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CENTER FOR MARITIME ARCHAEOLOGY AND CONSERVATION

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DIRECTOR OF CRL

Christopher M. Dostal, Ph.D.

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Please send correspondence to: Center for Maritime Archaeology & Conservation

Anthropology Building 107

Texas A&M University

College Station, TX 77843-4352

United States

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On the Front Cover: Nautical Archaeology Program alumni Rafael Martinez Fança (left) and John Albertson (right) recording hull remains on the Highbourne Cay Shipwreck, featured on page 1. (Photo by Donny Knowles and the Highbourne Cay Shipwreck: Converging Worlds Project)

On the Back Cover: The completed *Heroine* model, as featured on page 12. (Photos by Chris Dostal)

From the Director- Christopher Dostal

Welcome to another edition of *News & Reports* from the Center for Maritime Archaeology and Conservation (CMAC) at Texas A&M University. A lot has changed with CMAC since the last issue; Dr. Donny Hamilton, the former director of CMAC and the founder of the Conservation Research Laboratory retired after more than 4 decades of service in August of 2020. Dr. George Bass, the father of Nautical Archaeology and the founder of the Institute of Nautical Archaeology passed away in March of 2021, leaving behind an incredible legacy that we hope to continue. And of course, the world was thrown into disarray with the COVID-19 pandemic, which ground much of CMAC's field research to a halt for the better part of a year.

Through changes and loss, CMAC is still here, and I am proud to say that we are working towards a brighter and stronger future. Maritime archaeology is a global pursuit, and as such the center still holds true to its founding principle of supporting and coordinating faculty and student field research projects around the world. In these pages, you will gain a brief glimpse into the extraordinary research done through CMAC over the past few years, with projects from the US, Canada, the Caribbean, and Europe, utilizing both tried-and-true methodologies and experimenting with cutting-edge technologies.

As things get back to normal, our faculty and students are hitting the ground running, and we have a sizable amount of exciting field research to share in upcoming issues. The research projects featured in this issue and future projects are made possible through the generous support of funding agencies and through individual supporters. If you find yourself inspired by our research and wish to support specific projects or the general mission of CMAC, you can either reach out to me directly or go donate online through our website: <https://nautarch.tamu.edu/cmac/>



Chris Dostal
Email: dostalc@tamu.edu
Phone: 979-845-5242

CMAC
Anthropology Building
MS 4352 TAMU
College Station, TX 77843

In Memoriam Dr. George F. Bass (1932-2021)

It is with deep sadness that we announce the passing of Texas A&M University Distinguished Professor Emeritus George F. Bass on March 2nd, 2021.

It is an uncommon privilege, not possible in many fields, to have met and known the founder of our discipline. The faculty, alumni and present students of the Nautical Archaeology Program have been fortunate to count George Bass, the Father of Nautical Archaeology, among our mentors, professors, and as a friend.

George Fletcher Bass received his Master's Degree in Near Eastern Archaeology from Johns Hopkins University in 1955 and subsequently received a doctorate in Classical Archaeology from the University of Pennsylvania in 1964.

During his doctoral studies, he served as co-director of the excavation of the Bronze Age Cape Gelidonya Shipwreck, the first excavation of ancient shipwreck in its entirety, the first excavation in which archaeologists dived on-site, and the first underwater excavation that sought to replicate scientific standards of archaeological practice from terrestrial excavations.

Following the completion of his doctoral studies, Bass served as faculty at the University of Pennsylvania until 1973 when he founded the Institute of Nautical Archaeology (INA), serving as President of INA from 1973 until 1982 and again from 1996 to 1999.

In 1976, INA affiliated itself with Texas A&M University and Bass established the Nautical Archaeology Program, serving as a professor and chair of the Nautical Archaeology Program until his retirement in 2000.

Bass was a prolific researcher and author, directing or managing numerous projects principally in Turkey, but also throughout the



Mediterranean and North America.

After his retirement from teaching, Bass remained a staunch advocate for nautical archaeology and stayed active both within INA and the Nautical Archaeology Program. His engagement, advice, and friendship has influenced successive generations of nautical archaeologists.

It is difficult to overstate the influence that George Bass has had on the discipline of nautical archaeology. His extensive meticulous field research and his many influential publications were foundational to underwater archaeological methodologies, and he has expanded the way we all think of seafaring history. The discipline is indebted to his innovations and his commitment to the education and training of future generations of nautical archaeologists, which continue to carry on the legacy of his life's work.

Revisiting the 16th-Century Highbourne Cay Shipwreck

Charles D. Bendig

Nautical Archaeology Program, Texas A&M University

Skin divers exploring the coral reef system near the northern extent of Highbourne Cay in 1965 stumbled upon the remains of a concreted ballast mound. The site is situated within the confines of what modern navigation charts label as ‘Allen’s Cut’ (fig. 1). This area is part of the northern half of the Exumas, Bahamas, and roughly 35 miles southeast from the country’s capital, Nassau, New Providence. Over the following years, the skin divers contacted salvors from Bermuda and Smithsonian Institute historian, Mendel Peterson, to retrieve the visible artifacts from the area. The salvagers recovered most of the larger iron artifacts, including three anchors, wrought-iron breech-loading cannons, numerous wrought-iron swivel guns, shot, rigging, and multiple types of fasteners originally used in the hull’s assembly. Few examples of personal possessions were recorded, only the handle of a knife inlaid with gold. No obvious cargo was identified. Peterson recorded the items and published a preliminary survey about the 1960s salvage. He also noted that the ballast protecting the extents of the bow and stern had been removed, exposing hull structure. Many of the iron artifacts from these early investigations are on display at the Mariner’s Museum in Newport News, Virginia, or housed in warehouses owned by the Smithsonian Museum in Washington, D.C. The location of smaller artifacts, such as the knife handle, are currently

unknown.

Graduate students from the Nautical Archaeology Program at Texas A&M University (TAMU), supported by the Institute of Nautical Archaeology (INA), began investigating the Highbourne Cay shipwreck in the 1980s. This group was already involved with an ongoing project in the Turks and Caicos recording the early 16th-century Molasses Reef shipwreck on behalf of the government. The TAMU/INA team was mainly interested in Highbourne Cay due to Peterson’s publication reporting a similar vessel type from the same period.

Initial survey work by the graduate team in 1983 reported that the earlier removal of the ballast rock by the salvagers left no surviving hull structure in these areas. Fortunately, the team were able to determine that the rest of the concreted ballast mound still contained significant wood underneath. Based on these findings, the TAMU/INA team returned to the site in 1986 for 19 days to conduct limited excavation and survey the surrounding area.

Magnetometer surveys of Allen’s Cut did not locate any major anomalies and a terrestrial survey visiting three freshwater springs on Highbourne Cay found no artifacts. The rest of the time allocated for investigating the shipwreck focused on excavation and recording the surviving hull structure. When the ship originally sank to the limestone seabed, it landed on

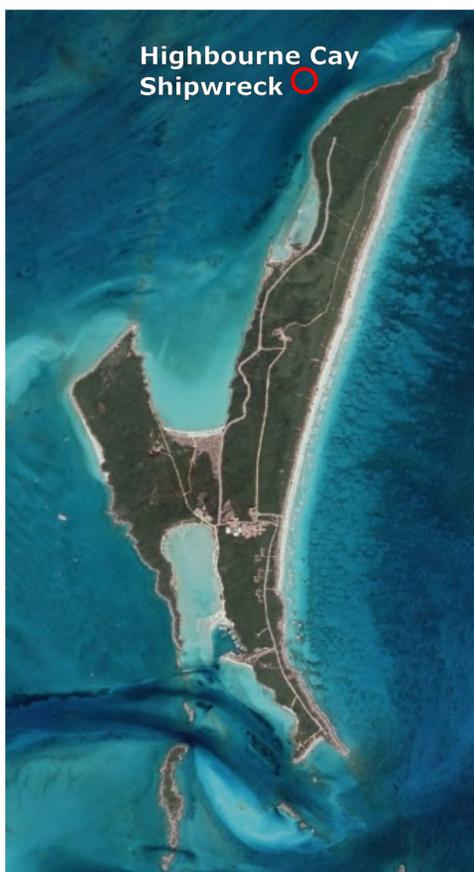


Figure 1: Satellite image of Highbourne Cay,



Figure 2: 2017 Andrew Willard recording the aft section of the Highbourne Cay shipwreck in 2017. (Image courtesy of Donny Knowles and the Highbourne Cay: Converging Worlds Project)

its keel and slowly ground into the seafloor creating a trough. The 1986 team was able to relocate this trough and followed it from the stern towards the center of the ballast mound. Additionally, the team located timbers at the bow terminus of the same trough and cut a two-meter wide trench through amidships. Some of the key features uncovered during this investigation included an expanded section of the keelson for the mainmast, cuts into the keelson for the placement of a pump, and the keel-stem scarf junction. Few ceramics were removed from the site, along with a handful of ballast and wood samples.

