Abstract

WOOD AND STEEL:

USING MODELING TO ANALYZE SITE FORMATION OF THE EARLY TWENTIETH CENTURY VESSEL *FRATERNITÉ*

By

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December 2020

Director: Dr. Nathan Richards
DEPARTMENT OF HISTORY

The purpose of this thesis is to decipher the signatures of archaeological site formation processes occurring at an early-twentieth century wooden sailing vessel (specifically, *Fraternité*, 1918-1919) shipwreck site. Using historical and archaeological research the author created a series of 3D models representing the different stages of *Fraternité* throughout its life and after its wrecking. Through studying these models, it was possible to understand cultural and non-cultural site formation processes (from storms to salvage) and assess how the site formation at the site may differ from other types of vessels. The study also proposes how the site may continue to change, and what information can be gleaned from the site about early-twentieth century American shipbuilding.

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Master of Arts in Maritime Studies

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DEDICATION

This thesis is dedicated to Donald Eugene Smith who served as a Tank Commander with the rank of Staff Sergeant in the 777th Tank Battalion in World War II. He was a master woodworker and would have appreciated the design of the *Fraternité*.

ACKNOWLEDGEMENTS

This thesis would never have seen the light of day without many supportive people. First, I would like to thank Dr. Nathan Richards for all the guidance he has given me throughout this entire project. He was the one that introduced this project to me in the first place and then continuously helped me stay on track even though it took me longer then he or I liked to finish. I would also like to thank Patty Smith for spending many hours editing this paper chapter by chapter. She has supported me throughout this process and pushed me to do my best and not give up even when I got stuck and the going got tough. Finally, I would like to help all my friends for continually believing in me. They helped me through many tough times when I thought that I would never finish and helped me during late night conversations to talk through some of the harder parts of the study.

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CHAPTER ONE: INTRODUCTION

Located around 650 miles due east of Cape Hatteras, North Carolina, is the island chain known as Bermuda. A wealth of maritime cultural heritage from the last 500 years and from many different cultures can be found around the more than 100 islands which make up the country. Of interest to this research project is a shipwreck from the early 20th century located near the northern most island of St. Georges (Figure 1). This wreck was formerly the ship *Fraternité*, an American-built, French-owned, auxiliary schooner built at the end of First World War (WWI) to help rebuild the French merchant marine. Since *Fraternité* never made it to France, the wreck has been battered by both the natural elements of Bermuda and Bermudian ship breaking activities to make it the wreck it is today.

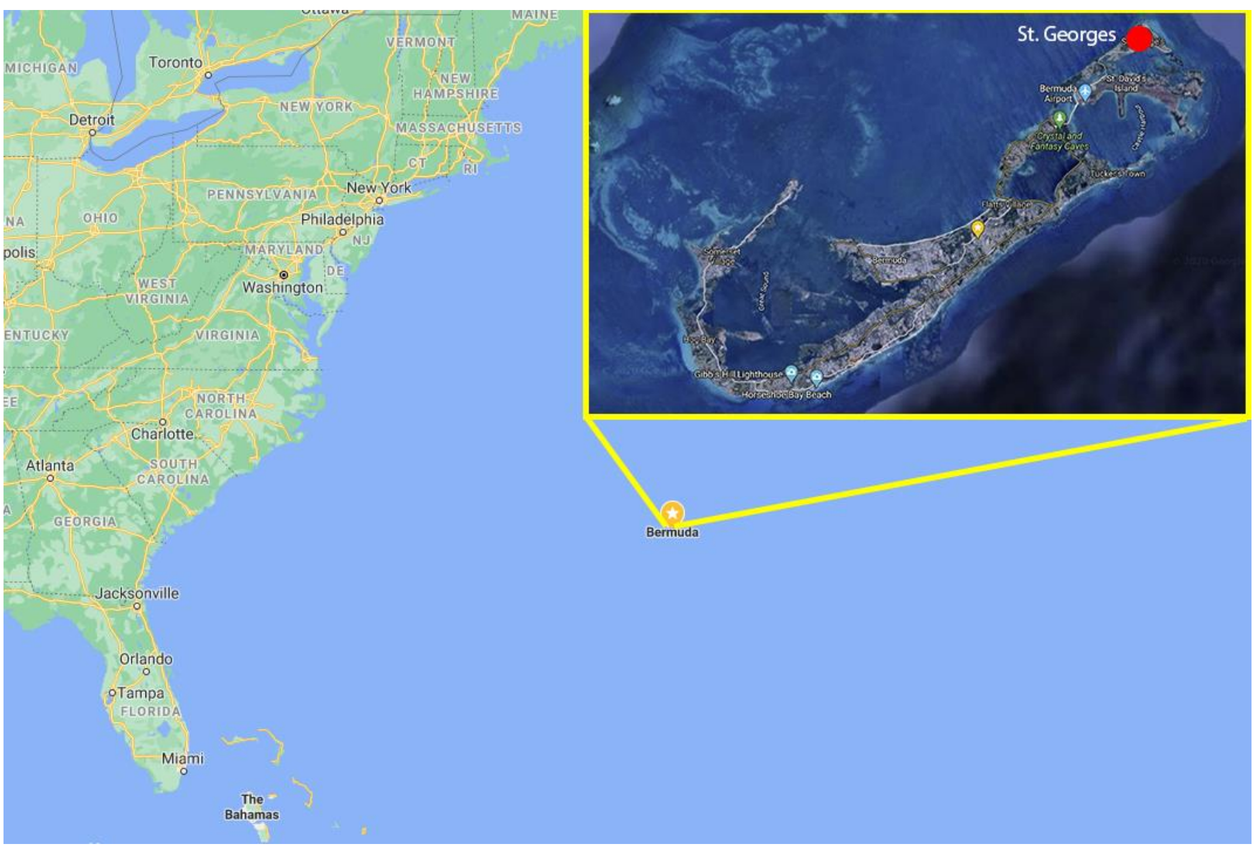


Figure 1. Bermuda in relation to US east coast, and location of St. Georges in relation to Bermuda (Image courtesy of Google).

Bermuda is well known for its history of ships wrecking on the extensive reef system which surrounds the islands. The discovery of the island chain was most likely made by Juan de Bermudez during his 1505 voyage from the Americas back to Spain. It quickly became a common landmark for sailors in a maneuver called the “Bermuda turn,” where ships sailing from Florida would sail towards Bermuda, turn east after passing it, heading on towards the Azores, and then on to Europe (Quinn 1989:4). Gonzalo Fernandez de Oviedo was the first to give a written account of Bermuda in 1526, when he chronicled his 1515 journey, during which he attempted to land pigs on the island for any future shipwrecked sailors (Greene 1901:220). The Spanish had some basic interest in settling the islands, sending Estevao Gomes to explore and map the islands and followed with Fernando Camelo to create a settlement around 1525. Despite these attempts, no permanent settlement was created by the Spanish, thus leaving the task to the English (Watts 2014:12).

The English ran into the islands when, on its way to Jamestown, *Sea Venture* struck a reef surrounding Bermuda after it was separated from the rest of the resupply fleet during a hurricane on 28 July 1609. After 10 months of living on Bermuda, mapping and building two ships, the crew of *Sea Venture* made their way to Jamestown with tales of the easy life to be had there. The Virginia Company was enthralled by these tales, and in 1612 they sent a ship with around 50 settlers and a governor to settle the islands (Watts 2014:14). As the colony on Bermuda continued to grow, many of the shipwrecks which surrounded the island were one source of much needed supplies, and sometimes a way of making a little extra money.

Jumping forward in time, Bermuda saw its economy changing at the end of the 1800s away from maritime commerce to tourism and international business. However, this change did not stop ships from wrecking around the islands. Shipwrecks became more a consequence of weather and human error rather than a lack of good navigational technologies and knowledge of the area (Watts 2014:221,237). Ships like *Fraternité* ran into the outer reefs when they did not have a local Bermudian onboard nor have any charts of the Bermuda reef system.

Fraternité was one of the ships ordered by France from the United States to help bolster the French merchant fleet following WWI. France and the rest of Europe suffered major casualties to their merchant fleets during the war. Overall, France ordered 26 steam ships and 40 auxiliary schooners during 1917 to be finished by late 1918. The contract for the 40 auxiliary schooners, of which *Fraternité* numbered, was won by the Foundation Company (Haviland 1972:6). The Foundation Company started work on this contract quickly, beginning construction out of one of their shipyards located in Tacoma, Washington on 14 August 1918 (The Foundation Company 1918:2).

Cox & Stevens was the company which came up with the designs for the auxiliary schooners built by the Foundation Company. The schooners were designed to have up to 3,500-ton dead weight capacity, which was on the upper limit of tonnage for a wooden ship, using Oregon fir with fully steel strapped hulls (The Rudder 1919:244). In overall length, each of these ships was about 280 feet long and 45 feet wide at midships. With five large thick masts and steam engines controlling two propellers, they could sail under most conditions with ease. The masts doing most of the work when there was a wind and the engines picking up the slack when the wind was low or nonexistent (Haviland 1972:5-8). The hull of the ship was constructed with large timbers, with one frame every three feet, giving it a strong skeletal structure when combined with the steel strapping. There was a great sense of optimism about these auxiliary steam schooners. The overall design and construction quality were seen to be good, however this proved not to be the case. Many of the vessels were never finished and the ones that did make it to France were quickly abandoned for the superiority of steel ships (Haviland 1972:7).

Fraternité's own journey and fate may have played a part in the abandoning of this vessel design. Although it only took three months to complete the ship from beginning to end, it did not have a successful journey to France. The long voyage started out well enough, but engine problems started to emerge while they were making their way around the southern tip of South America. It was not until reaching Savannah, Georgia and attempting to set out across the Atlantic that the engines totally failed, and the ship had to come in for repairs. After receiving repairs, *Fraternité* again struck out towards France, but wrecked in Bermuda (Haviland 1972:16).

Wrecking on the outer reef system of Bermuda proved disastrous for *Fraternité.* There was no way off the reef system they had hit, and the ship received too much damage to the hull. It took only a few hours for most of the hull of the ship to be filled with water (*Royal Gazett*e 1919a). Salvage operations began almost immediately to save as much of the cargo as possible. It took almost two months for the cargo of the ship to be salvaged where it had wrecked, during which time it had been sold to multiple different companies (Watts 2014:241). Once the vessel had been relieved of enough of its cargo, it could be moved to a new location closer to shore. This was done, as well as the burning of the ship, to allow for easier access to valuable salvage materials. *Fraternité* came to its final resting place at the end of May 1919 (*Royal Gazett*e 1919c).

All these events led to *Fraternité* laying where it does today and presents a case for disentangling how cultural transformations and environmental predations can change a ship into a wreck. The archaeological site also provides an opportunity to examine how the integration of extensive use of steel in early 20th century ship construction may alter the disintegration of wooden ships. To measure and interpret these processes, photogrammetry and three-dimensional (3D) computer aided design (CAD) will help to show how *Fraternité* has changed through time.

Research Questions

The principal purpose for this study is to examine how both cultural and non-cultural site formation processes have altered *Fraternité*. Some of the site formation processes which affect a wooden ship are different than those that affect a steel ship, and some of the processes which affect a composite ship are different from those that affect either a wooden ship or a steel ship.

Primary question

- How has the *Fraternité* transformed from a ship to the derelict mess it is today?

Secondary questions

- How is the site formation of a wooden, steel strapped wreck different from a wholly wooden or wholly steel vessel?
- How will the vessel continue to disintegrate?
- What can this wreck teach us about early 20th century ship building?

