THE ZIBBY GARNETT TRAVELLING FELLOWSHIP

REPORT BY KIMBERLY ROCHE

CONSERVATION OF MARINE ARCHAEOLOGICAL ARTEFACTS FROM USS MONITOR AT THE MARINERS’ MUSEUM AND PARK

VIRGINIA, UNITED STATES

05 JUNE to 18 AUGUST 2017
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**Introduction**

My name is Kimberly Roche, and I am a 26-year-old Irish-American completing my second year in MSc Conservation Practice at Cardiff University. In fulfilment of this degree, I completed eleven weeks of work placement this summer at The Mariners’ Museum and Park in Newport News, Virginia. Thanks to funding from Zibby Garnett Travel Fellowship (ZGTF), it was possible to travel to the United States (US) to complete a placement in my selected specialism of marine archaeological conservation.

Prior to undertaking my summer placement, I had worked on various maritime projects both in the United Kingdom (UK) and US. Although I initially pursued a placement in the UK, opportunities in British maritime archaeology were limited for the summer in question. I was fortunate enough to secure an internship at The Mariners’ Museum and Park. However, I was in need of funding to support my travel to Virginia. I first heard of ZGTF from a colleague at Cardiff University, Chloe Pearce, who had received funding for her work placement in 2016. The fellowship awarded me £400 toward the total cost of my trip. In total, my trip cost £1,305.49, supplemented by an £812 grant from Cardiff University and savings. Had it not been for the generous support of ZGTF, I would likely not have gained relevant experience in my specialism.

After gaining my master’s qualification, it is my distinct hope to work in maritime heritage in the UK, working side-by-side with maritime archaeologists to preserve the unique and challenging finds associated with marine environments. I am optimistic that this experience, and the support of ZGTF, will help create future opportunities in the sector.
**Study Trip**

I completed my internship in marine archaeological conservation at The Mariners’ Museum and Park in Newport News, VA from 05 June to 18 August 2017. I travelled to Washington, DC on 18 May, prior to beginning the placement. During this time, I visited family and explored the many heritage institutions and cultural attractions in the DC area.

On 03 June, I travelled by train to Newport News, where I met my extended family members who were hosting me in Suffolk, VA for the duration of the internship. Throughout my time in Hampton Roads (the geographical area encompassing the cities of Newport News, Hampton, Suffolk, Portsmouth, Chesapeake, Virginia Beach and Norfolk), I explored the region to better understand the local culture and people since I was new to the area. To achieve this, I frequented local restaurants and attractions, such as heritage institutions, wildlife parks and beaches.

In July, I had the opportunity to travel to Florida, my home state, with the department’s maritime archaeologist for a scuba diving trip. It was during this trip that I finally earned my open water diving certification and was able to experience the hidden world where most maritime heritage exists: underwater.

My travels in and around Hampton Roads and the US served to augment the practical conservation experience I gained during my placement. These experiences helped me not only to better integrate into the community I was working in, but also to more effectively engage the public in my position at the museum. I returned to the UK on 07 September.
The Mariners’ Museum and Park

The Mariners’ Museum and Park is located in Newport News, Virginia, and maintains a permanent collection and exhibitions on maritime history in Virginia, the US and throughout the world. The museum itself is situated on a 550-acre park, with 5 miles of running trails around Lake Maury in the park (Figure 3). The museum is a privately run, non-profit institution that was established in 1930. The mission of America’s National Maritime Museum is to connect people to the world through the water.

Figure 1. Map of the United States with Virginia Indicated (Courtesy Apple Maps)
Figure 2. Map of Hampton Roads with The Mariners' Museum and Park Indicated (Courtesy Apple Maps)

Figure 3. Map of the Museum Park and Noland Trail with the Museum Indicated (© Jonah Adkins 2014)
The USS Monitor Center

The Mariners’ Museum and Park is the official repository for artefacts excavated from the USS Monitor, designated by the National Oceanic and Atmospheric Administration (NOAA). The USS Monitor, an ironclad steamship, fought in service of the Union during the American Civil War (1861-1865). She is famously known for her service in the Battle of Hampton Roads on 09 March 1862, staving off a potentially devastating victory by the CSS Virginia, a Confederate ironclad (The Mariners’ Museum and Park 2017). The artefacts are conserved and displayed in the USS Monitor Center, a designated wing of The Mariner’s Museum.