The ceramic sherds supported the archaeologist's beliefs that the Highbourne Cay shipwreck was also from the early 16th century. Wood samples indicated that the hull was made from white oak (*Quercus* sp.) and that pieces from the pump well (a wooden box built to protect the pump) utilized trees from the willow (*Salicaceae*) and cedar (*Cupressaceae*) families. After exposing sections of the hull, the graduate team backfilled the site with fine sand and reburied the exposed wood with the previously removed ballast. Any of the exterior ballast that had

coral were placed last with the hope that the various species would regrow in the disturbed areas. Before departing, the archaeological team left a permanent plexiglass sign at the site informing anyone visiting that the shipwreck contained no treasure and that it was protected by the Bahamian government.

Over the following decades, no scientific revisits were attempted, although the locals who lived in the area periodically continued to dive at the site. Texas A&M doctoral student, Nicholas Budsberg, began visiting with Bahamian officials in 2012 about returning to the shipwreck. Budsberg believed that the Highbourne Cay shipwreck might provide an ideal *in situ* preservation case study for evaluating how well the hull remains survived after several previous decades of disturbance and learning additional information about early European exploration of the Caribbean. Budsberg visited the site in 2013 with the support of government officials, local interest groups, and Bahamian volunteers. This visit was predominantly concerned with collecting initial data about the current state of the site for future work. In 2015, Budsberg assembled a small team that



Figure 3: Ceramic handle - a loosely compacted, sand-tempered, coarse earthenware. (Image courtesy of Sarah Budsberg and the Highbourne Cay: Converging Worlds Project)

included, Charles Bendig, then a graduate student at the University of West Florida, as well as Chuck Meide and Sam Turner, members of the St. Augustine Lighthouse and Maritime Museum's Lighthouse Archaeological Maritime Program. Over the course of two weeks, the 2015 team excavated a parallel trench near amidships confirming that the timber remains originally mapped by the 1986 team survived intact. The site was visually photographed, video recorded, and a three-dimensional photogrammetric model was built.

Evidence from the 2015 investigation also revealed that the site was not perfectly preserved. Previous reburial efforts eventually led to the repositioned ballast slumping and sliding in excavated areas. The position of the ballast mound in Allen's Cut was also inhibitive, as the location is only 8 m deep and experiences tide switches with an active current (5-7 knots at flood tide, 3-5 knots during the ebb). Prior to the original disturbance by the 1960s salvagers, site formation processes led to the ballast slumping at the bow and stern as the hull decayed, naturally deflecting the surging current. The 2015 survey identified that over the past 30 years the current was slowly cutting beneath the surviving concreted ballast mound and destroying the preserved wood underneath. Based

on this analysis, Budsberg, Bendig (now a doctoral student at Texas A&M), and Dr. Filipe Castro devised to return in 2017 with a full field crew to conduct a renewed investigation and preserve the site. This fieldwork was supported by the Center for Maritime Archaeology and Conservation (CMAC), the National Geographic Society, Institute of Nautical Archaeology, Orchard Garden Hotel, Stuart Cove's Dive Bahamas, Highbourne Cay Resort and Marina, Explorer's Club, and the TAMU Anthropology Department.

The 2017 project was an international collaboration that included 28 personnel representing 22 institutions from across 13 countries. CMAC funds were incredibly supportive, allowing the principal investigators to set up the necessary logistics and during subsequent excavation. Fieldwork took place over nine weeks and was unfortunately cut short due to the arrival of Hurricane Irma in early September. Over the course of the field season, the team was able to conduct biological surveys of the surrounding environment, transplant living corals, recover 500 artifacts, excavate and record most of the surviving hull structure (fig. 2), and create multiple photogrammetry models. Team members also revisited the freshwater springs, created a high-resolution map of the island using drone footage, and built lasting relationships with government and local stakeholders who continue to monitor the shipwreck today. Research on the latest findings is still ongoing, including analyses of the ceramics (fig. 3), dendrochronological studies of the wood, hull reconstruction, delving into archive materials, and reviewing the other artifacts in the collection. In the meantime, the project team is planning to return to Highbourne Cay in the next few years to finish the data collection that was impeded by Hurricane Irma and hopefully answer a few remaining questions about the identity of the shipwreck.

Archaeological Investigation and Artifact Recovery from the King's Shipyard Site (2019)

Daniel Bishop

Nautical Archaeology Program, Texas A&M University

In mid-May 2019, I led a six-week underwater investigation of a mid-18th-century submerged site (the King's Shipyard) in Lake Champlain near Fort Ticonderoga, New York. The archaeological team included staff from Lake Champlain Maritime Museum, graduate and undergraduate students from Texas A&M University, and local volunteer divers. Funded by the Institute of Nautical Archaeology, this team surveyed the hull remains of two wrecks (KS-1 and KS-2) thought to be ex-French vessels that were captured by the British and used during the Seven Years' War on Lake Champlain. One of the goals of this survey was to examine the hull construction and

artifacts found on the sites to validate their tentative national identities (fig.1).

The King's Shipyard presents a challenge to archaeologists trying to understand artifact provenance. The site has seen continuous use from the mid-18th century to the present. From the outset of this project, we expected to recover intrusive artifacts or, at the least, artifacts from one of three periods: mid-eighteenth, late-eighteenth, or nineteenth century. While most of the artifacts recovered from the site are more easily identifiable and can be approximately dated, others defy typical methods of seriation and typological/technological classification. These



Figure 1: Operations during the 2019 King's Shipyard survey.

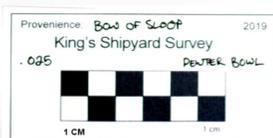


Figure 2: Pewter bowl recovered from KS-1. (Photo by Cheryl Gilligan)

“troublesome” artifacts make vessel identification much more complicated, especially because the majority of the artifacts were deposited over a ten-to-fifteen-year period. It is hoped that further analysis will give us a better understanding of the nuances of this site’s provenance.

The underwater survey focused largely on the stem, stern, and a partial frame section on KS-1. These test excavations yielded artifacts that shed light on the vessel’s use, abandonment, and how people interacted with the vessel after it sank. Among the artifacts recovered from KS-1 are a pewter bowl, leather shoe fragments, animal bone (horse, pig, and deer), seeds, nuts, a gun flint, lead shot, whiteware ceramics, brick fragments, a 26th Regiment brass button from a British Army uniform, brass buckles, and barrel staves (figs. 2–4). However, some of the most informative artifacts are the fasteners that were recovered. Many of the square nails used to laterally fasten the framing components of the sloop were of a clenched design, which is typically diagnostic for French ship construction (fig. 5). Other than these fasteners, we did not observe any diagnostic artifacts suggesting French origin; this does not necessarily mean that there are no other diagnostically French artifacts on this wreck, as we only excavated around 2

percent of this site.