Previous Research

Over the last few decades, archaeologists have examined ship disintegration in many ways. Extensive studies of wooden-hulled, composite (a ship with ferrous frames and a wooden hull), and ferrous-hulled (iron and steel) ships have been completed (Sexton 1991; MacLeod 1998; Jeffery and Sexton 2007). Qualitative and quantitative studies, in addition to research concerning individual cultural and environmental processes have also been produced (Stewart 1999; Piero 2004; Gibbs 2006; Richards 2008a; Bera 2015; Keith 2016). So far, no one has done these studies on a transition period ship like *Fraternité* to see if there are any differences.

Even though *Fraternité* is a wooden ship, it was built with so much metal that it almost resembles a composite ship in many ways. There have been a few studies surrounding composite ships from around the late 19th century and early 20th centuries, but not many. Robert Sexton wrote an article in the *Bulletin of the Australian Institute for Maritime Archaeology* in 1991 discussing composite ships. Sexton defined composite built ships as “vessels constructed with an iron frame in association with wooden planking” (Sexton 1991:59). Later developments around composite shipbuilding led to vessels with diagonal iron strapping used to reinforce large wooden hull ships. Sexton’s article focused on the invention, construction, and development of composite ships by examining the codes which were used as guidelines for the ships, as well as compared some of them (Sexton 1991:60,64).

Bill Jeffery and Robert Sexton worked on *Zanoni*, an English composite vessel built in 1865 which wrecked near South Australia in 1867. Their project in the late 1980s and 1990s focused on the history, construction, and excavation of the wreck, as well as some photogrammetry and conservation efforts with the intention of identifying what caused the ship to wreck (Jeffery and Sexton 2007:152-154).

Ian MacLeod took a different direction when looking at several composite shipwrecks as well as some iron wrecks around South Australia by focusing on iron corrosion He looked at *Zanoni* (1867), *Iron King* (1873), *Willyama* (1907), *Clan Ranald* (1909), *Songvaar* (1912), *Investigator* (1918), and *Pareora* (1919). By focusing on the iron corrosion of these wrecks, he considered the implications for site managers and tourism. On the composite *Zanoni*, MacLeod examined the pH and the corrosion rates in multiple places around the wreck before and after sacrificial anodes were attached. Through this study, he endeavored to determine how the environment near the site affected the wreck when anchoring at the site was prohibited and anodes continued to be used with the site being monitored (MacLeod 1998:81-83). On the other wrecks, he used the same kind of procedures and discovered that the rate at which the iron is deteriorating in the region is changed based on water depth and movement in the area. MacLeod's method for corrosion tracking allows archaeologists to examine the state of a wreck by comparing findings with original specifications (MacLeod 1998:90).

Fraternité specific research was carried out by an East Carolina University (ECU) team led by Dr. Nathan Richards and Dr. David Stewart in 2008 as part of a study of the abandoned ships which lay around St. Georges Island, Bermuda. The goals of their project were to study the economics behind the gathering of ships in the area and salvage of the vessels, identifying and creating a list of the wrecks, and recording the sites for recommendations about management (Richards 2008b:4). In collaboration with the National Museum of Bermuda (then the Bermuda Maritime Museum) the ECU team surveyed *Fraternité* in 2008, created a detailed site plan (Figure 2), and gathered primary sources about the wreck and its subsequent salvage.

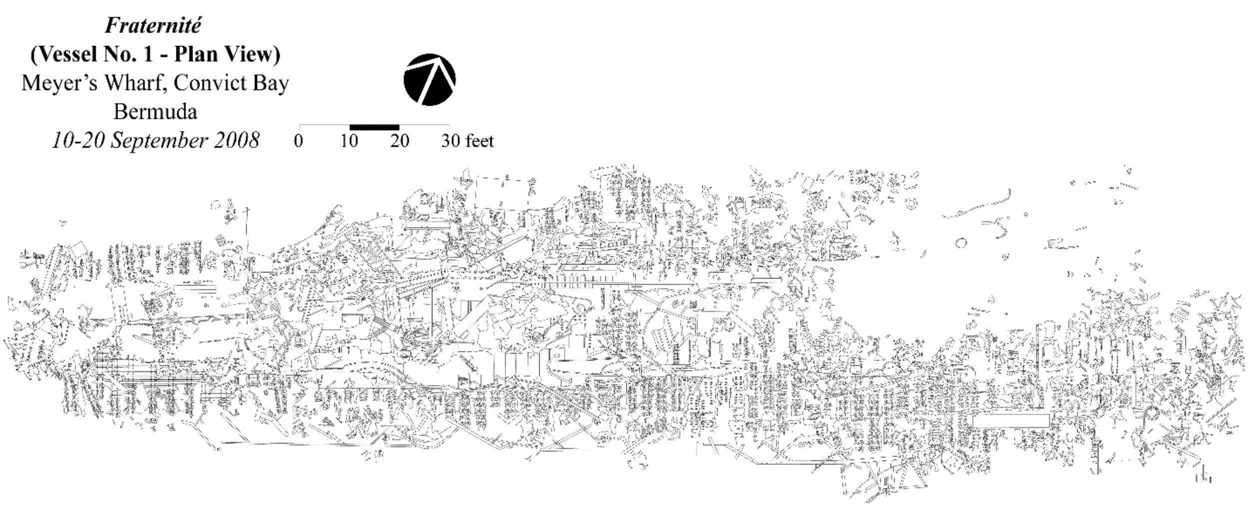


Figure 2. *Fraternité* 2008 site plan (Courtesy of Nathan Richards, Maritime Studies, East Carolina University).

The survey was carried out with non-intrusive recording methods using scaled drawings, photography, and underwater videos. Richards described the wreck as “a large debris field of timber and iron ship parts” (Richards 2009:6). This project will build upon the historical and archaeological datasets collected over 2008-2009 by East Carolina University.

Theory Background

Studying the site formation processes occurring at a site is one of the best ways to understand how a ship became the wreck it is today. In the early years of the underwater archaeology, people like Frédéric Dumas (Cousteau 1953), Honor Frost (Frost 1963), and Peter Throckmorton (Throckmorton 1964, 1970) studied how shipwrecks formed, but there was little explicit theory behind their studies. The theory behind site formation processes really started to be laid out by Michael Schiffer and Keith Muckelroy during the 1970s (Keith 2016:2-3). While elements of both author’s work will be utilized, this study will focus on the scholarship of Schiffer, which exists within the context of Schiffer’s *behavioral archaeology approaches*. Schiffer broke site formation into two major processes, cultural formation processes, or *c-transforms*, and non-cultural formation processes, or *n-transforms*. Schiffer defines c-transforms as the impact humans have on an artifact or site after its original use. He defines n-transforms as the impact on artifacts or sites from non-human sources like the environment (Schiffer 1987:7).

C-transforms can be further broken down into four major parts, *reuse*, *cultural deposition*, *reclamation*, and *disturbance processes*. Reuse is when and artifact is given a new use during its lifetime before it is discarded (Schiffer 1987:28). Cultural deposition includes the transferring of an artifact to an archaeological context. This includes the process of discarding and abandonment (Schiffer 1987:47). Reclamation processes such as salvaging, scavenging, and collecting from a site are another way that humans affect how a site has developed (Schiffer

1987:99). Reclamation processes will be one of the major c-transforms to look for on the wreck of *Fraternité*. Disturbance processes are separated from reclamation because the artifact or site does not reenter human society, they are instead changed in some way and remain in their archaeological context (Schiffer 1987:121). On a shipwreck this could include events like an anchor dragged through a site.

N-transforms focus on the environment's effect on an artifact or site. There are many factors in the environment of a site which will determine how it has weathered the effects of time and come to the condition the archaeologist finds it is in. Deterioration can come to artifacts in three ways; chemical, physical, and biological. Chemical agents like acids can soften and melt metals; physical agents can come in the form of erosion by wind or water; and biological agents like flora, fauna, and bacteria can also eat away at artifacts (Schiffer 1987:148-149). N-transforms not only attack artifacts at a small scale, but also, they can attack whole sites on a larger scale. Regional or local environmental factors, like the composition of the soil and sediment, can affect how a site deteriorates in several ways, including how these factors cover a site or how they are included in the concretion processes. Events like freak weather or continual weather patterns also affect shipwreck sites (Schiffer 1987:233). With the location of the *Fraternité* wreck in Bermuda, an area hit by many storms each year with hurricanes passing through occasionally, these types of N-transforms have likely greatly affected it.

Keith Muckelroy (1978), like Schiffer, researched site formation process analogs (utilizing different terminology), but unlike Schiffer, whose work was focused on terrestrial archaeological sites, he studied the disintegration of underwater shipwrecks. Muckelroy showed how, in simple terms, a ship goes through the wrecking process. His discussion indicated that some material might float away, and then the ship might be salvaged with the salvaged materials no longer being part of the wreck. Disintegration of materials would then take place with some artifacts or parts of the site disappearing forever. Movement on the bottom of the sea, ocean, river, or lake could also occur and change the site. He pointed out that it was possible for these last three processes to happen in any order and for a site to go back and forth between them over time. Muckelroy also included outside materials being added to a site like modern glass bottles or aluminum cans. Excavation of the site would also be one process which ultimately affects it. Finally, after all these processes occurred it would be possible to observe the distribution of the site and its artifacts (Muckelroy 1978:158-159).

Other researchers have taken the work of Schiffer and Muckelroy and have extended the work into different directions. This has included Ian MacLeod (1982), David Stewart (Stewart 1999), Martin Gibbs (Gibbs 2006), Brad Duncan (2006), and Alicia Caporaso (2017). Of relevance to the current investigation of *Fraternité*, Nathan Richards continued the work of Schiffer with a specific focus on cultural transformations involved with deliberate ship abandonment and the creation of ship graveyards, like the one at Meyer's Wharf (Richards 2008a:54). Leading the Abandoned Ships Project in Australia, he helped to record over 1,500 the remains of discarded vessels. As part of the project, Richards and Staniforth (2006) did non-intrusive surveys to determine what events led to the ships being abandoned. Studying the cultural transformations which caused the wreck to end up where it is and what that says about the people who left it there (Richards and Staniforth 2006:84-86).

Research Methodology

This project has been undertaken in three separate phases. First, historical research was undertaken to get as much information about c-transforms and n-transforms which occurred in the past that may or may not have left visible marks or left marks which may have disappeared from the wreck. The historical research also helped guide the archaeological modeling process by informing what transforms to include. Newspapers such as the *Royal Gazette* included short excerpts on the salvage operations of *Fraternité* right after it wrecked, as well as some of the natural events which occurred at the site, like the ocean current action constantly rubbing the ship against the reef. Many of these articles are located at the Bermuda National Archives and were brought together by the ECU team during their previous research of the site. Extensive research was also done on the construction of the vessel. Books, such as Charles Desmond's *Wooden Ship-Building* (1919), Henri Paasch's *From Keel to Truck* (1901), Cole Estep's *How Wooden Ships are Built* (1984), and J. Richard Steffy's *Wooden Ship Building and the Interpretation of Shipwrecks* (1994), were used to help understand what ship building practices were being used before, during, and after the construction of *Fraternité*. The plans for the ship, which are essential for the modeling process, were found at the Mystic Seaport Museum in Mystic, Connecticut.