Figure 4. Reconstruction of the USS Monitor at the USS Monitor Center (The Mariners’ Museum and Park 2017)

Figure 5. Schematic of USS Monitor (The Mariners’ Museum and Park 2017)
On 30 December 1862, the *Monitor* was being towed by the USS *Rhode Island* off the coast of Cape Hatteras, North Carolina when she began to take on water during a storm. The USS *Rhode Island* mounted a rescue operation, saving many of the forty-nine sailors aboard the *Monitor* before she sank in the early morning of 31 December 1862. However, sixteen sailors died with the ship.

The wreck site of the *Monitor* was discovered in 1973 by a team of experts from Duke University, University of Delaware, the State of North Carolina and Massachusetts Institute of Technology (Broadwater 2012). In 1975, the site became the first designated sanctuary under the National Marine Sanctuary Act of 1972. Since its designation, the site has been monitored and overseen by NOAA (NOAA 2017). The site was formally excavated from 1998 to 2002 – recovering in excess of two hundred and ten tonnes of material, including the steam engine and gun turret (The Mariners’ Museum and Park 2017).

*Figure 6. Excavation of the Monitor’s Gun Turret in August 2002 (NOAA 2017)*
Conservation Laboratory and Team

The Batten Conservation Complex, located in the USS Monitor Center, comprises the conservation laboratories and storage facility for Monitor artefacts. The complex is comprised of a large “Wet Lab,” where wet conservation is carried out on large scale artefacts, a “Dry Lab” for artefacts after they have received wet conservation treatment and a “Work Room” where conserved objects will soon be available for study. An observation platform outside the Wet Lab allows museum guests to view the status of large artefacts undergoing conservation treatment.

Figure 7. Batten Conservation Complex Wet Lab (The Mariners’ Museum and Park 2017)

Figure 8. Batten Conservation Complex Dry Lab (The Mariners’ Museum and Park 2017)
I was fortunate to work with an extremely qualified and welcoming group of heritage professionals during my time at The Mariners’ Museum and Park. Will Hoffman, Director of Conservation, and Elsa Sangouard, Senior Conservator, were my primary mentors during my placement. Elsa and I met weekly to discuss the status and future plans for the artefacts I was responsible for treating. She was also freely accessible for any questions I had outside our meeting time. In addition, conservators Kate Sullivan, Laurie King and Lesley Haines were great resources. The rest of the members of staff included Conservation Administrator Tina Gutshall, Material Culture Specialist Hannah Fleming, USS Monitor Center Director John Quarstein, USS Monitor Collections Manager Michael Saul and Development & Communications Writer/Researcher Julie Murphy.

Figure 9. Conservation Department Staff in the Dry Lab at The Mariners’ Museum and Park (From Left: Tina Gutshall, Elsa Sangouard, Hannah Fleming, Kate Sullivan, Will Hoffman, John Quarstein, Kimberly Roche, Michael Saul, Laurie King, Julie Murphy, Lesley Haines
Individual Projects

Prior to beginning my placement, Will Hoffman had consulted me on the types of materials I was interested in treating. Although my primary research focus had been the chloride-based corrosion of metals, I was hoping to work on at least one organic as well. I had, in the past, treated and reconstructed a waterlogged leather shoe and was interested in working on additional waterlogged material. Upon beginning my placement, Will and Elsa assigned me four artefacts to treat: wrought iron small finds, a copper alloy/iron composite firing hammer, a waterlogged wood tool handle and a concreted composite artefact. I was responsible for conducting research, formulating treatment plans, documenting and treating the artefacts.

Wrought Iron Small Finds

One of the many challenges faced when treating artefacts from marine contexts is the length of time required to desalinate the artefacts. Desalination, a method whereby the salts (chlorides) which drive metal corrosion are removed from the substrate, is a critical step in conserving these artefacts and preserving them for the future. As my placement was a mere eleven weeks, it was nearly impossible to take an artefact through treatment, start to finish. Fortunately, Will and Elsa were very thoughtful in this regard and addressed the challenge by assigning me two groups of wrought iron finds in different stages of treatment.