Before beginning conservation treatment of the organic artifacts, I worked with Cheryl Gilligan, the Lake Champlain Maritime Museum’s archaeologist and bone analyst. Gilligan evaluated the faunal remains and made some surprising discoveries, the most significant of which were butcher marks on

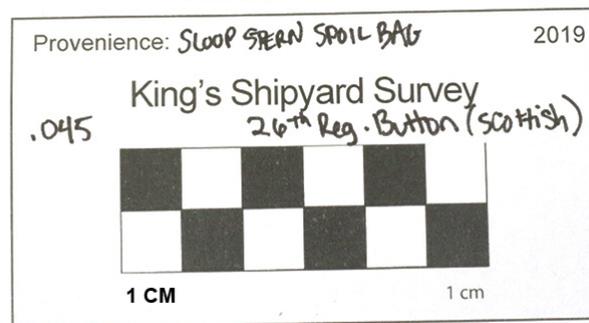


Figure 3: A 26th Regiment button recovered from KS-1. (Photo by Cheryl Gilligan)



Figure 4: Leather shoe fragments recovered from KS-1. (Photo by Cheryl Gilligan)



Figure 6: Horse scapula with butcher marks. (Photo by Cherilyn Gilligan)

the horse bones (see Figure 6). This, together with the identified remains of deer and evidence of seeds and nuts (see Figure 7), demonstrates that the sailors aboard this vessel had a relatively diverse diet. It also reveals that they relied on foraging and hunting game to supplement their military victuals.

Above all, the King's Shipyard artifacts will be most useful when we compare them to those of

Boscawen, a British sloop built in 1759 that is also located at the site. More research into how KS-1 and *Boscawen* tie into broader eighteenth-century military provisioning strategies is currently underway.



Figure 7: Walnut shells recovered from KS-1. (Photo by Cherilyn Gilligan)

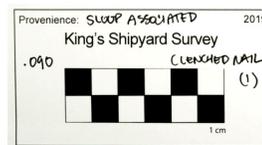


Figure 5: Square iron clench nail from KS-1. (Photo by Cherilyn Gilligan)

With generous support from CMAC and Texas A&M University's Conservation Research Laboratory, these artifacts are in the final stages of their various conservation treatments. After conservation, they will be stored in Fort Ticonderoga Museum's repository.

The Three-Dimensional Recording, Modelling, and Reconstruction of the *Katie Eccles*, a Great Lakes Schooner From the Last Years of Sail

Benjamin M. Ioset

Nautical Archaeology Program, Texas A&M University

In the past decade, three-dimensional recording methods have come into their own in nautical archaeology, allowing the development of three-dimensional representations of sites which can be used for further study and site-monitoring. Particularly prominent has been Agisoft Metashape, a structure-from-motion photogrammetry

software which enables the development of three-dimensional models with photorealistic textures from a series of successive, overlapping photos. Using the Exchangeable Image Format (EXIF) data and pixel data, the program identifies shared points which are then able to be positioned in three-dimensional space, forming a sparse point cloud, representing the subject's



Figure 1: The intact bow and bowsprit of the *Katie Eccles* (Benjamin Ioset)

geometry. Metashape's workflow enables the successive rendering of a dense point cloud, of a mesh and allows the application of photorealistic textures, providing an accurate and scalable representation of the site.

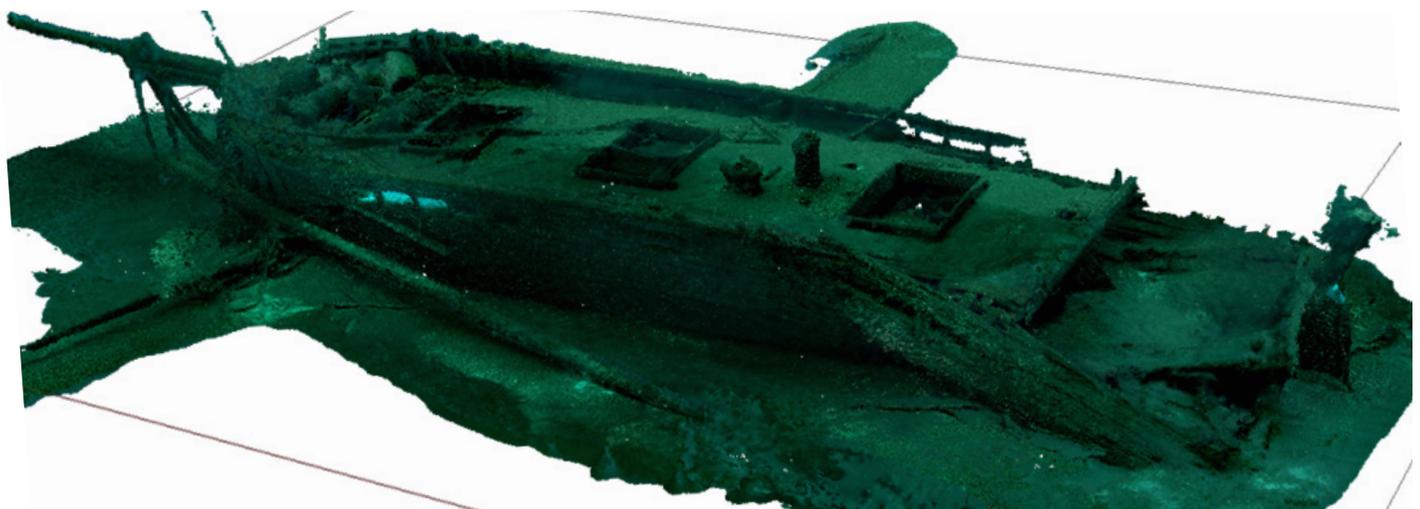
In 2019, as part of wider dissertation research into the last generation of schooners operating on Lake Ontario, the author led a project to record the remains of the *Katie Eccles*, a well-preserved two-masted schooner, built in 1877 and lost off Prince Edward County, Ontario at the end of November 1922. The Last Schooners Project was made possible by the financial support and loans of equipment from the Texas A&M University Department of Anthropology, from the Center for Maritime Archaeology and Conservation, and from the Institute of Nautical Archaeology.

Among the principal objectives of the 2019 field season of the Last Schooner Project, was to utilize photogrammetry in the study of hull form and construction, as these relate to the routes and economic role for which the vessel was intended. In contrast to the longer-distances of the inter-lake bulk freight trade, *Katie Eccles* operated its entire career within Lake Ontario and the Upper Saint Lawrence River, shedding light on a historically underrepresented role in the Great Lakes coastwise trade and in the intensive commerce conducted between

Canadian and American ports across Lake Ontario throughout the 19th and early-20th centuries.

Analysis of hull design on the Great Lakes has been impeded by an absence of ship line's, which form the conventional means of portraying a three-dimensional hull in two-dimensions. While formalized drafting of ship lines was used in the 19th century, this method was seldom if ever used by shipwrights building wooden vessels on the Great Lakes. Of the thousands of sailing vessels plying the Great Lakes in the 19th and early-20th centuries, lines exist for approximately thirty-five sailing vessels. This absence of comparative data has impeded our understanding of how sailing vessel hull forms developed chronologically, as well as how designs were adapted to fulfill various roles within the Great Lakes maritime economy. Therefore, producing a set of lines plans for the *Katie Eccles* was among the objectives of the 2019 field work.