The second phase of the project involved 3D modeling. With the help of a 3D computer aided design program like McNeel's *Rhinoceros 5* or *Rhinoceros 6 (Rhino)*, it was possible to create several models of the ship starting with one as it looked when it was launched. Models were then made of the status of the wreck at multiple different points throughout its history. These models include the initial wrecking, further wrecking damage, falling of the masts, and the burning of the ship. With these models and the information gained from the ECU survey and photos, it was possible to create a model showing the ship in its current degraded form. The precedence for this type of modeling can be observed in Kara Fox's thesis, "Matters of Steel: Illustrating and Assessing the Deterioration of The World War II Merchant Freighter *Caribsea*"

(2015). In her study, she created a historical model, a model of sinking, a salvaged model, a current model, and a predictive model (Fox 2015:93).

Lastly these models, along with the archaeological and historical evidence, were analyzed to determine how *Fraternité* has degraded over time from cultural and non-cultural transforms. Kara Fox (2015) laid out how these models can be analyzed using site formation theory. Discrepancies can be gleaned by comparing the model of the original ship to a model of the wreck. These discrepancies can then be explained by historical records of events and site formation theories. A mast shown in the original model could have been taken off by a storm, while degraded iron braces would have been caused by some form of corrosion (Fox 2015:131,133). By creating and examining these models, it is possible to see how the site formation of *Fraternité* was different from other ships built during the early 20th century, how the ship might continue to degrade, and how it is different from other wooden or steel ships.

Thesis Structure

Chapter One is the introduction, setting the stage for the methodology and theory for this study, and includes the research questions this study is based around. Chapter Two presents the historical context of *Fraternité*. The chapter will go into detail about World War I and ship construction during that period. It will also discuss the company which constructed *Fraternité*, the ships construction, its voyage, and eventual wrecking. Chapter Three discuses in more depth the theory used as the basis for this project. The site formation theory discussed in this chapter provides a necessary understanding in the processes which have affected this site, including the cultural and non-cultural transforms that affected the ship in both its systemic and archaeological contexts. Chapter Four lays out the methodology used for this project, including the research that was carried out and the bases for model construction. Chapter Five provides the results of the modeling and goes in depth to show the information that was used to create each model; historical, wrecking and salvage, and archaeological, and the modeling steps taken. Using information from each previous chapter, Chapter Six brings the research questions back into the discussion. The research questions are discussed by applying the history, theory, and methods to the models, to best answer these questions. Finally, Chapter Seven wraps up the study with a conclusion on this project and provides a discussion of further research that could be carried out at the site.

CHAPTER TWO: A HISTORY OF FRATERNITÉ

Fraternité came along during a transition period in ship construction. Wooden ship building was on the way out while iron and steel vessels were becoming a great deal more prominent in the United States. WWI had profound effect on why ships, such as *Fraternité*, were built. The massive amount of Allied naval and merchant vessels which were sunk due to German unrestricted submarine warfare created a need for cheap, quickly built ships to replace those lost. During this period in which *Fraternité* was built, the United States had an abundance of timber so wooden ships could be made much more cheaply and quickly than iron or steel vessels. Large, fast, and strong ships were needed to carry supplies to warships around the world as well as trade goods through dangerous waters. One of the ship types commonly used to accomplish this was the magnificent schooner of four, five, six, or seven masts. Due to the length of some of these vessels, iron and steel components, such as steel strapping and extensive use of ferrous fasteners, needed to be added to strengthen the hulls and combat longitudinal strains. Some of these vessels boosted their velocity by incorporating coal or steam engines to drive propellers in conjunction with the ship sails to help speed them along (Haviland 1972:5-6).

The Foundation Company was one of the companies to facilitate the construction of these large wood transition vessels for the war effort and several years after the end of WWI by creating dockyards specifically designed for these ships. Contracted by the French Government to build 40 five-masted auxiliary schooners, the Foundation Company built two shipyards, one in Portland, Oregon and the other in Tacoma, Washington. One of the vessels built in Tacoma, *Fraternité*, was a great example of this vessel type. *Fraternité* was built in 1918 and sank off the Bermuda coast during its maiden voyage on its way to France. After wrecking on the outer reef system, the easily accessible cargo was salvaged, then the vessel was moved closer to shore for additional salvage work, and has remained there for 100 years. *Fraternité* was a product of its time, quickly built, and quickly abandoned; but it is one of the few remaining remnants of this transitional period in the history of ship construction.

This chapter will set *Fraternité* in its proper historical context to gain a better understanding of the ship. Without understanding the historical context, it would be impossible to understand the full site formation of *Fraternité*. Firstly, this chapter presents information about WWI and the destruction of many merchant marine vessels as the backdrop for the construction of *Fraternité*. It is also important to understand the background of wooden ship construction during the time of *Fraternité* and before. This will allow for a better grasp on why such a large ship with sails and engines was made and why it was built with the wood and steel used. Next, this chapter will discuss the Foundation Company and its history as well as the shipyard in which it was constructed to provide a better understanding of local factors that played a part in the ship formation. *Fraternité's* construction and design also delve deeper into understanding how the ship was built and its construction timeline. Although it is a short section, the voyage of *Fraternité* is also presented and shown in this chapter, along with the history of the wreck itself. These sections will help with recognizing processes that occurred from the life and historical recorded wrecking of the ship, which could impact its site formation.

World War I

World War I, remembered as the Great War, saw destruction around the world. Millions of men were sent to participate in bloody battles and millions died fighting them. The men and the supplies required to maintain the armies were transported in thousands of military vessels and merchant ships. Along with the prodigious loss of life, there was an extensive loss of property as well. Not only was the landscape scarred by trenches and pockmarked by artillery blasts, the sea and ocean floors were littered with the hulks of both the military vessels and merchant ships. At the beginning of the war, both sides believed that battles at sea would take place between heavily armed dreadnaughts and that submarines would only play minor roles in protecting the shores and breaking up blockades. The German surface fleet was too small and weak to destroy the British Grand Fleet in open combat. To fight back, Germany commanded its U-boats to attack the unarmed merchant ships which supplied Great Britain and its military. The first victim of this new tactic was *Glitra*, a British merchant steamer, sunk by a boarding party from a U-17 boat on October 1914. Following international law, the captain of the U-17 boat allowed all the crew of *Glitra* to get into lifeboats; and even taking his gallantry a step further, he had the lifeboats towed close to the shore (Tarrant 1989:12). During the early parts of the war, U-boats would surface when they found an unsuspecting target and give the crew a warning to abandon the ship before destroying it with deck guns, or explosives placed by boarding parties.

In November 1914, Great Britain declared the North Sea a war zone where trade could not take place, setting up a blockade against Germany in order to put more pressure on the strained Germany economy. Along with this declaration came the order for Allied merchant vessels to arm themselves, to ignore previous rules for combat, and to shoot submarines on sight. German officers were not pleased with these changes, which led to Vice-Admiral von Pohl suggesting that German subs should also abandon previous rules of combat and attack British Allied merchant vessels without any warning. Germany set up a counter–blockade. As part of this counter-blockade, the Germans suggested that neutral ships should not sail into British ports unless they provided Germany detailed information on the ship as well as its cargo, which could not contain any material relating to war supplies in any way. Admiral von Tirpitz disagreed with this plan, believing this strategy would be counter to international law. He also cited obvious problems of the British ships deciding to fly neutral flags to attempt to deceive Germany, increasing the possibility of making mistakes and sinking neutral ships, making neutral powers angry. However, since Germany believed that the blockade placed on them was illegal, they instead decided to declare the waters around Great Britain as a war zone (Simpson 1972:73).

The Kaiser formally made the declaration of the war zone on 5 February 1915. The very same day, he also made an announcement to Germany's U-boat commanders in which he mentioned the sinking of enemy merchant vessels without warning. He recognized the loss of life which might occur but did not dissuade his commanders from taking this step. Instead he just told the commanders to save the crews, if they could, and if they could not, then it could not be helped. Within a few days, the Kaiser realized there could be ramifications for the U-boat actions, so he told his commanders that they were not to attack neutral merchant ships unless they could accurately identify them as fake and flying false colors. In the official report from Germany was the assertion that all enemy merchant ships in the new war zone would be destroyed after 18 February 1915, also alleging that loss of life may not be able to be prevented (Simpson 1972:74-75).

In a letter sent by the United States in response to the German proclamation, the threat was made that any destruction of an American vessel or the loss of American lives would result in the United States holding Germany accountable as betraying the rights of a neutral power. This thinly veiled threat forced Germany to quickly reconsider its position or risk war with the United States. Germany offered that it would return to warning merchant vessels before attacking if England would allow food and other similar supplies past its blockade and stop arming merchant ships. England, however, confirmed that it had no intention of taking either of these steps (Simpson 1972:77-78). On the seas it was a war of strangling the enemy into giving up by starving them out. Since Britain had the superior navy, they were unwilling to give up such a huge advantage. Germany had only one choice since they could not defeat the Grand British Fleet, which was to continue their path of reliance on U-boats sinking merchant ships (Tarrant 1989:14).

This new unrestricted warfare began with the sinking of eleven merchant ships, one French and ten British, with five destroyed without warning and resulting in 27 deaths. Along with these vessels, the first neutral vessel was attacked without warning, but not sunk. A Norwegian tanker was towed to shore when Germany was still trying to placate the United States. Young U-boat commanders, who were not well schooled in politics and not given clear instructions, were cut off from command due to the nature of U-boats during the period (Tarrant 1989:15). The inevitable conclusion suggested that mistakes would be made, and other merchant ships would pay the cost. From March 1915 to May 1915, U-boats were able to sink 115 merchant ships even though there were only around five to six U-boats at sea at any given time. Of those 115 ships, 22 belonged to neutral powers (Tarrant 1989:18).

One of the first and most well-known destructions of a merchant ship came with the sinking of RMS *Lusitania*. On 7 May 1915, a U-20 boat sighted *Lusitania* and without warning fired a torpedo at the ship which detonated on the starboard side right behind the bridge. The explosion of the torpedo was not the only explosion, because almost immediately another explosion came from the inside of the ship from one of the cargo holds. This much larger explosion is the one that officially sank the ship, and likely came from explosive contraband which the vessel was bringing to Great Britain. The first official report which made its way to the American Embassy set the casualties at almost a thousand with at least a hundred Americans counted among the dead. When the United States sent its letter of disapproval to Germany,

Germany responded that the American loss of life was regrettable, but the sinking of *Lusitania* was not an illegal act citing that *Lusitania* was armed, had been given orders by the British government to fly the American flag, had been used for troop transport in the past, was an auxiliary cruiser for the British, and carried contraband munitions (Simpson 1972:154, 158, 177, 201-202).

Despite Germany not wishing for the United States to enter the war, Germany continued their campaign of destroying merchant vessels. In 1914, only 3 merchant vessels were sunk due to U-boat actions. Around 636 merchant vessels were recorded as sunk by Germany during 1915 versus the 468 recorded by the British. This discrepancy can be explained by the fact that Britain did not record the sinking of fishing vessels or other vessels under 500 tons. During 1916, Germany recorded the sinking of 1,309 total British, Allied, and neutral merchant ships. With the arrival of the United States into the war during 1917, Germany increased its unrestricted submarine warfare and the British recorded a total of 2,609 merchant vessels lost throughout the year. The final year of the war saw the destruction of around 1,305 merchant vessels. Nearly 6,000 merchant ships from the Allied powers as well as other neutral nations were destroyed by German U-boats throughout the war. This incredible loss of an important part of the war effort as well as the economies of the victim nations had to be made up for in some way. The response was swift with nations, especially the United States, going into overdrive to churn out new merchant ships to replace what they had lost (Tarrant 1989:152-153).