The first group, henceforward referred to as Iron Group 1, was an assortment of seventeen wrought iron keys, bolts and assorted parts from the carriage of the port Dahlgren Shell Gun. The artefacts had already been photographed and documented and were in wet storage in a low concentration sodium hydroxide solution (NaOH). I transferred the artefacts to the wet lab and began electrolytic reduction (ER) to desalinate the wrought iron.
Samples of the solution were taken biweekly and analysed using ion chromatography (IC) to determine the concentration of chloride ions extracted from the artefacts (Appendix I). After 4 weeks in ER, the rate of chloride extraction began to slow, indicating that it was time for a solution change. The artefacts were cleaned using ultrasonic, placed in a fresh hydroxide solution and restarted in ER.

The second group, Iron Group 2, was a selection of nuts and studs from the port Dahlgren Gun carriage. This group had completed desalination in ER at the time of my arrival at the museum and needed to be taken through the final stages of treatment. I planned to discontinue ER, rinse, dewater and apply a final coating.
The artefacts were disconnected, rinsed until at a neutral pH, dewatered in acetone and relocated to the dry lab prior to coating.

![Image](image.png)

*Figure 12. Wrought Iron Stud(D04) from Iron Group 1 - Before Treatment*

During examination, it became apparent that the dense product layer (DPL), caused by a build-up of corrosion products, had not been sufficiently removed during treatment. Because the DPL present on *Monitor* wrought iron artefacts had caused problems with recurrent corrosion, the laboratory introduced a method of mechanical cleaning called dry ice blasting. Dry ice blasting emits dry ice pellets or shavings by compressed air. The impact force, contraction of the surface products/concretions and micro-explosions caused by the sublimating dry ice contribute to the cleaning of metal surfaces (Cutulle and Kim 2015). However, when the artefact is cleaned at room temperature, it is the mechanical force of the particle impact that has the greatest effect on removing the wrought iron DPL, in this case (van der Molen et al. 2011). Extensive experimentation and surface analysis has been carried out by Will Hoffman and Laurie King to determine the optimum parameters for the safe application of the technique on archaeological materials. Publication is forthcoming.
Although the nuts and studs had already been treated once by dry ice blasting, it was necessary to retreat the artefacts by completing a second round of dry ice blasting. Prior to retreatment, the DPL was sampled for additional analysis.

Figure 13. The Author Dry-Ice Blasting the Studs During Retreatment

Figure 14. Wrought Iron Stud (D04) Before and After Dry-Ice Blasting Retreatment
After the nuts and studs were retreated by dry-ice blasting, they were dewatered again in acetone to ensure all moisture was removed. Final coatings of tannic acid and Paraloid B-44 were applied prior to packaging and storage.

![Figure 15. Iron Stud from Iron Group 1 (D04) - After Treatment (Courtesy Kate Sullivan, The Mariners’ Museum and Park)](image_url)

The sample collected from the DPL during mechanical cleaning was tested for chloride concentration through a process called digestion. The DPL sample from the wrought iron stud, only 0.07 g, was dissolved in warm HNO₃, neutralised with NaOH and vacuum-filtered to precipitate the dissolved iron as hydroxide. The filtered chloride-containing solution was diluted by a factor of 500 and analysed using IC to determine the concentration of chlorides.

The results of IC indicated that the digested sample contained just over 471 ppm [Cl]. The analysis underscored the importance of mechanically removing the DPL to ensure sufficient desalination and inhibit future corrosion of the artefacts.
The analysis was completed thanks to the instruction and supervision of volunteer chemist, Ralph Spohn.

Figure 16. The Neutralised Solution is Vacuum-Filtered to Remove Iron; with Ralph Spohn

Figure 17. The Dissolved Iron is Precipitated as Iron Hydroxide During Filtering
**Copper Alloy Firing Hammer**

The starboard Dahlgren Gun, excavated from the turret, contained a copper alloy firing hammer. The artefact, which also contained a wrought iron pin at the head, had been previously desalinated and was in wet storage awaiting the final stages of treatment. The initial plan for the artefact was to chemically clean the copper alloy to remove the copper carbonates formed during ER in sodium sesquicarbonate solution. Mechanical cleaning would be completed on the iron firing pin to remove ferrous corrosion products around the pin. A final protective coating would then be applied.