Between 13-21 June 2019, three researchers from Texas A&M University's Nautical Archaeology Program and one volunteer, conducted remote video recording of the *Katie Eccles* site in Canadian waters of Eastern Lake Ontario using a remotely operated vehicle (fig.1). The use of a Teledyne Seabotix LBV-150-2 remotely operated vehicle was used as provincial



(Figure 2: The 2019 photomodel of the *Katie Eccles* (Benjamin Ioset)

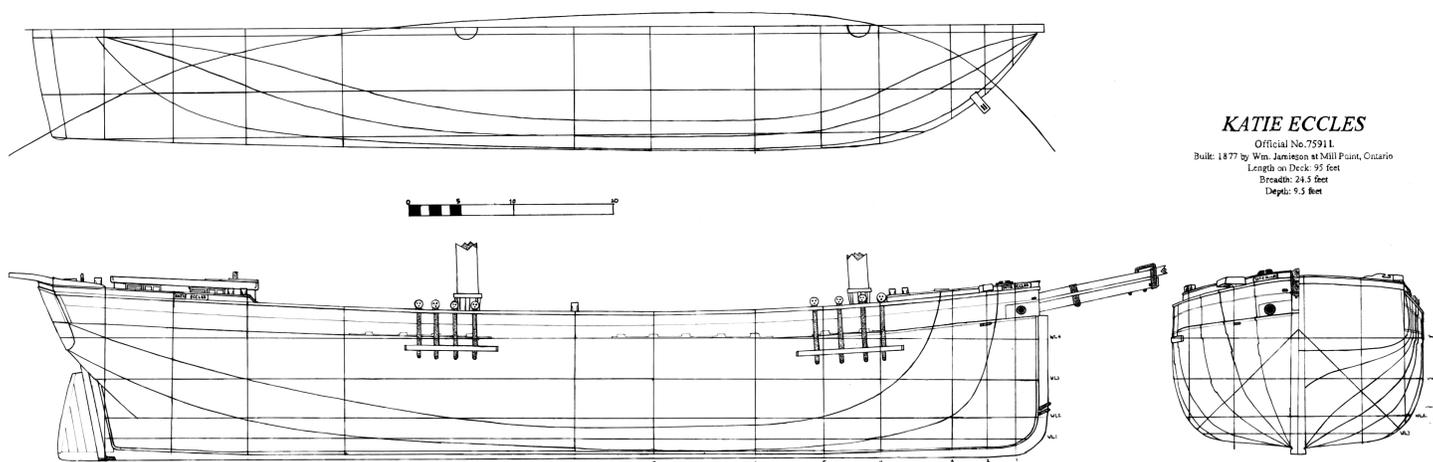


Figure 3: Reconstructed lines drawing of Katie Eccles (Drawing by Benjamin Ioset, Copyright 2020)

regulatory restrictions made diving operations impossible within the available planning period and budgetary restrictions. Over three days on site, nearly eight hours of digital video was recorded on a GoPro Hero 7 mounted to the frame of the LBV-150, as the internal camera, used for piloting the ROV, was of comparatively low-resolution. The site was recorded in successive panning passes around the hull at depth intervals of approximately one meter. Recording video eliminated the need to plan lateral overlap between successive photographs, though vertical overlap was planned between successive passes.

After the end of the short field season, individual video frames were extracted directly in Agisoft Metashape and were grouped into overlapping chunks, each representing a section of the site. The separation of the site into chunks was necessary to reduce overall processing time in Metashape. Once each chunk had been processed into a sparse point cloud and then to a dense point cloud, the chunks were aligned. The principal difficulty was in obtaining sufficient overlap between these chunks to permit the software to align adjacent chunks accurately. For some chunks manual input of markers on shared points between photos was required to align the chunks. Once aligned, a mesh and textures was rendered for the unified model (fig.2). The model

was scaled to 1:1 by inputting known distance between markers which derived from on-site measurements taken with a scaling bar attached to the LBV-150. As the standard deviation of error across the site remained high, the breadth amidships from the 1877 enrollment record was used to constrain the scale further.

To produce a set of lines representing the form of the hull, the photo model was imported as an .OBJ file into Rhino3D, a three-dimensional modelling software. The “Section” command was then used to take section profiles along the longitudinal centerline at regular intervals. After the original rise and run of the sheer was estimated from historical photographs, these sections were aligned at their stations, and adjusted into a faired set of lines (Fig.3).

This combination of digital recording methods and traditional drafting proved both effective and remarkably efficient means of producing a set of lines from well-preserved, largely intact archaeological vessels. Future research by the author will include the digitization of the hull lines in Rhino3D and the hydrostatic analysis of the hull in the Orca plug-in for Rhino3D.

The Shipwrecks of La Hougue: Diversity in the Shipyards

Marijo Gauthier-Bérubé

Nautical Archaeology Program, Texas A&M University

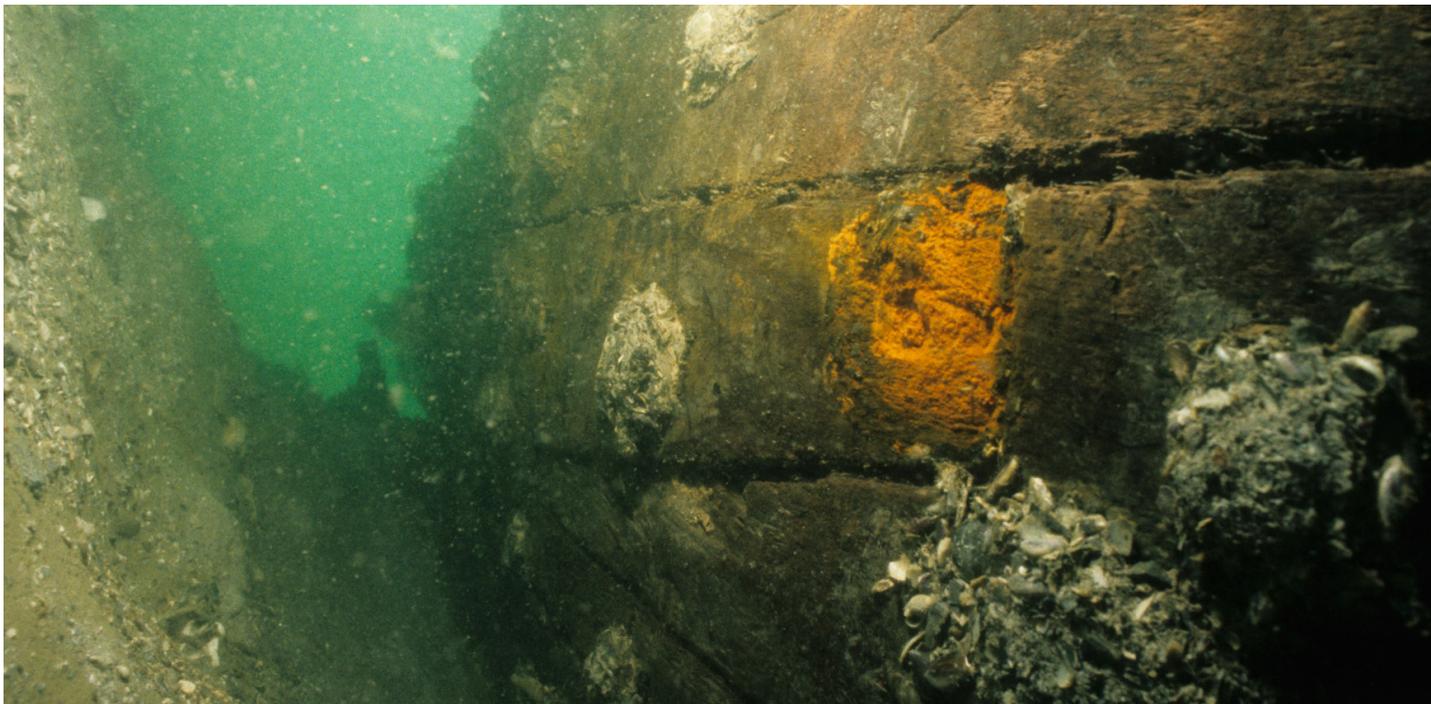


Figure 1: Hull section on the wreck E (Frederic Osada, ©Ministère de la Culture DRASSM)

In 1692, during the battle of La Hougue between the French and a coalition of the British and the Dutch, five French first-rates were sunk at Saint-Vaast-la-Hougue, France. Discovered by local divers in the 1980s, the wrecks were excavated between 1990 and 1994 by the Direction des Recherches Archéologiques Subaquatiques et Sous-marine. La Hougue's wrecks provided extensive data, both individually and as a group, about late 17th century French shipbuilding. Not only do these wrecks give the opportunity for a detailed comparative analysis between each other, they also added to what has been a limited corpus of French shipwrecks of the same period.