According to the Department of the Navy, 197 American merchant vessels were destroyed or badly damaged throughout the war (Navy Department 1923:7-18). The United States government decided to work towards establishing a better merchant marine and a naval auxiliary by a federal act passed on 7 September 1916 which created the United States Shipping

Board. The board was comprised of five commissioners appointed by the President with the approval of the Senate. The Shipping Board's duties were to acquisition ships after construction, operate the new ships, and regulate shipping and shipbuilding. With the passing of the *Shipping Act* in 1917, the Shipping Board was able to create the United States Shipping Board Emergency Fleet Corporation with an initial capital funding of $50 million and another almost $3 billion given to them by Congress to start construction on an emergency fleet. The two major functions for the Emergency Fleet Corporation was to construct new vessels and then operate them for the Shipping Board (Mattox 1920:4-7).

At first, some people within the Emergency Fleet Corporation believed that building a large wooden ship fleet using shared designs could be done quickly and cost efficiently; and therefore, be able to out build what ships U-boats could destroy. The demand for steel from munitions' plants was high, so steel ship manufactures had to compete for resources. The United States had an abundance of wood so new shipyards were created to focus on building wooden vessels. With the increase in wooden ship production, other countries also needed to rebuild their merchant fleets, so they worked with the Emergency Fleet to set up contracts with American shipbuilding companies to construct ships for their countries. However, these vessels were inferior to their steel counterparts, with three percent of the wooden ships built considered to be complete failures. The ships could not compete with steel vessels, but they were still able to help the nations the ships were built for, at least some, in rebuilding their merchant marines and keeping supplies flowing (Mattox 1920:18, 244).

Background to Wooden Ship Building

With wooden ship construction going back a few millennia, designs have always been changing. However, one of the biggest factors for the development of wooden ship construction was the economic drive to trade more goods over great distances. *Fraternité* came along as iron and steel shipbuilding exploded and almost completely replaced wooden shipping. The 19th century really started this trend with more iron ships being built leading to the decline in building wooden ships. During that transition, shipbuilders experimented with using iron and steel to various extents in wooden vessels. Some vessels were designed to have steel frames with a wooden hull known as a composite vessel, while others, like *Fraternité*, were strengthened with iron or steel strapping (Graham 1956:74-75). There is a theme of transition and change in the background of ship construction at the time. There were changes to schooner rigs being placed on larger and larger ships. There was a need for greater speed and carrying capacity for trans-Atlantic trade. The addition of steel was implemented into the ever-increasing size of wooden ships, and ultimately there was a transition from wooden ships dominating the seas to steel vessels. These transitions shaped how *Fraternité* was designed and built.

The five masted schooner rig of *Fraternité* is one of its defining characteristics. A schooner rig has been used on many different sized vessels as well as different hull types. What would one day develop into the schooner rig started on small vessels around the 16th to early 17th century in the Netherlands. The Dutch may have introduced their ideas to Bermuda and influenced what would also become the Bermuda rig (Marquardt 2003:9). The term schooner started to show up when describing American vessels in port records in 1716 and continued to show up with many different types of hulls in the later part of the 18th century (Marquardt 2003:97). Schooner was still a loose term by 1855 with some brigantines and barquentines falling under its umbrella. It was around 1880 when the term schooner was given more specifically to fore-and-aft rigged ships with two or more masts. Some still had square sails on the foremast (MacGregor 1984:87). In terms of hull construction, schooners had no real consistency, with hulls designed for whatever service the vessel was meant for. Schooners were used for naval warfare, trading, fishing, yachting, and whaling (Marquardt 2003: 110-111). Schooners became anything with a schooner rig. Typically, schooners had one, two, or three masts during the early 19th century and before. However, during the latter part of the 19th century the great schooners – four, five, six, and seven masted – became more popular. Many were used for carrying large amounts cargo around the United States to support the growing industrial nation (Snow and Lee 1999: xiii). Others, like *Fraternité*, were built to support the war effort and became trading vessels afterward.

An important aspect of trade at the time was speed. The faster a ship could move, the better off it was in escaping possible threats and making more money. The combination of sails and steam engines gave *Fraternité* decent speed for its size. In general, the speed of any ship is determined "by the relation of its displacement to the size of its rig" (Chapelle 1967:401). The use of both sail and steam driven propellers allowed for the large wooden *Fraternité* to travel at around 10-1/2 knots (*The Rudder* 1919:245). This is the same speed at which much smaller wooden ships were going just a little over half a century before *Fraternité's* construction. For example, *Sea Witch*, a clipper ship which was built in 1845 and designed for speed, also had an average speed of 10-1/2 knots (Chapelle 1967:329). Using five masts with a schooner rig and steam powered twin propellers allowed for *Fraternité* to travel across oceans quickly, making it ideal for transporting goods over long distances. The addition of engines also allowed for traveling when there was no wind, taking away a more unpredictable element to travel.

Another defining characteristic of *Fraternité* and this transition period is steel strapping. As wooden ships got larger, the longitudinal bending strains had a greater effect on their hulls. When a wooden ship is built long enough the need for some form of bracing is needed to help protect the vessel from hogging or sagging. Hogging is when the longitudinal stress on a ship causes the ends to bend down, and sagging is when the center of the ship bends down. In larger vessels, wooden supports are not enough to overcome changes in the longitudinal shape. It, therefore, was necessary to use iron or steel to help strengthen the wooden structure in some way (Desmond 1919:31, 94). One of the ways metal was incorporated was through strapping the frames. Iron or steel strapping extends across the entirety of the outside or inside of the ship's frame. This idea of strapping vessels originated with Robert Seppings to strengthen ships of war and was first used in 1805 (Seppings 1818). The straps are run diagonally across the frames to add to the strength and stiffness of the vessel. To make sure the strapping does not get in the way of planking is it placed in grooves in the frames so that it fits flush and planking can be placed over it. To secure to each frame iron or steel fasteners were used (Davis 1918:46).

The ultimate characteristic of this transition period was the change from wooden ships to steel ships. While Europe faced a timber shortage during the 18th and 19th centuries, the United States was still flush with timber, especially on the west coast. This resulted in European nations turning to iron-built ships earlier than Americans did. It was far cheaper for Americans to take advantage of their incredible lumber supply to build the schooner rigs. To switch to iron ship production rather than wood in the United States would have been a huge amount of money investment that was needed to buy all new equipment. The saws and adz which shipbuilders used had to be replaced with furnaces and powered hammers (Tylor 1958:4). During the 19th century, iron and steel shipbuilders in the United States could not compete with iron shipbuilders in the United Kingdom or wooden shipbuilders in the United States. However, with WWI and the rise of the iron industry in the United States, metal vessels started to become easier and cheaper to make. During the war and the few years after there was a last push to create many wooden vessels, but the resurgence did not last long and many of the wartime shipyards closed shortly thereafter (Hutchins 1948: 15). *Fraternité* was part of that resurgence of quickly made, large wooden vessels, of the same design, most of which had very short careers.

The Foundation Company

The Foundation Company started as just that; a company focused on the construction of building foundations. As the company saw success in their field they started to grow, and as the company grew so did the scope of their construction work. The Foundation Company opened branches all over the United States as well as a branch in Canada, working on projects such as the construction of bridges and dams. With the outbreak of the war, the company expanded once again into industrial plant construction, building some of the largest plants in the United States. Franklin Remington is the man who took the Foundation Company on its biggest change with the venture into ship building (The Foundation Shipbuilder 1918b:1).

Franklin Remington was from the Remington family which founded E. Remington and Sons, one of the leaders in the manufacturing of firearms and typewriters. Remington had a brain for business and did not let opportunity pass him by. The destruction of merchant vessels around the world throughout WWI left a high demand for shipbuilders. Remington, then president of The Foundation Company, met with the Emergency Fleet Corporation in 1917 to discuss the possibility of private companies working with the government to rebuild the merchant fleets (International Marine Engineering 1918:387). The government agreed to the partnership and the Foundation Company was given the rights to construct a shipyard, with ten ways, near Newark, New Jersey, and was the first to complete a wooden ship for the Emergency Fleet Corporation (International Marine Engineering 1918:393).

As the Foundation Company began to grow its shipbuilding capability, the company started to take on more contracts from other governments. Five cargo ships were contracted by the British Imperial Munitions Board and a new shipyard was built for the purpose in Victoria, British Colombia. France was not to be out done by the Americans and the British and wanted to rebuild its merchant fleet as well. Forty wooden auxiliary schooners were agreed upon in the contract between the French government and the Foundation Company, with all to be delivered by the end of 1918. To accommodate the construction of so many ships in such a short time, the Foundation Company built two more shipyards, each with 10 ways, on the west coast to take advantage of the abundant timber supply. One of the two shipyards was built in Portland, Oregon, and the other was built near Tacoma, Washington (International Marine Engineering 1918:393). Construction started on the Foundation Company plant located in Tacoma, Washington on 14 August 1918, and when the flags were raised over the facilities at completion, there was an American flag and a French flag (The Foundation Shipbuilder 1918a:1).

The Foundation Company shipyard number four was one of the largest shipyards in the entire world in 1918, located in the Tideflats of Tacoma on 50 acres of land (Tacoma Public Library 1918a). The location was picked due to the abundance and the ease of access to Oregon fir trees. The location where the shipyard was built was under several feet of water before over a million cubic yards of fill were brought in to create a suitable work area. To construct the 10 ways and all the buildings which were necessary for the shipyard, over five million feet of lumber were used in the construction (The Foundation Shipbuilder 1918a:2). Just behind the 10 ways was the two story, 20,000 square foot, mill building. The first floor was open to the air and would have been where the woodworking equipment was located, while the second floor was used as the mold loft where molds for various parts of the ships structure where made (Tacoma

Public Library 1918b). Aside from the ways and the mill building, there were many other important buildings littering the property making it appear almost like its own small city. There was an air tool house, a wash and locker building, a main office, riggers quarters, a machine shop, and a blacksmith shop which all made up some of the other major buildings. Some of the smaller buildings included a copper and tinsmith shop, pipe bending shop, boiler house, air compressor house, sheds for punch and shear machines, planning sheds, a shed for making treenails, a strapping and bolting building, a lumber storage shed, and 10 hoist houses (International Marine Engineering 1918:393). At its height, the shipyard employed around 4500 people, but at the end of the war, along with a decline in the need for wooden ships, the shipyard closed in 1919 (Tacoma Public Library 1918c, 1918d).

The Foundation Company and their Tacoma shipyard were one of the lucky companies that were able to complete their contract and deliver most their ships to France. Other similar companies which had contracts with France for similar vessels did not complete their contracts in time before the ships were no longer required. Seaborn Shipbuilding Co., Wright Shipbuilding Co., and Tacoma Ship Building Co. had not completed their quota of 20 ships for the French Government. There were 13 unfinished ships, left unfinished, which were all towed to Lake Union near Seattle until someone decided what to do with them. It was not until 1926 that a decision was made. The partially completed ships were sold to the Washington Tug and Barge Company to be scrapped (Tacoma Public Library 1926b). On 11 June 1926 the 13 ships were set on fire at the mouth of Minter Creek near Henderson Bay. The ships burned all night until they burned all the way to the waterline and the fire burned itself out. The Washington Tug and Barge Co. then set to work recovering what they could of the iron and other materials worth any money left after the blaze (Tacoma Public Library 1926a).