![Figure 18. Copper Alloy-Iron Hammer - Before Treatment](image)

However, after examining the desalination records of the artefact, it became apparent that the object may not have been sufficiently desalinated. As the artefact had been in ER with several other large artefacts, a new baseline would need to be established prior to additional treatment. To establish this baseline, the hammer was placed in ER in a sodium sesquicarbonate solution.
A preliminary chloride concentration was taken while the hammer was in wet storage, the day after starting ER and then again two weeks after that point. The concentrations were approximately 0, 12 and 13 ppm per 200 g/L of object, respectively. This indicated that the hammer had not been sufficiently desalinated. The chloride concentration was monitored biweekly until the end of my placement. At the end of Week Eight, the sesquicarbonate solution was renewed because the chloride extraction rate had begun to slow. The hammer will remain in ER until the chloride concentration is consistently less than 5 ppm per 200 g/L of object.

Table 1. Desalination of Copper Alloy - Iron Firing Hammer

**Wood Tool Handle**

A waterlogged wood tool handle had been discovered in the concretion of another artefact. The tool handle was heavily stained by iron corrosion products but was otherwise stable and relatively strong. To remove the iron staining, the artefact was first cleaned mechanically with an ultrasonic scaler which was particularly effective at removing the staining. Additionally, the artefact was immersed in ammonium citrate dibasic, a chelating agent, to extract the remaining iron embedded in the wood’s microstructure.
As a result of increased visibility of the object’s surface during treatment, the presence of a small graphitised cast iron nut at the base of the handle was observed.
The cast iron ring would have been part of the handle butt plate. A metal instrument was connected to the handle but had completely corroded. An outline of the tool can be identified in the original X-radiograph (X-ray) of the concretion. The small, graphitised nut eventually separated from the handle during treatment and was accessioned. Treatment of the two components continued separately from this point, and the nut was placed in its own container to desalinate, where it remained for the rest of the summer.

![Figure 21. Tool Handle Nut - During Treatment](image)

The handle was ready to be immersed in a bulking agent to stabilise the structure prior to freeze-drying. The strong and durable nature of the object indicated that cellulose decay was not very extensive. The handle was placed in an initial solution of 5.0% w/w polyethylene glycol (PEG) with a molecular weight of 2000.
The plan was to increase the concentration of PEG 2000 by 5% every two weeks. This was to avoid structural collapse that could occur by displacing water molecules with a much denser material, PEG in this case. Approximately one week after the second increase to 15% w/w PEG 2000, biological growth was observed on the wood. A biocide was added to the PEG solution to inhibit further biological growth. Another conservator will continue the treatment until the PEG concentration reaches 40% w/w, at which point the handle will be freeze-dried.

**Concreted Valve**

One of my favourite projects during the placement was the deconcretion of a concreted composite artefact that was most likely a component of the hull. The object reveals an exposed barrel valve and six-hole flange, both of copper alloy material. However, the rest of the concretion was difficult to identify, apart from possibly two additional flanges in the centre and top of the concretion. In an attempt to ascertain additional information, the artefact was analysed using X-ray. Unfortunately, the concretion surrounding the object, made primarily of calcium carbonate (CaCO₃), was too dense to observe any features below the surface.

![Concreted Valve - Before Treatment](image-url)
Since there was very little information on what was beneath the surface, I proceeded slowly, deconcreting the object by pneumatic chisel until surface features of the artefact could be identified. Once I was comfortable that I had established the borders of the object, deconcretion proceeded slowly with a hammer and, sometimes, a chisel. The carefully applied force was effective at separating the concretion from the artefact underneath. However, the elbow valve and twelve-hole flange (top half of the artefact) were identified as graphitised cast iron. Therefore, deconcretion proceeded especially slowly in this area and was not carried out to completion. Instead, the deconcretion was focused on the join of the copper alloy and graphitised cast iron components which were separated by a vulcanised rubber gasket.
In total, the artefact lost approximately one-third of its weight during the deconcretion, decreasing from roughly forty to thirty kg. The copper alloy and cast iron components are clearly visible. As a result of the mechanical force applied to deconcrete the artefact, a slight crack appeared through the graphitised twelve-hole flange. The crack was supported with vinyl padding and two 2” C-clamps. The artefact will remain in wet storage prior to separation of the component parts.
**Team Projects**

In addition to the individual projects discussed, I also spent approximately one day per week working the conservation team on larger group projects. These projects usually focused on large artefact treatments, which required more than one person. These projects were extremely insightful into the communication and teamwork involved in carrying out conservation duties for these objects – transporting, mechanically cleaning and preparing solutions for large artefacts.