The five wrecks are:

- *Merveilleux* (wreck D or E), a 96-gun ship built in 1691 by Blaise Pangalo in Brest
- *Foudroyant* (wreck D or E), a 94-gun ship also built in 1691 by Pangalo in Brest
- *St-Philippe* (wreck A/B), 80-gun ship built in 1665 by Gédéon Rodolphe in Toulon
- *Magnifique* (wreck C), an 80-gun ship built in 1680 by François Chapelle in Toulon
- *Ambitieux* (wreck F), a 96-gun ship built in 1691 by Honoré Malet in Rochefort

Historians have thoroughly documented the late 17th Century as the birth of France's first navy through the study of treatises, ordinances and other archival documents. This approach, however, is limited to written evidence and has not yet integrated a holistic analysis of the archeological record. The wrecks

represent an important period of change when newly created institutions, dedicated to the theorization of shipbuilding, challenged traditional construction methods, and in which standardization of dimensions and proportions, as well as the practice of drawing were being introduced. However, shipwrights did not automatically approve of these new practices and resisted with their traditional knowledge and wooden template methods. Understanding the architectural features of the archeologically recorded shipwrecks may explain how the French Navy developed and standardized beyond the limits of written documents. The shipwrecks of La Hougue have construction similarities yet form distinct groups when looking at the framing pattern and other assemblage practices. For example, the ships built in Toulon in the Mediterranean sea, *Saint-Philippe* and *Magnifique*, are both built with a single frames. The *Ambitieux*, built by the same shipwright that built *La Belle*, has a double frame

construction with no half-floor timbers which is exactly the same as *La Belle*. Finally, *Merveilleux* and *Foudroyant* both have full double-frame construction as they are both built in Brest by Pangalo. While none of the wrecks have enough archeological remains for a full analysis of their design method, the variety of framing methods also reveal that there was a diversity of design technique being used at the same time. Multi-site analysis can be a powerful tool of analysis to track changes in technology and techniques used for shipbuilding. Together, the wrecks of La Hougue combined with the other known French wrecks have the potential to highlight the traditions and changes that characterized this era of shipbuilding. Not only will it add to the general history of European wooden shipbuilding, but also to the history of science.



Figure 2: Rigging element being excavated on the wreck AB in 1994 (Frederic Osada (c) Ministère de la Culture DRASSM)

The Model Reconstruction of the Western River Steamboat *Heroine*

Glenn Greico

Ship Model Laboratory, Center for Maritime Archaeology and Conservation

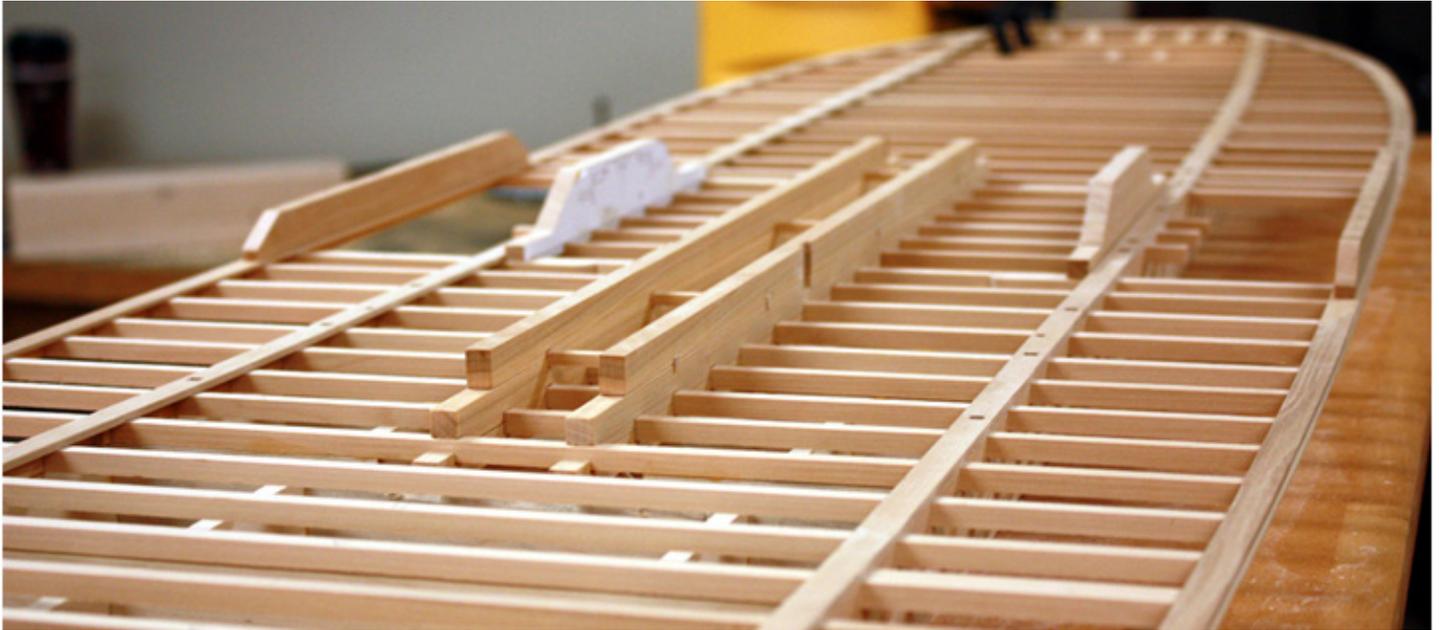


Figure 1: Model of *Heroine's* main deck. Most of the main deck structure has survived on the wreck.

In the first quarter of the 19th century, the opening of the western rivers provided an opportunity for rapid expansion in the United States. Shallow winding rivers and long stretches of uninhabited land brought about the need for a new type of vessel. The Western River steamboat was born out of a need for a hardy, reliable, shallow draft vessel that could negotiate the obstacles and tight turns of the rivers and utilize the muddy waters for steam production while being easy to maintain far from civilization. In only a few decades, the design would evolve into a highly specialized vessel perfectly suited for the task, but very few examples of these early boats exist.

Between 2002 and 2008, one early example, *Heroine*, was excavated by the Oklahoma Historical Society and the Institute of Nautical Archaeology under the direction of Kevin Crisman. Built in 1832 in New Albany, Indiana, she was carrying supplies to Fort Towson in what

is now Oklahoma when she ran onto a snag in the Red River just miles from her destination. The Oklahoma Historical Society commissioned the Center for Maritime Archaeology's Ship Model Laboratory to build two 1:12 scale models, one for the Oklahoma History Center in Oklahoma City and the second for the visitor's center at the Ft. Towson Historical Site.

Working from the extensive excavation notes and reconstruction drawings provided by Dr. Crisman, two waterline models were created of the 136-foot-long 150-ton vessel. The completed reconstructions represent what *Heroine* would have looked like early in her career, but the wear and tear on her machinery, being an important aspect of her history and character, was reproduced in the models. Broken and repaired paddlewheel and flywheel flanges, worn bearings, and numerous wrought iron patches were indicative of the harsh conditions on the river. The models were left unplanked

on the port side, allowing details of *Heroine's* construction to be seen.

Incredibly, almost all of the hull and deck structure including the massive support timbers for the cast-iron engine, flywheel, and paddlewheels survived nearly two centuries in the strong currents of the Red River (fig. 1). Despite most of the superstructure being lost, the location of postholes, machinery, and other structures in the deck hint at what the upperworks looked like. Two massive stacks of heavy timbers called cylinder timbers on either side of the centerline of the deck supported the heavy engine flywheels and drive train. Multiple notches, holes, and fasteners in these timbers gave a footprint for the engine, pumps, and water supply line. Extensive research by Dr. Crisman provided a very plausible reconstruction of the entire vessel. For the model, all of the wooden structure was constructed out of Castello boxwood, a species of wood chosen for its appearance of white oak at this scale.