Construction of *Fraternité*

Cox & Stevens was the company which came up with the designs for the auxiliary schooners built by the Foundation Company. The schooners were designed to have up to 3,500-ton dead weight capacity, which was on the upper limit of tonnage size for a wooden ship, using Oregon fir with fully steel strapped hulls (*The Rudder* 1919:244; Figure 3). The overall length of the vessels was approximately 280 feet (ft.), the beam at midships was 45 ft. 6 inches (in.), and they had a depth of hold of 22 ft. 5 in.

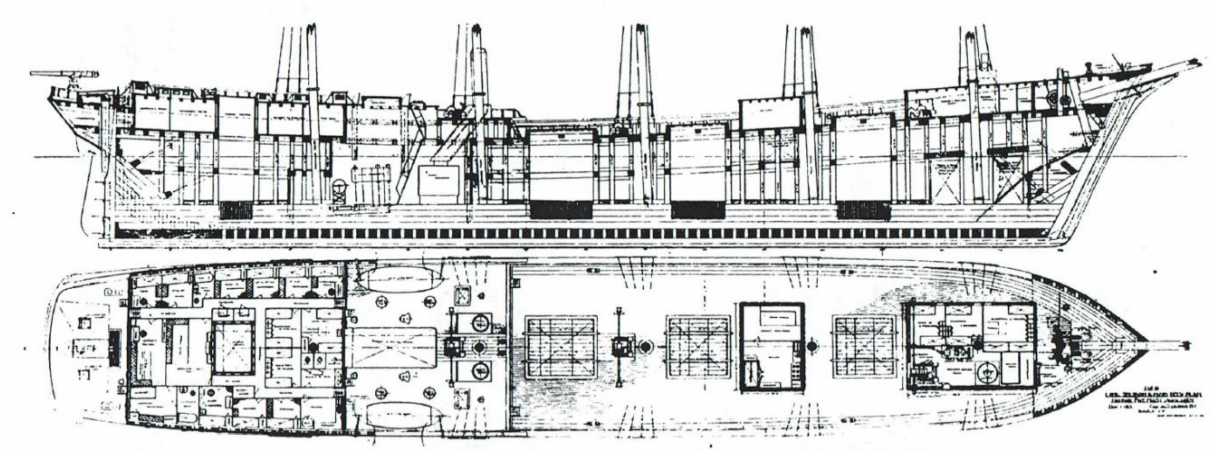


Figure 3. Longitudinal section and main deck plan of 3,500 D.W. tons auxiliary schooners, designed by Cox & Stevens (The Rudder 1919:245).

These schooners were designed to be driven primarily by their five masts, with diameters of 25 or 26 in. and lengths of 115 ft., but also were equipped with auxiliary steam engines (Haviland 1972:5-8). The vessels would have used whichever propulsion system was correct for the circumstances. The five masts would have been used for traveling long distances across open ocean while the engines would have been used for more precise movements closer into shore. Two triple-expansion steam engines were used which utilized 1,800 square feet (ft.^{2}) of heating area and could get the ship up to 10-1/2 knots. To feed these mammoth engines, 200 tons of coal were needed along with another 200 tons available for emergency situations. These auxiliary schooners could get the highest rating for their type by the Bureau Veritas (*The Rudder* 1919:245). Frames and planking for these vessels were made of large timbers. The frames were spaced 3 ft. apart with 1 ft. sided and a little over 2 ft. molded dimensions. Bottom planking had an average length of 45 ft. and a thickness of 5 in., while the bilge planking had an average length of 55 ft. and a thickness of 5-1/2 in. (Haviland 1972:7). The original purpose for which the ships were designed was as supply vessels for war ships and were able to move quickly and operate with a small crew (Tacoma Public Library 1918e). Cox & Stevens auxiliary schooners at the time were great ships which would have served well as long distance cargo ships. However, this optimism at design and construction was short lived, just like the careers of many of these vessels.

There are a few major steps in the construction of a vessel like *Fraternité*, including the placing of the keel assemblage, addition of the frames, and addition of the planking. *Fraternité*'s keel assemblage was laid out first, including the major components of the bow and stern. The keel is the backbone of the ship giving it much of its longitudinal strength (Figure 4). The major components of the bow include the stem and the apron giving the bow its structure and shape (Figure 5). The stern's most important timber is the sternpost supporting the stern of the ship and providing a place to set the rudder against (Desmond 1919:45-51, Figure 6). After the full backbone structure of the ship was in place, the frames were added. The frames give the vessel its shape and transverse strength (1919:52, Figure 7). After the frames are added in a long ship like *Fraternité* extra longitudinal support is needed. More wooden components do not have the strength to stop the ship from changing shape so steel straps are added to support the structure. They act as almost a basket going from below the turn of the bilge to near the gunnel and stretch most of the length of the vessel (1919:94, Figure 8). The last major step is the addition of the planking which cover the frames on both the inside and outside of the ship. These planks, when caulked, proved the watertight barrier which keeps the ship afloat (1919:56-57, Figure 9). There are many other components to building a ship like this, but these are just a few of the biggest steps. For more detailed information about this type of ship construction see Desmond's treatise, Wooden Ship Building, 1919.

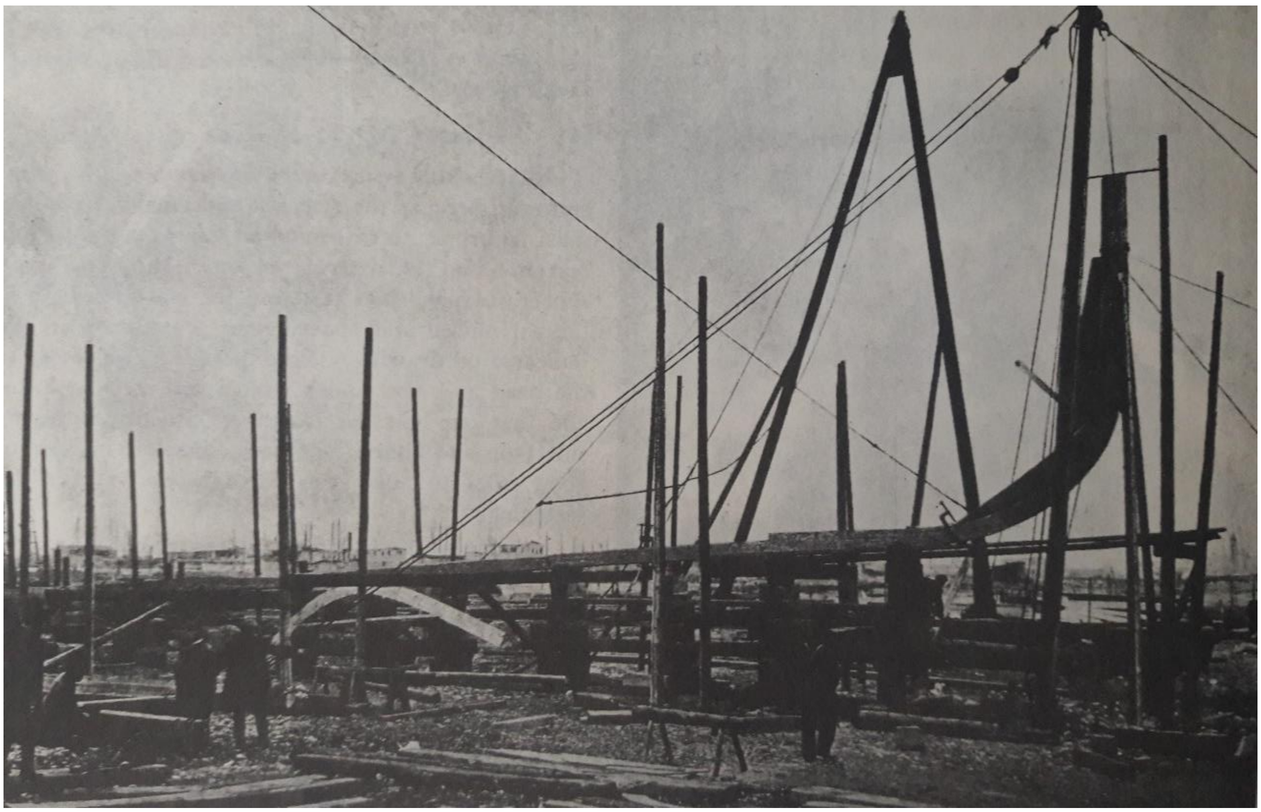


Figure 4. Keel set up (Desmond 1919:48).

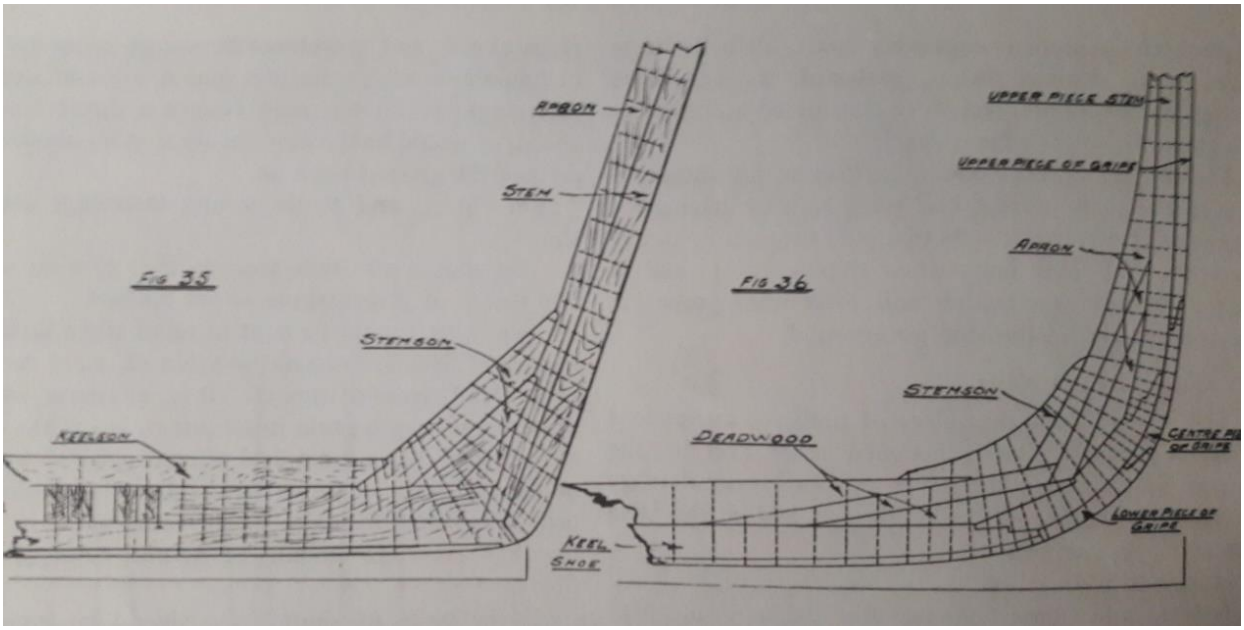
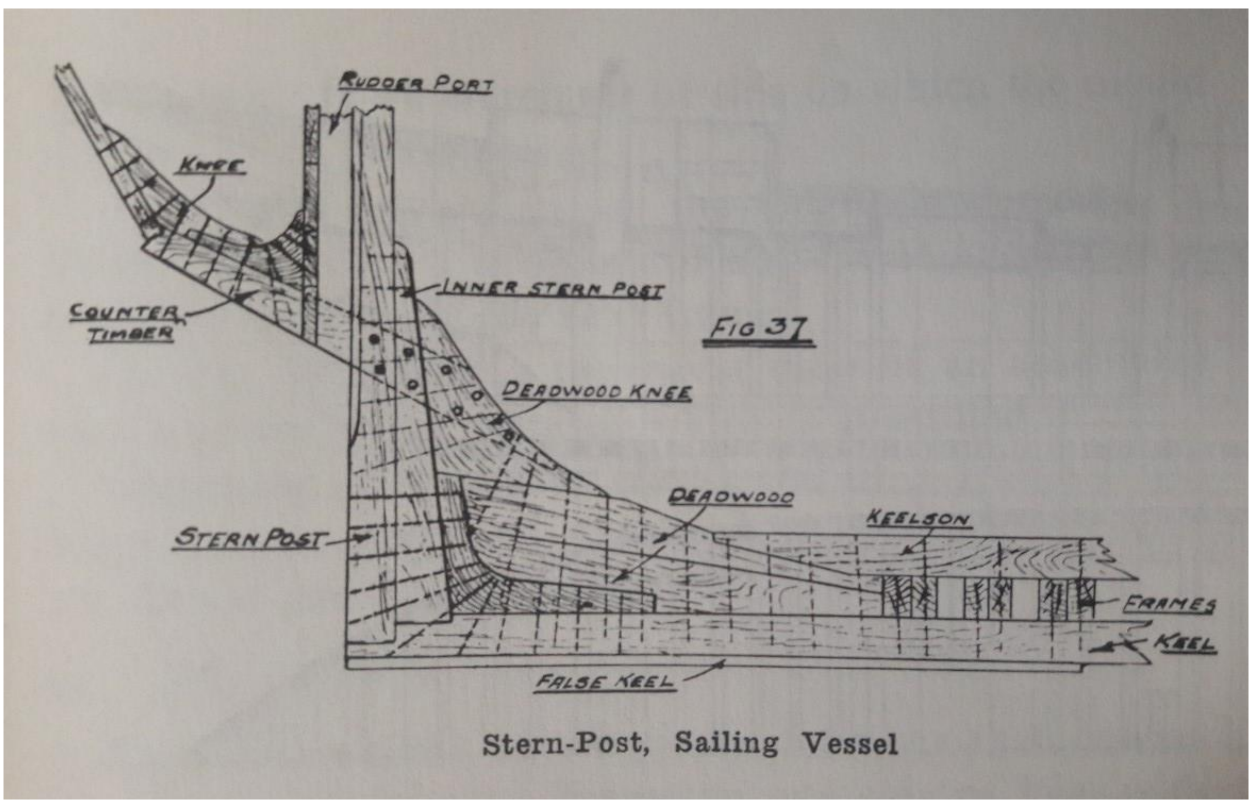


