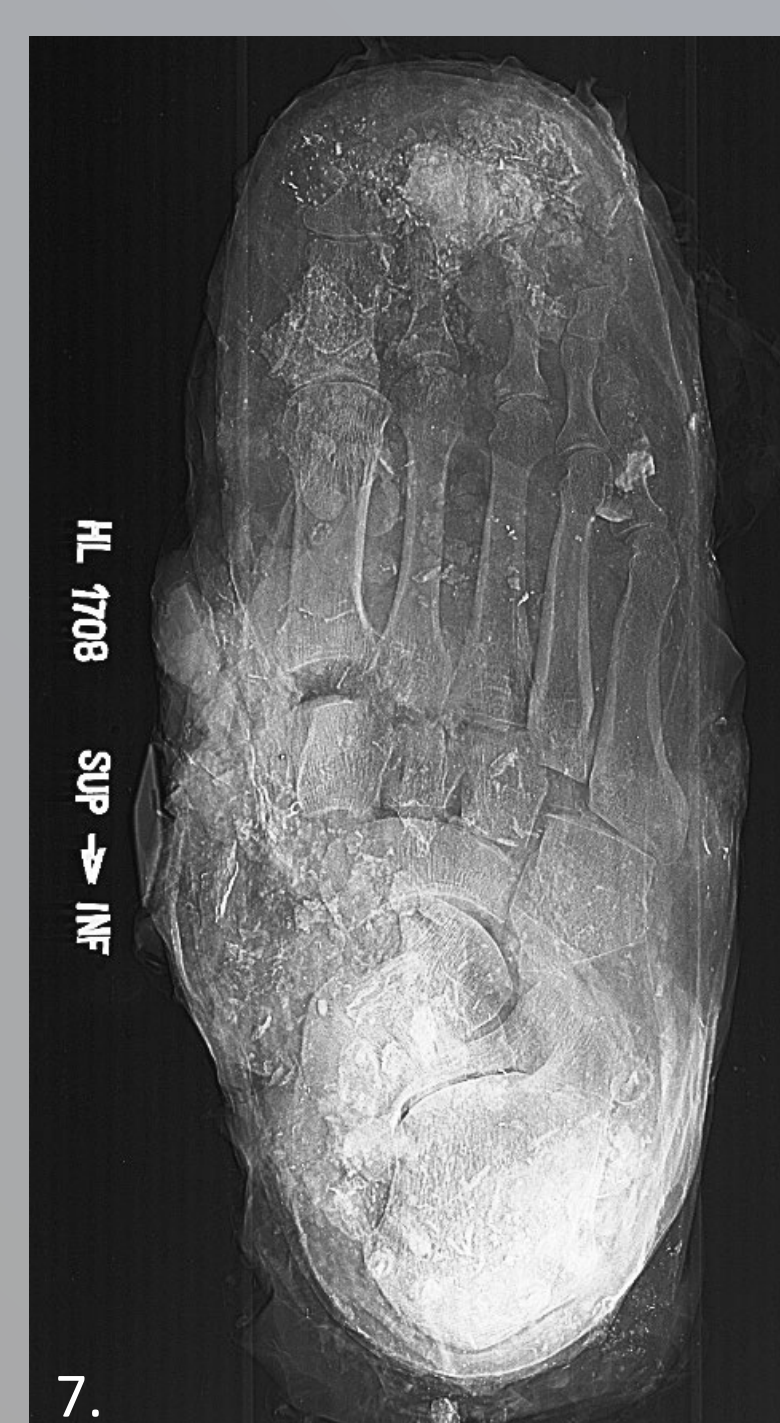


Fig. 7: Top view of X-ray of leather shoe HL-1708 still containing the foot bones.
Fig. 8: Leather shoe HL-1708 in a waterlogged state with foot bones still inside
Fig. 9: Profile view. X-ray of leather shoe HL-1501

4. Chelating iron corrosion products:

Several studies were done in leather samples from the shoes to remove iron staining. The removal of superficial iron was achieved with mechanical tools (dental scalers and water jets). For in depth removal, different chelating agents were tested ultimately choosing ammonium citrate dibasic. The goal of the chemical cleaning was to enhance the overall aesthetic of the artifact, to reduce the brittleness of the leather, and to slow down the hydrolysis of collagen catalyzed by iron corrosion products¹. During chemical cleaning, the solution turned gradually dark brown. This phenomenon was attributed to the iron-citrate complex formation.



Fig. 10: Leather sample before chelating agent testing. Fig. 11: Waterlogged leather sample after diammonium citrate 5% w/w bath. Fig. 12: Leather sample after polyethylene glycol treatment and freeze drying.

5. Conservation and freeze drying

The 16 leather shoes and fragments were treated in 2004 using mechanical and chemical means to reduce iron staining. It was decided not to chemically treat some of the shoes because of the unique carbonated skin impressions that were found on the insoles. The majority however, was treated using a 5% w/w solution of ammonium citrate dibasic. The time required for the treatment varied based on the degree of iron present in the leather. After an extensive rinsing process in dionized water, the shoes were impregnated using the standard leather treatment at the time, 30% w/w of polyethylene glycol 400 for three weeks. The shoes were then freeze-dried.



Fig. 13: HL-1501 before cleaning. Fig. 14: HL-1501 during mechanical cleaning. Fig. 15: HL-1501 after chemical cleaning.
Fig. 16: HL-1501 After freeze drying. Picture taken in 2004. Fig. 17: HL-1501 during freeze drying.

6. Two decades in storage

Due to the lengthy and invasive treatment process that the shoes experienced, they required specific and stable environmental conditions during their long-term storage. Because of the presence of iron corrosion products in addition to the hygroscopic nature of polyethylene glycol, the ideal RH should be 45% with very slight fluctuations. However, the rooms in which the shoes were originally stored presented several problems with the HVAC system. Therefore unstable environmental conditions impacted the shoes and led to a darkening of the preserved leather. In 2014 new store rooms were built for the *Hunley* collection² and even though the environmental conditions greatly improved, the leather had already darkened permanently.



Fig. 18: Crewmember Carlsen's leather shoes HL-1501 and HL-1508 (Fig. 19) after 20 years in storage. Shoes darkened over time. Pictures taken in 2022

7. Future plans

The conservation and long term storage of the shoes and future exhibit was revisited in 2022. In collaboration with archaeologists at the WLCC, stylistic options for the shoes were considered as conservators developed a new conservation plan for their reconstruction. Material challenges relating to the fragile condition of the previously waterlogged leather, and ethical considerations concerning the level of intervention called for, are being addressed in treatment solutions. These shoes present the opportunity to consider the changes in conservation decision making that have been developed over the past twenty years as well as the results of a changing environment. At the end of their reconstruction the shoes will be ready for display alongside many of the other artifacts from this historic vessel.

References

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