Heroine's paddlewheels were driven by a single high-pressure double-acting horizontal



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Figure 2: Fragments of two cast iron standpipes and a high-pressure check valve

engine supplied with steam from a number of horizontal fire-tube boilers. The engine also powered two water pumps, one low-pressure pump for pulling water from the river, and a high-pressure pump to force water into the boilers. Comparing *Heroine* to other vessels of the period, it was determined that she most likely had four single flue boilers. Unfortunately, the engine and boilers are missing from the wreck, most likely salvaged for their iron. However, a handful of artifacts from the boiler and water

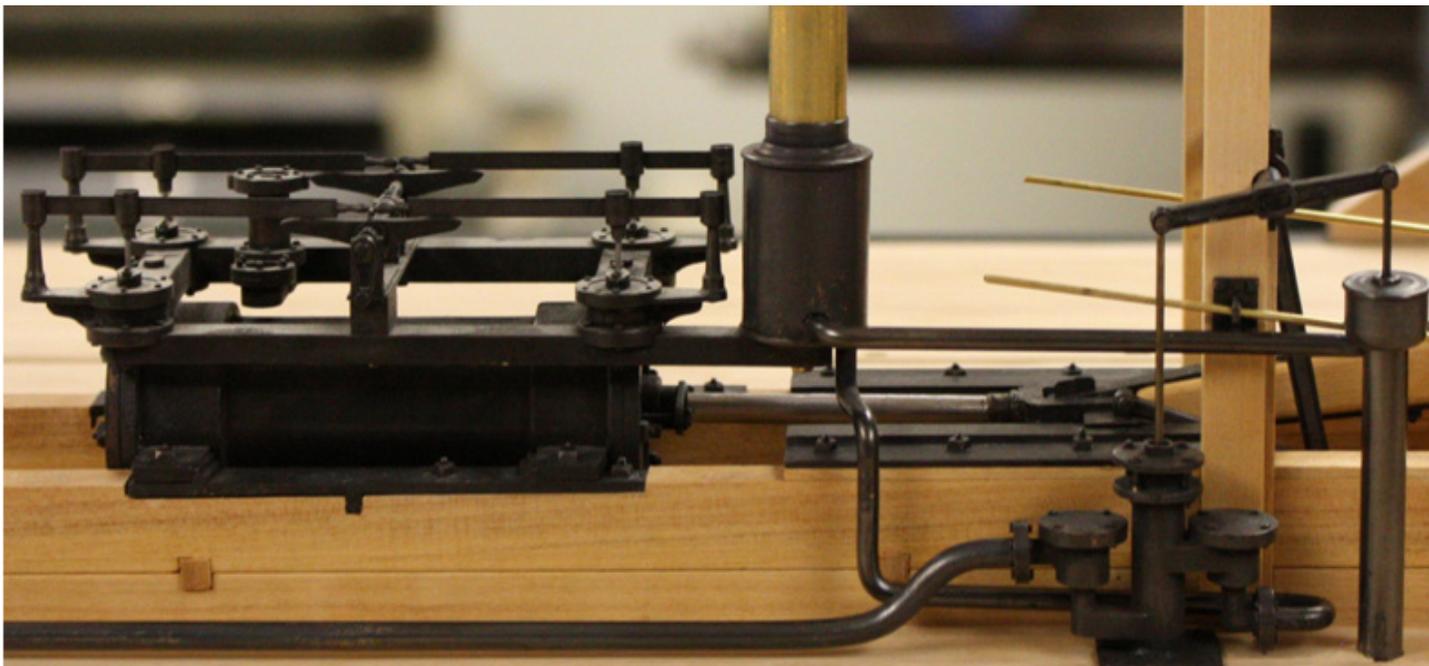


Figure 3: Model of the reconstructed feedwater pumps and supply line.

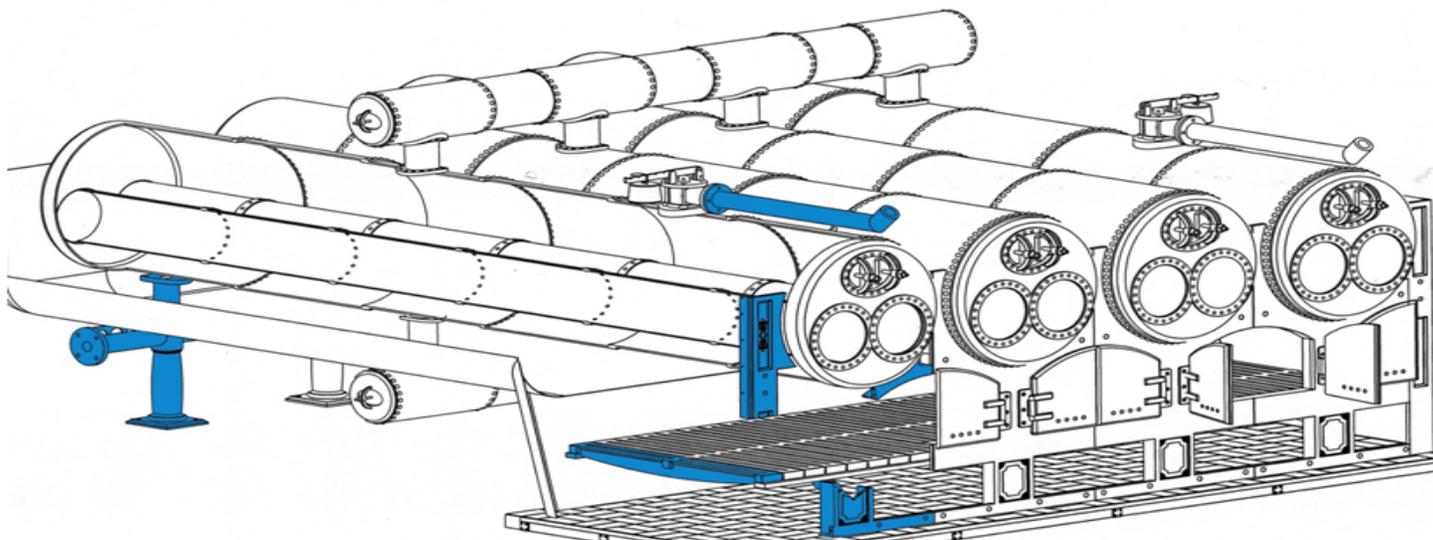


Figure 4: Drawing of the reconstructed boilers showing recovered artifacts highlighted in blue.

supply line were recovered from the site and provided important details of their construction. Fragments of two cast iron standpipes that supported and carried water to the boilers and a high-pressure check-valve represented the most important components (fig.2) while contemporary engineering drawings added the missing details (fig.3).

Surprisingly little of the cast iron drive train, flywheel, and paddlewheels were missing. This allowed a very thorough analysis of these parts,

and a complete 3D AutoCad reconstruction of these structures also provided valuable clues about the missing parts of the engine, such as the stroke of the cylinder and the design and dimensions of the steam valves. The huge cast iron flywheels and simple valve cam arrangement suggested an early form of horizontal steam engine similar to stationary engines seen in factories of the period.

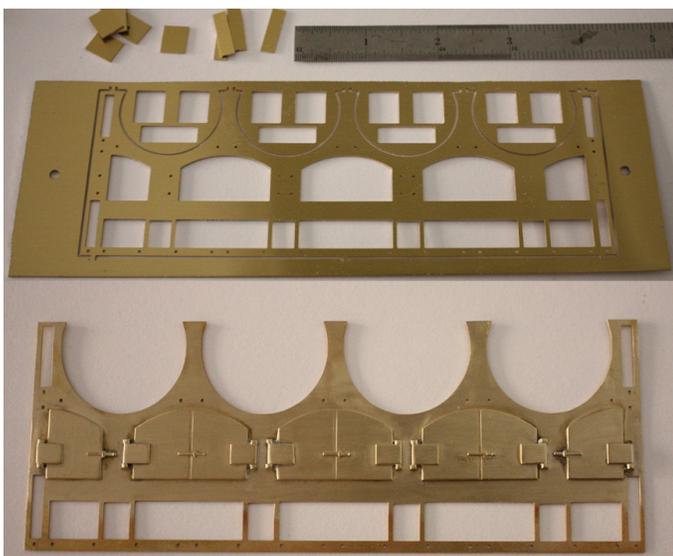


Figure 5: Boiler façade CNC milled in brass.