Figure 5. Bow assemblage, Sailing Vessel (Desmond 1919:50).



Stern-Post, Sailing Vessel

Figure 6. Sternpost, Sailing Vessel (Desmond 1919:51).

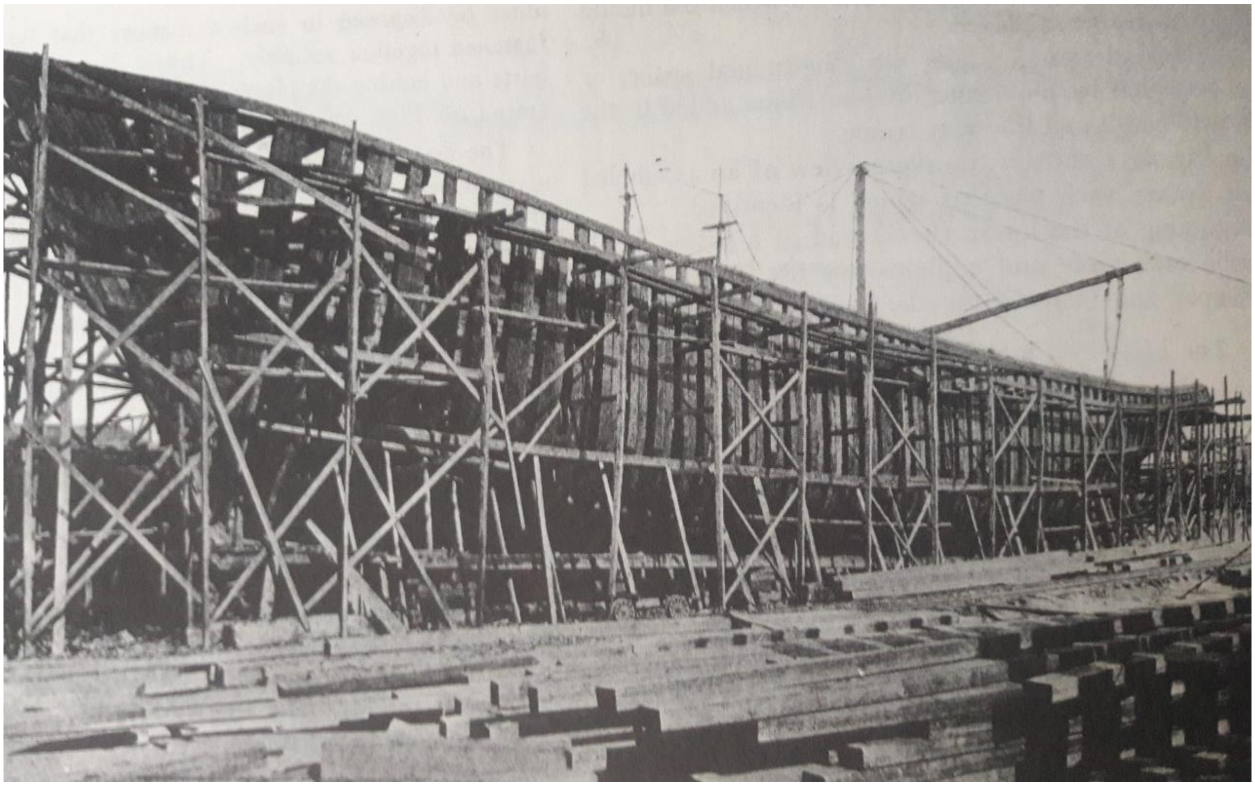


Figure 7. Framing a 4-masted schooner (Desmond 1919:54).

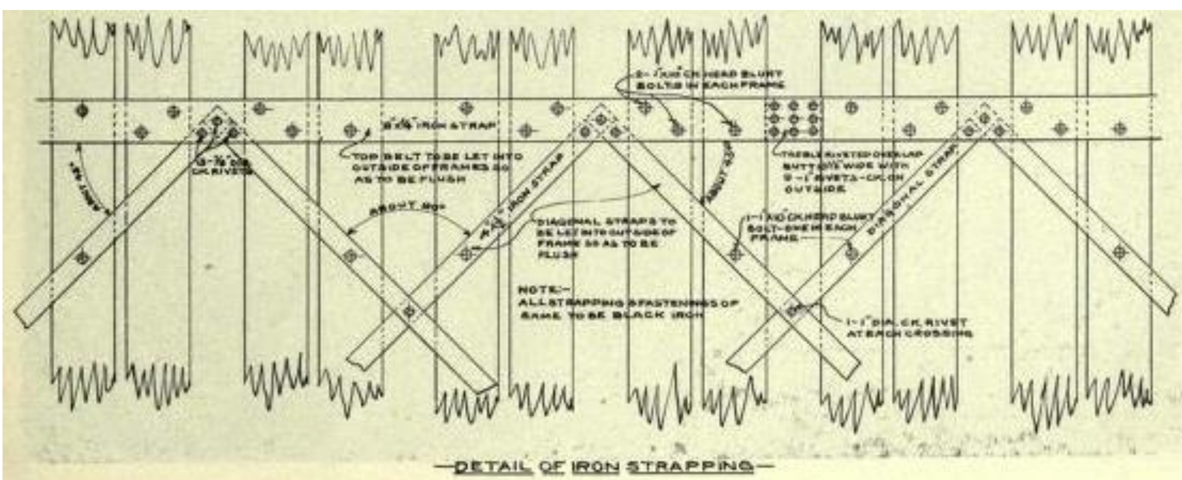


Figure 8. Detail of iron strapping to support larger wooden vessels (Desmond 1919:94)

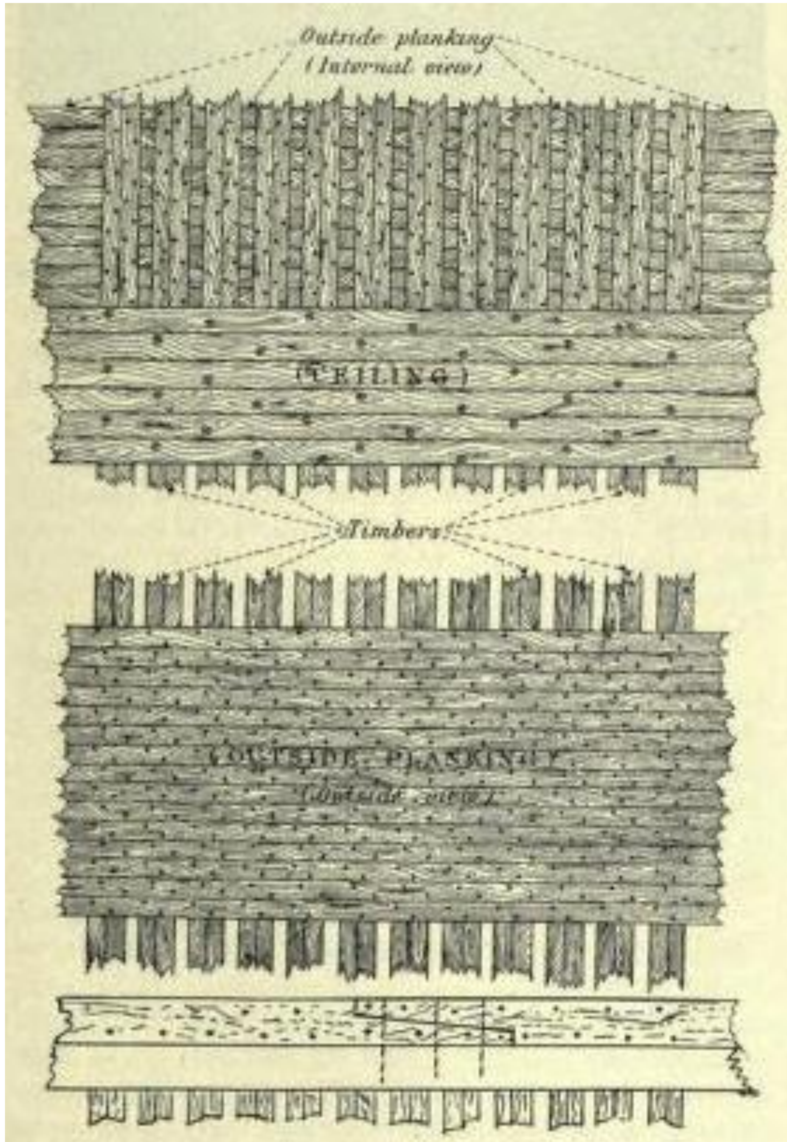


Figure 9. Example of planking (Desmond 1919:57).