Several large, wrought iron artefacts from the turret were desalinating and in need of another round of dry ice blasting. I worked with different members of the conservation staff to: disconnect the artefacts from electrolysis, remove them from their large tank, document and dry ice blast them, and return them to their tank to restart electrolysis. This process was time-consuming and required constant communication and coordination between all members of staff. Such work was planned in advance over a five-day period, and different staff was scheduled accordingly. Different large artefact projects were organised in the same manner throughout the summer.

*Figure 26. Laurie King Dry Ice Blasts a Large, Wrought Iron Artefact*
Community Engagement and Leisure

An important aim of my placement was to gain a deeper understanding for Hampton Roads and the museum’s role in the community. As a native Florida, I was thrilled to be back near the water and took advantage of visiting the local beaches and coastline. My beach of choice was at First Landing State Park where I received free parking from the National Park Service with my museum ID badge. I also visited the Virginia Aquarium, Norfolk Waterfront, USS Wisconsin, Hampton Roads Naval Museum and Cape Henry Lighthouse free of charge with my ID.

Aside from the beach, my favourite leisure activity during my placement was running the Noland Trail. The Noland Trail is a scenic five-mile trail that encircles Lake Maury in The Mariners’ Museum Park (Figure 3). I would often run the trail before or after work with Kate Sullivan, an activity that carried over into my passionate discussions with museum visitors.

During the summer, I gained a new dive buddy in maritime archaeologist Hannah Fleming, when I finally earned my scuba dive qualification. Not only did I fulfil a lifelong ambition, but the experience augmented my research and practical work on maritime artefacts. I was also fortunate enough to visit the Colonial Williamsburg conservation laboratories and receive a tour of the facility from archaeological conservator Emily Williams.

In addition to financial support from ZGTF, this placement was possible thanks to housing and transportation generously provided by my cousins, Catherine and Dave. This experience would have been incomplete without the daily party provided by their three daughters and my roommates, Abby, Caitlyn and Charlotte.
Conclusion

Support from ZGTF enabled me to gain valuable experience in my chosen specialism. Prior to the placement, I had begun to question whether it was possible to specialise in the conservation of maritime archaeological artefacts. The field is small and opportunities can sometimes be limited. However, my placement at The Mariners’ Museum and Park confirmed for me how much I enjoy this specialism and hope to work in the sector. The research and practical experience I gained, as well as the treatment rationale and methodology I employed will serve me well in the future, both on site and in the conservation laboratory.

The three weeks of additional work undertaken afforded me more time to treat artefacts and experience the local community. My priorities felt particularly well suited to The Mariners’ Museum and Park, where research and public engagement are at the forefront of their mission. The relationships I developed with the staff at the museum were incredibly valuable, both personally and professionally, and is the aspect of my placement which I am most grateful for. I wish to extend my sincere gratitude to all the conservators who carried out the rest of these treatments and have kindly sent me happy artefact updates.

Since completing my summer placement, I have returned to Cardiff, Wales where I will complete my final year of postgraduate study. I have continued my volunteer work with the Newport Medieval Ship Project and completed a brief placement on the Rooswijk 1740 excavation in Ramsgate, England. The work I completed this summer will no doubt serve as a foundation for future work in maritime archaeological conservation.
Appendix I: Calculating Chloride Concentrations During Desalination

During desalination, samples of artefact solutions are taken biweekly and analysed using ion chromatography (IC) to determine the concentration of chloride ions. This value helps to inform conservators on the status of treatment by determining the amount of chlorides extracted during desalination. The concentration of chlorides is calculated based on the weight of objects (g) in volume of solution (L). A laboratory standard of 200 g of object per 1 L of solution has been established at The Mariners’ Museum and Park and other laboratories.

The chloride concentration, determined by IC, is quantitatively compared against the actual versus the ideal weight/volume ratio. The following example shows a preliminary calculation two weeks after starting ER on Iron Group 1. In this example, the chloride concentration is determined to be 7.57 ppm per 200 g/L of object. This value is consistent with an artefact that has recently begun desalination. According to this same ratio, desalination is complete after the concentration is consistently measured at less than 5 ppm per 200 g/L of object.

![Example of Chloride Concentration Calculation from Iron Group 1](image)

*Figure 27. Example of Chloride Concentration Calculation from Iron Group 1*
Bibliography