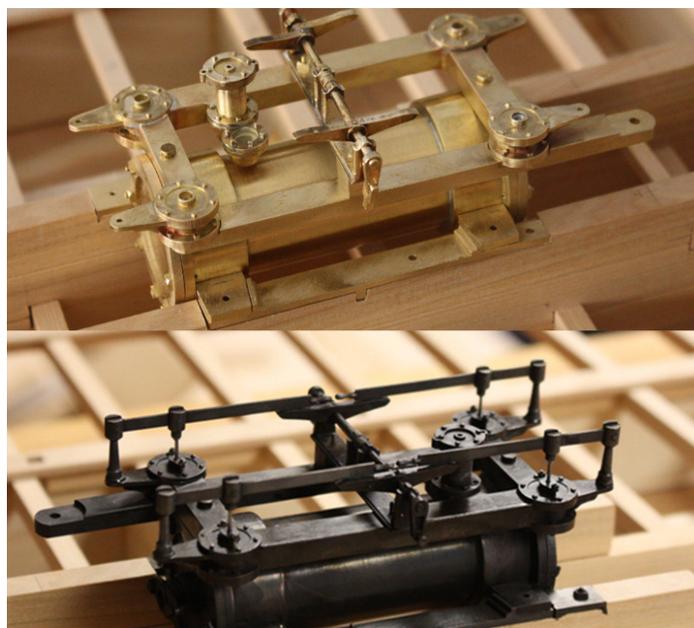


Figure 6: Model of Heroine's high-pressure engine before and after chemical blackening.

As the earliest excavated example of a western river steamboat, this machinery is a good illustration of the early evolution of this type of vessel.

Several ornate cast iron fragments of the boiler façade were recovered from the wreck, as well as a few pieces of what was determined to be thin sheet iron from the boiler surround and firebox. Although the cylinders themselves were not recovered, the geometry of the fragments contributed several important details including the boiler diameter, fire box dimensions, and the shape and placement of the firebox doors. A number of recovered fire grates provided additional dimensions for the firebox. Although only a handful of parts were recovered, they provided enough information for a nearly complete reconstruction of the boilers (fig.4).

With the entire boiler, engine, drive train, and wooden support structure reconstructed in 3D, it was then possible to machine the parts with a CNC (computer numeric control) mill (fig.5). Machined from brass, the components were then blackened to represent the appearance of the original cast and wrought iron parts (fig.6). When Heroine was constructed, her hull and lower deck were most likely constructed and launched before the machinery was installed. Once on the river, the machinery could easily be added on the open deck before the superstructure was constructed. This sequence

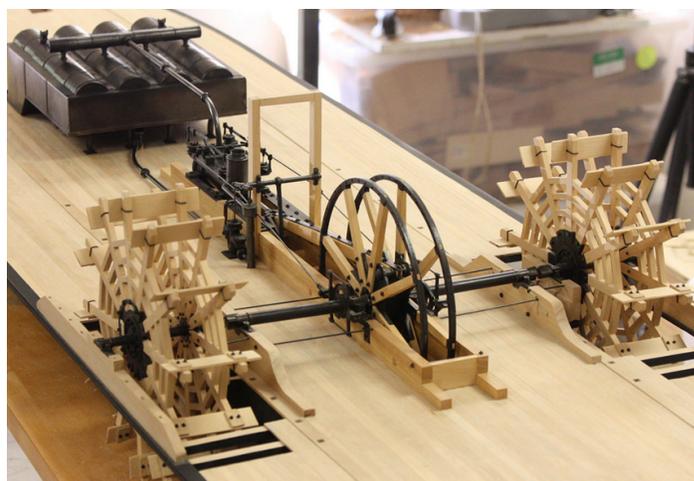


Figure 7: Model of completed engine and boiler arrangement on deck prior to the installation of the upperworks.

was followed with the model to show how she would have looked at different stages of her construction (fig.7).

Although most of the iron artifacts from the wreck were recovered and conserved, it was only possible to preserve a fraction of the wooden structures, leaving the rest to slowly erode in the Red River's strong currents. Thankfully, the efforts of the Oklahoma Historical Society, the Institute of Nautical Archaeology, the Center for Maritime Archaeology, and the archaeologists and volunteers who excavated and conserved the vessel have so thoroughly recorded Heroine's remains that her structure could be represented in the models (fig.8).



Figure 8: Completed model of the western river steamboat Heroine (photo by Chris Dostal)

San Giacomo di Galizia: a 16th-century shipwreck from Ribadeo, Spain

Raúl O. Palomino Berrocal

Nautical Archaeology Program, Texas A&M University

In 2011 the Spanish public institution Portos de Galicia started dredging works on the Mirasol Dock in the Port of Ribadeo, located in the province of Lugo, in northern Spain. The objective of the dredging was to improve maritime transit in the area, but before work began, archaeological surveys through SCUBA diving was conducted to confirm the absence of archaeological remains. Finding no evidence of visible archaeological material on the bottom, dredging started on 14 November. All operations ceased two weeks later when the dredge was blocked by fragments of timbers and what seemed to be a layer of lead.

Due to this event, new surveys were conducted in the vicinity and a shipwreck was found. The remains consisted of a wooden ship covered with a lead sheathing below the waterline. These characteristics indicated that the vessel must have been built between mid-16th and early-18th centuries. Since the dredge damaged the hull slightly, the area was protected immediately after the discovery to avoid any further damage.

In 2012, and later in 2015, the site was surveyed by Dr. Miguel San Claudio and subsequently excavated in 2018 (fig.1). The goals of the research were to determine the extent, depth, and preservation of the wreck. At the end



Figure 1: San Claudio's team during the underwater excavation.

of the investigation, the structure was reburied and protected with defensive framing to avoid any type of destruction or looting. During the excavation, several artifacts were recovered, with a priority placed on pottery since it serves as an excellent marker for cultural affiliation. Furthermore, structural elements were exposed in order to determine species, origin and to age via dendrochronological analysis, as well as the construction techniques applied on the vessel. Additionally, an historical investigation was done in collaboration with ForSEADiscovery, an EU-funded group that specializes in archaeology and dendrochronology. With the information gathered, it was determined that the ship belonged to the late 16th century; to be more precise, the shipwreck was that of the *San Giacomo di Galizia* (Santiago de Galicia).

As part of the ongoing research, team member Dr. Jose Luis Casaban from the Institute of Nautical Archaeology obtained the original documents of the contract and construction of the vessel. The *San Giacomo* was a galleon ordered by King Philip II of Spain as a part of the Spanish Armadas deployed during the Anglo-Spanish War (1585-1604). The shipwright in charge of the operation was Pedro de Ivella, a

Ragusan nobleman who served the King in the previous armadas and expeditions. Since the *San Giacomo* was the flagship of the Ragusean squadron, it was the first one to be built in 1590 in Naples. By 1594 the entire squadron was finished, and it was delivered to King Philip II. In 1597, the complete armada set sail from Coruña towards Falmouth. The goal was to disembark an expeditionary army and conduct the war directly on English soil. However, the Spanish forces encounter a storm on their way to England. Part of the Armada reached its objective and disembarked some troops, but the rest had to return to the Ribadeo just 171 km from their destination. Just days after the arrival, the *San Giacomo di Galizia* sank near the harbor where it is located today.