Fraternité's Voyage

Fraternité launched on 31 August 1918 and was fully outfitted by the beginning of October. *Fraternité* left Tacoma, Washington on 19 November 1918, making it to the tip of South America by 24 December 1918, and continued to Balboa, Panama in the following month. During this maiden voyage, the first reports of engine problems emerged, but the ship made it to Savannah, Georgia in the beginning of February 1919. From Savannah, the next destination for the ship was Nantes, France, however, more engine problems were encountered requiring *Fraternité* to return to Savannah. Within a couple of weeks, the ship was fixed and continued its journey, but ended its final sailing voyage on 3 April 1919 on the reefs of Bermuda (Haviland 1972:16). The below map shows this journey and all the major locations mentioned in Haviland's article (Figure 10). This is certainly an odd route to get to Bermuda since *Fraternité* did not go through the Panama Canal until it had already made it to the Caribbean Sea by traveling around south America.

Figure 10. Map of *Fraternité's* Journey (Courtesy of Google Maps, edited by Tim Smith 2020).

Fraternité's Wrecking

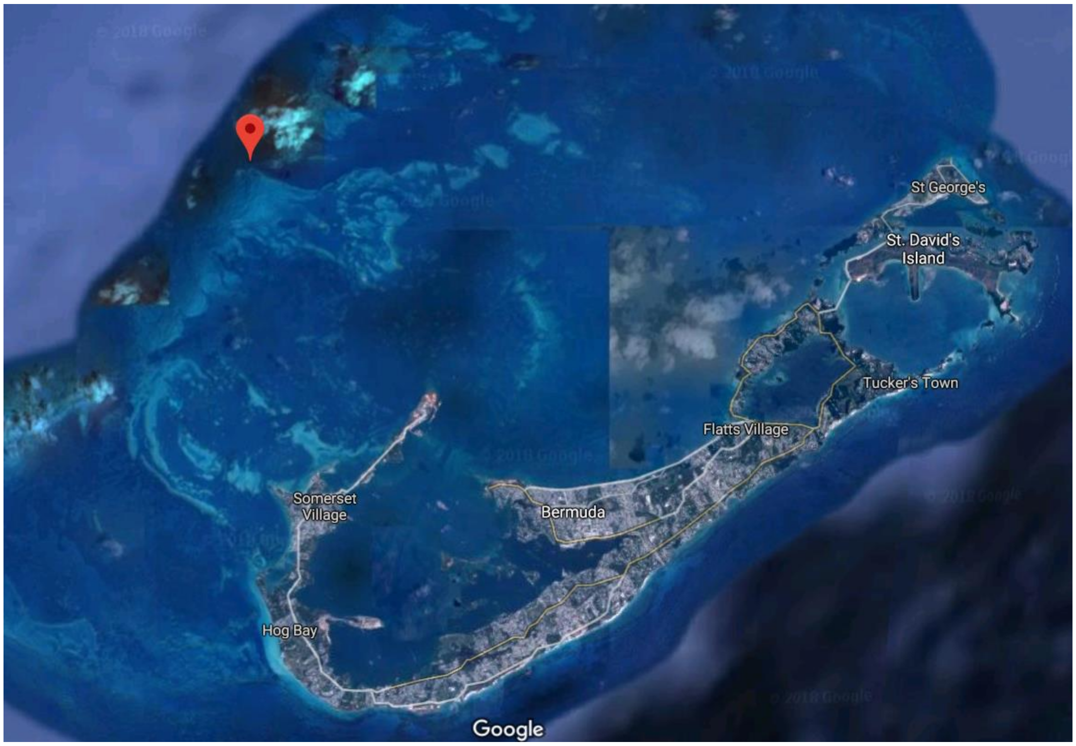


Figure 11. Close to location of initial wrecking (Courtesy of Google Maps).

Fraternité wrecked on the Ledge Flatts reef system which is located about eight miles North-West of Spanish Point (Figure *11*). The crew did not see the reef until it was too late. Running at about eight knots with all sails set and the steam engines on, *Fraternité* bounced over the first reef ledge and came down between two rocky reef outcroppings which were only barely covered by water and was immediately stuck. The sheer force of the impact broke part of the keel and split open some of the planking. Normally the ship had a draft of about 27 feet, but within a few hours there was already 20 feet of water in it. The full cargo of the ship was valued at $1.5 million, so work began almost immediately to recover what they could (*Royal Gazett*e 1919a). Bermudians from Hamilton worked to salvage as much of the 30,000 bags of flour from the ship as possible, as well as the sail canvas, and a large amount of copper. By 8 April 1919, the ship was slowly falling apart due to the winds and sea action in the area (*Royal Gazett*e

1919b). An attempt was made by Messrs. Wm. E. Meyer & Co., to pump out *Fraternité,* but it was unsuccessful due to part of the bottom of the ship no longer being in place (*Royal Gazett*e 1919c).

On the 23 April 1919, four of the masts of *Fraternité* fell to the deck, and 8,000 bags of the flour cargo were sold at auction (*Royal Gazett*e 1919d). Salvage of the whole copper cargo was finished on the 5th of May, and what remained of *Fraternité* was sold, including all remaining submerged cargo, at an auction by Messrs. B. W. Walker and Coy, to Messrs. W. E. Meyer and Coy St. Georges, for a total of £335 (*Royal Gazett*e 1919e). Sometime between the beginning of May and the end of May 1919, the vessel was again sold, this time to E. P. T. Tucker (Watts 2014:241). Around 26 May 1919, *Fraternité* was set on fire and what was left of the main part of the vessel was floated and towed into the South of St. Georges island near Meyer's Electric Welding Works. The fire revealed the engines and boilers which were highly valued (*Royal Gazett*e 1919f). A majority of *Fraternité,* without the sections of hull which broke off at the original wrecking site, still rests in the same place today, which is now known as Meyer's Wharf (Figure 12).

An ECU team lead by Dr. Nathan Richards and Dr. David Stewart examined and recorded the current site of *Fraternité* in 2008. The site is a scattered debris field with some areas of larger semi complete sections of planking and frame timbers. The ECU team recorded the site using scale drawings, photos, and videos. The sections of the ship that were left behind on the outer Bermuda reef system were not studied by the ECU team in 2008 and have not been subject to research (Richards 2018:49). More in-depth information on previous research on *Fraternité* can be found in Chapter Four.

Figure 12. Current location of Fraternité in Meyer's Wharf (Courtesy of Google Maps).

Conclusion

World War I created a demand for cheap, quickly built ships to replace losses sustained to merchant marines during the war. The Emergency Fleet Program created a vast number of wooden vessels to fill this need, and the Foundation Company was part of that program churning out wooden ship after wooden ship. These ships were hastily built and did not have the best designs, so they were quickly outclassed by the progression of shipbuilding to primarily iron and steel construction vessels. *Fraternité*, as a wooden five masted auxiliary schooner with steel strapping, is an example of the transition from wood to metal. By gaining an understanding of the history of the time period and the construction techniques used during it, as well as the history of *Fraternité* itself, it is possible to start to understand the context of *Fraternité* and the processes which affected the ship before and during its life afloat. Understanding the vessel's construction is the first piece of the puzzle to understand the site degradation. Site formation theory, discussed in the next chapter, can then be applied to the historical information in this chapter to gain more insight into the cultural and non-cultural events that impacted the ship.

CHAPTER THREE: SITE FORMATION THEORY

Some scholars contend that archaeological sites are snapshots depicting a moment or object in the past, frozen in time, waiting to be rediscovered; but this is a common misconception. This view is often referred to as “time capsules” (Bass 1983:92) or the “Pompeii premise” (Binford 1981: 37: 195-208). It is extremely likely that the site or object changed not only while being used, but also as it lay within the ground or underwater. Archaeologists attempt to understand these changes using archaeological site formation theory. Michael Shott defined formation theory as dealing with the archaeological record and how it is formed (Shott 1998:311). Site formation theory helps to pinpoint why certain pieces of a site have moved or become degraded.

The purpose of this chapter is to lay out a general history of site formation theory, and to show its importance in understanding how shipwrecks turn into the archaeological sites they are today. Through the years, many archaeologists have added to our understanding of how sites change over time. Archaeologists such as Michael Schiffer (1987) and Keith Muckelroy (1978) built up the basis for site formation theory, with a few differences. Other archaeologists such as David Stewart (1999), Ingrid Ward (et al. 1999), Martin Gibbs (2006), Nathan Richards (2008) and others built on the work already done and applied it to a range of site types to gain a better understanding of site formation processes and what they teach about the past. Through the studying of site formation, it becomes possible to take what is known about a shipwreck and deepen our understanding of the maritime historical record. This chapter focusses on site formation theory by looking at its background and the ideas of those archaeologists who have contributed to the theory. Site formation theory can be broken down into two major parts: the factors which changed a ship before it entered into the archaeological record, its *systemic context*; and the factors affecting a ship after it enters the archaeological record, or its *archaeological context*.

Background

The theory which became archaeological site formation started with work done by Michael Schiffer (1972, 1976, 1987) and Keith Muckelroy (1975, 1976, 1978). Cultural transforms and non-cultural transforms, developed by Schiffer, helped to show that describing the cause of a transformation made the consequences of the transformation predictable at other sites, therefore helping archaeologists better understand how the archaeological record forms. Similarly, Muckelroy strove to identify the processes affecting well-known underwater archaeological sites so the theory could then be applied to less well-known sites. Archaeologists such as David Stewart (1999), Ingrid Ward et al. (1999), Martin Gibbs (2006), and Nathan Richards (2008), continued to work towards a better understanding of site formation theory. Stewart helped shed light on the pre- and post-depositional processes and how some are studied more than others. Ward et al. placed emphasis on environmental impacts at sites and added that to Muckelroy's diagram which are discussed further in depth later in this chapter. Gibbs expanded on the theory by focusing a little more on the pre-wreck factors as well as adding to the flow diagram of Muckelroy and Ward et al. Richards tied a lot of the work of Schiffer and Muckelroy together, as well as shed more light on abandoned ships as a lesser studied cultural transformation.

Michael Schiffer, a terrestrial archaeologist, is well known for his work in laying a foundation for a comprehensive theory of archaeological site formation. He broke site formation into two relatively simple transformation categories which take place on a site to transform it from what it was like in its use (systemic) context to what it was like when studied by archaeologists (its archaeological context). These two processes he called *cultural transforms*, or *C-transforms*, and *non-cultural transforms*, or *N-transforms*.

Cultural transforms are those caused through the agency of humans who affect the site or artifact in some way after original use. Schiffer points out the processes when humans may interact with the archaeological record through *reuse*, *deposition*, *reclamation*, and *disturbance*. Reuse is defined by Schiffer as "a change in the user or use or form of an artifact, following its initial use" (Schiffer 1987: 28). For Schiffer, reuse encompasses lateral cycling, or a change in its user, recycling, a secondary use, and conservation. Deposition is when humans move a site or artifact which is no longer in use and discard it in some way, moving from its systemic environment to its archaeological resting place (Schiffer 1987:47). The discard of objects can be modeled using various equations that Schiffer discuses in his book *Formation Processes of the Archaeological Record* (1987). Reclamation is when humans decide to remove something from its archaeological context and move it back to a systemic context. Locations may be abandoned by one group and used by another later or used by the same group again. Items may be salvaged or scavenged for materials to make new things. Schiffer uses collecting and pothunting as reclamation processes for taking artifacts from the surface or subsurface respectively and transporting them elsewhere (Schiffer 1987:114). Disturbance refers to humans effecting the archaeological record of an artifact, but without returning it to a systemic context. This is often done through the movement of earth by trampling, plowing, or digging on a site. Construction is one of the most common human disturbances of the archaeological record (Schiffer 1987:140).