Besides the research conducted by San Claudio and Casaban, the author performed an analysis of the hull based on the written sources provided by the previous researchers. This process started with the reconstruction of the ship in two dimensions. First, the original measurements were used to reconstruct the shape of the hull and, later, the internal framing with the AutoCAD software (fig.2). Once the two-dimensional reconstruction was finished, the

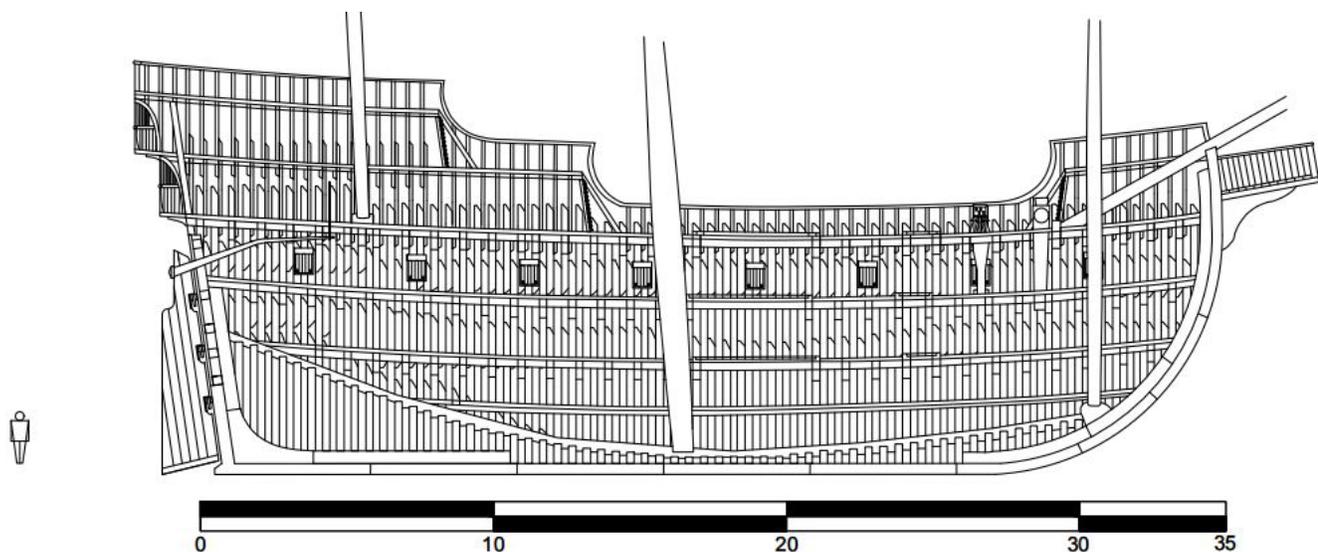


Figure 2: 2-D reconstruction of the ship's internal framing.

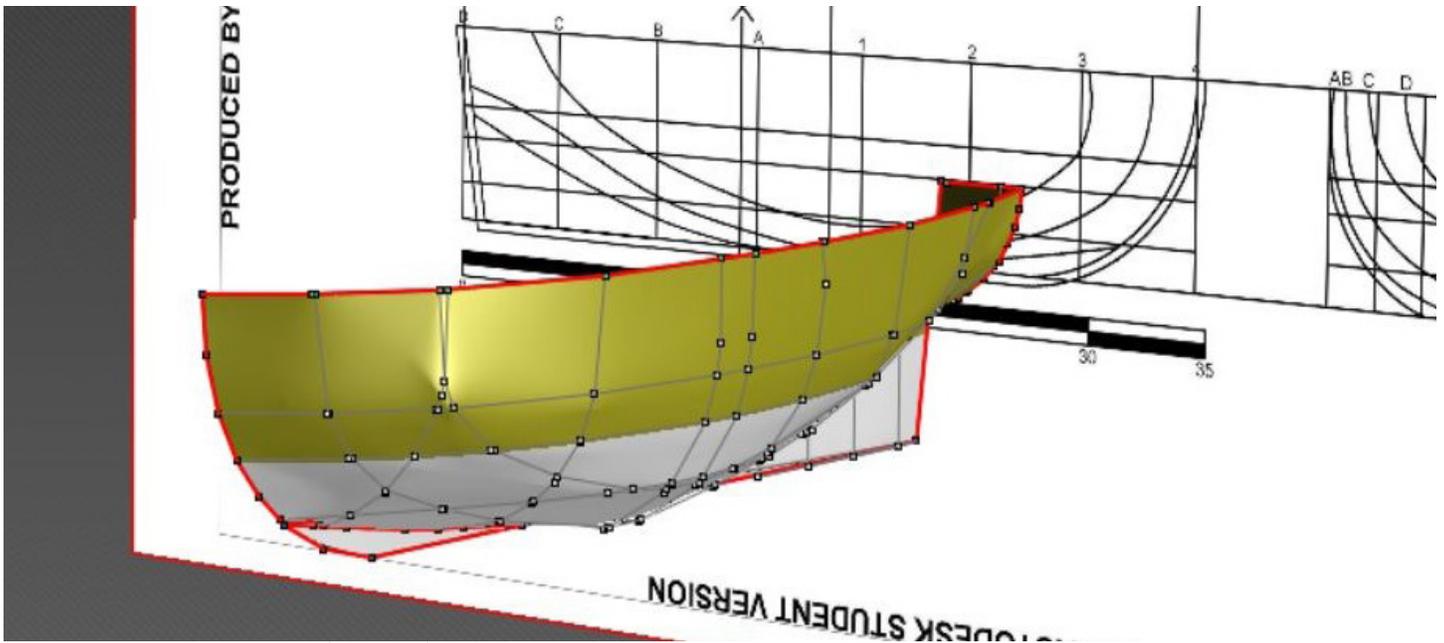


Figure 3: 3-D reconstruction of the ship’s hull in DELFTship.

second phase of the project was to recreate it in three-dimensional space. This was achieved with the DELFTship software, which also allows the user to analyze the hydrostatics and resistance of the ship (fig.3). The results obtained from the analysis showed that the vessel presented tension in the lower part of the hull along the keel (fig.4). In a wooden ship, this tension could cause a considerable fracture, potentially leading to the sinking of the vessel. Likewise, San Claudio holds the hypothesis that when the ship ran aground by the stern, the keel broke making any attempt at salvage impossible.

The present research is part of an ongoing project to evaluate the use of DELFTship as a tool for archaeologists to analyze shipbuilding and seafaring technology from a technical approach. Despite the promising results, more research is still required to have more dependable outcomes from this methodology. On the other hand, the remains of the *San Giacomo di Galizia* are the subject of ongoing investigation and protection plans to preserve its heritage for future generations.

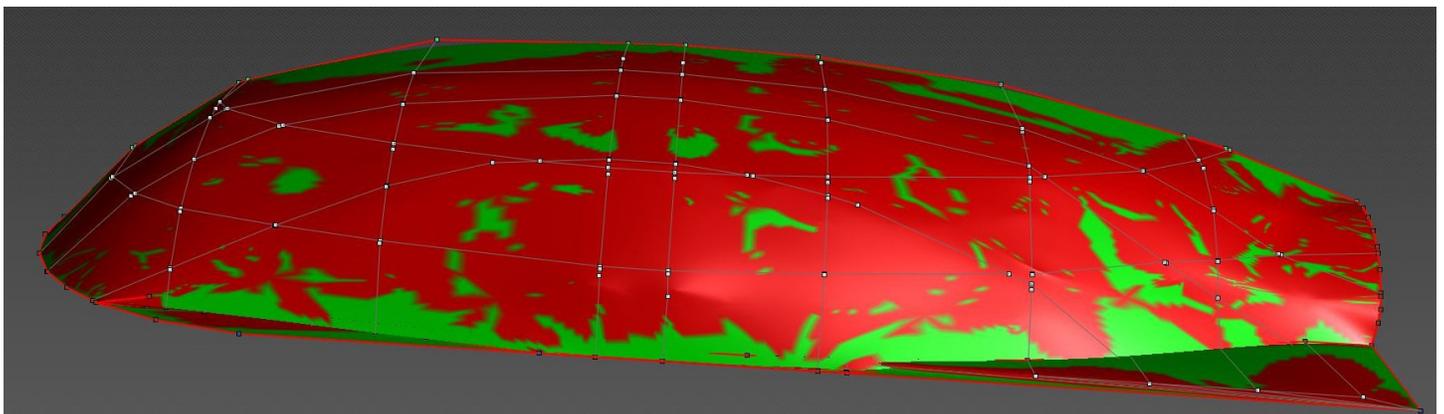


Figure 4: 3D model showing the physical tension in the green. sections.

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