Non-cultural transforms are summed up in three major ways by Michael Schiffer; how objects are added to a site by noncultural methods, how objects are modified by noncultural methods, and how a site is modified by noncultural methods (Schiffer 1987:199). Artifacts can deteriorate in many ways, all depending on their environment and the materials they are made from. Schiffer mentions that if deterioration is looked at from just one of these angles and not all perspectives, then major factors may be missing from discussions of how an archaeological site has formed (Schiffer 1987:146). The major factors which determine how artifacts degrade are due to physical, chemical, and biological processes. All these agents can affect an artifact in both its systemic and archaeological context. Chemical factors, such as the humidity of an environment or acidity of the soil, can have various effects on an artifact changing its molecular makeup. Physical factors, such as the movement of water, can substantially displace and erode the surfaces of artifacts or sites. Biological factors include both microscopic organisms, animals, and plants. Animals, such as moles, may create burrows in a site and move artifacts around while bacteria may slowly eat away at organic material. The makeup of an artifact, such as whether it is comprised of wood, metal, or some other material, also plays a large part in the process. What degrades wood in one way may degrade a metal in a different way or leave it entirely untouched (Schiffer 1987:148-149).

Also working on site formation theory around the same time as Michael Schiffer, but entirely separately, was another archaeologist, Keith Muckelroy, who focused on the same processes for shipwreck sites. In *Maritime Archaeology* (1978), he was mostly concerned with the application of site formation through the understanding of already well documented shipwrecks with the purpose of using the same concepts to understand all wrecks. Figure 13 shows how Muckelroy laid out the model for the processes that a ship went through to become the site which archaeologists study. This interpretation tried to consider the inputs and outputs of the system as well as a wreck's environment to understand the processes which influence a shipwreck (Muckelroy 1976:281).

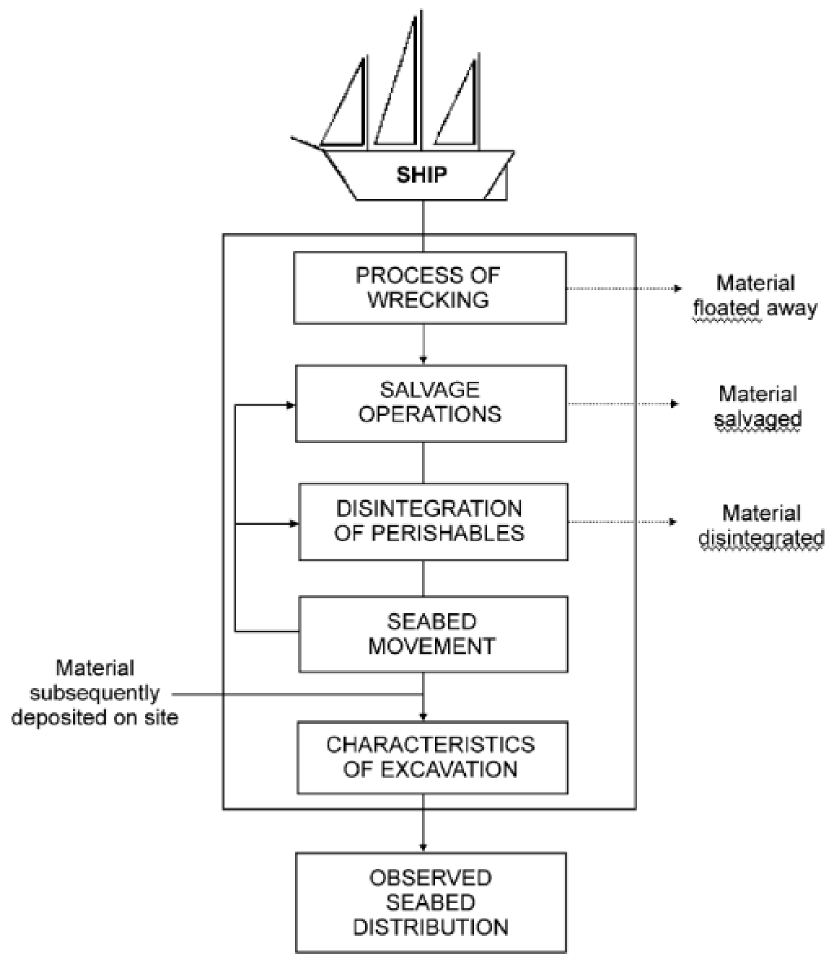


Figure 13. Development of a shipwreck (Muckelroy 1976:282).

The forces which Muckelroy identifies are *extracting filters* and *scrambling devices*. Some processes may work as both extracting filters and scrambling devices while others may only work as one process. Extracting filters include anything that subtracts something from the site. This includes the first three boxes in Figure 13, *process of wrecking*, *salvage operations*, and *disintegration of perishables*. These three forces remove material from a site either leaving no trace or possibly leaving behind clues for archaeologists to identify that these forces were exerted upon a site (Muckelroy 1978:165). Scrambling devices include processes associated with the wrecking of the vessel itself and any subsequent seabed movement which may shuffle the site around and turn what was once a planned and organized ship into something seemingly disorganized (Muckelroy 1978:169).

The important application of the theories presented by Muckelroy was to be able to understand how a ship became the deteriorated wreck, so careful steps could be taken to follow the flow backwards to determine the original makeup of the ship. He believed archaeological site formation could also be used to help understand how a site might further deteriorate in the future (Muckelroy 1978:215).

Archaeologists such as David Stewart (1999) have continued to work towards deepening our understanding of archaeological site formation. At the time of writing his article "Formation Processes Affecting Submerged Archaeological Sites: An Overview" Stewart showed that underwater archaeologists had not created "coherent bodies of theory for their field" (Stewart 1999:566). Other archaeologists had written on the subject before, but most of the time these writings were on just one site or area and not on an overarching theory. Stewart also wrote,

> Too often, underwater sites, especially shipwrecks, are treated simply as "time capsules." In reality, underwater sites, like those on land are the result of complex formation processes that can result in the mixing of strata, destruction of artifacts, and deposition of new material. For this reason, understanding the formation processes present must become a primary goal of archaeologists studying submerged sites (Stewart 1999:585).

He describes the factors which bring a ship to its archaeological context as *depositional processes* and those after a ship's deposition as *post-depositional formation processes*. Depositional processes are the direct factors which brought a ship to its resting place such as a wrecking or abandonment event. Stewart also discussed how some of these depositional and post depositional processes are more well-known and studied than others (Stewart 1999:584).

A diagram based off Muckelroy's original processes was created by Ingrid Ward and her co-authors (Ward et al. 1999; see Figure 14). Their diagram focuses more specifically on the environmental factors of wreck formation which involves two major modifications - the *sedimentary processes* and *hydrodynamic processes*. Different types of sediment such as gravel, sand, and mud can affect a site in diverse ways. Additionally, high energy sites are more likely to undergo elevated physical deterioration than a low energy site. However, sediment type may also influence chemical or biological deterioration (Ward et al. 1999:564).

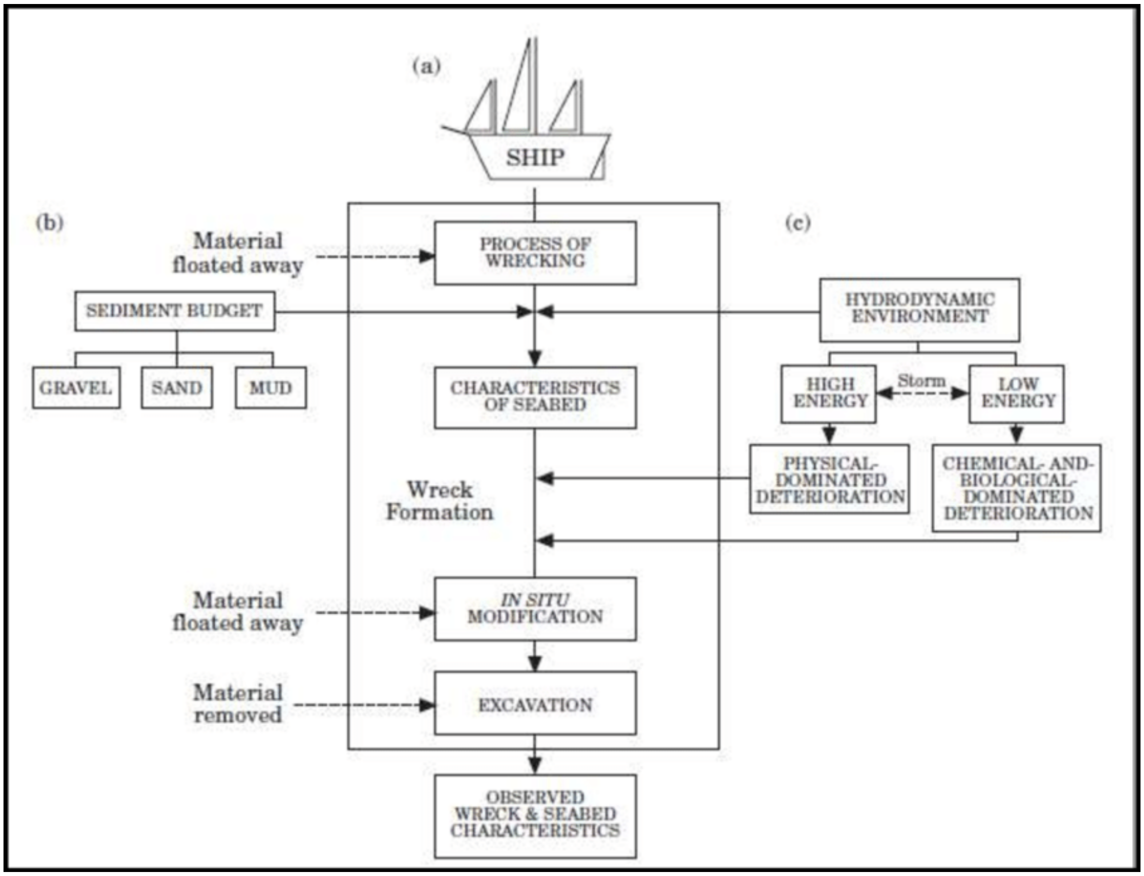


Figure 14. An expanded version of Muckelroy's (1978) flow diagram (Ward et al. 1999:564).

Building on the work done before him, especially Muckelroy, Martin Gibbs also created a model for site formation theory (Figure 15). One of his most important additions to previous models was putting more emphasis on certain pre-impact factors which affect site formation before the ship even wrecks. These pre-impact factors are part of Gibbs using previously developed *disaster response* structures and applying them to studying wreck formations and their archaeological signatures. Disaster response shows that no matter the disaster it can be broken down and examined within a system of processes which demonstrates both the physical and behavioral changes (Gibbs 2006:7). Gibbs followed Leach's 1994 disaster response structure with stages encompassing *pre-impact*, *impact*, *recoil*, *rescue*, and *post-trauma*. Within Gibbs' modified structure, the pre-impact shows what happened before the wreck occurred. Impact deals with what occurs during the wrecking process. Recoil is what happens directly after a wreck like sailors and passengers leaving the ship. Rescue includes a possible rescue from the disaster and is the stage where many disaster accounts get their start. Post-trauma includes the long-term effects on the ship and crew after the disaster (Gibbs 2006:7-14).

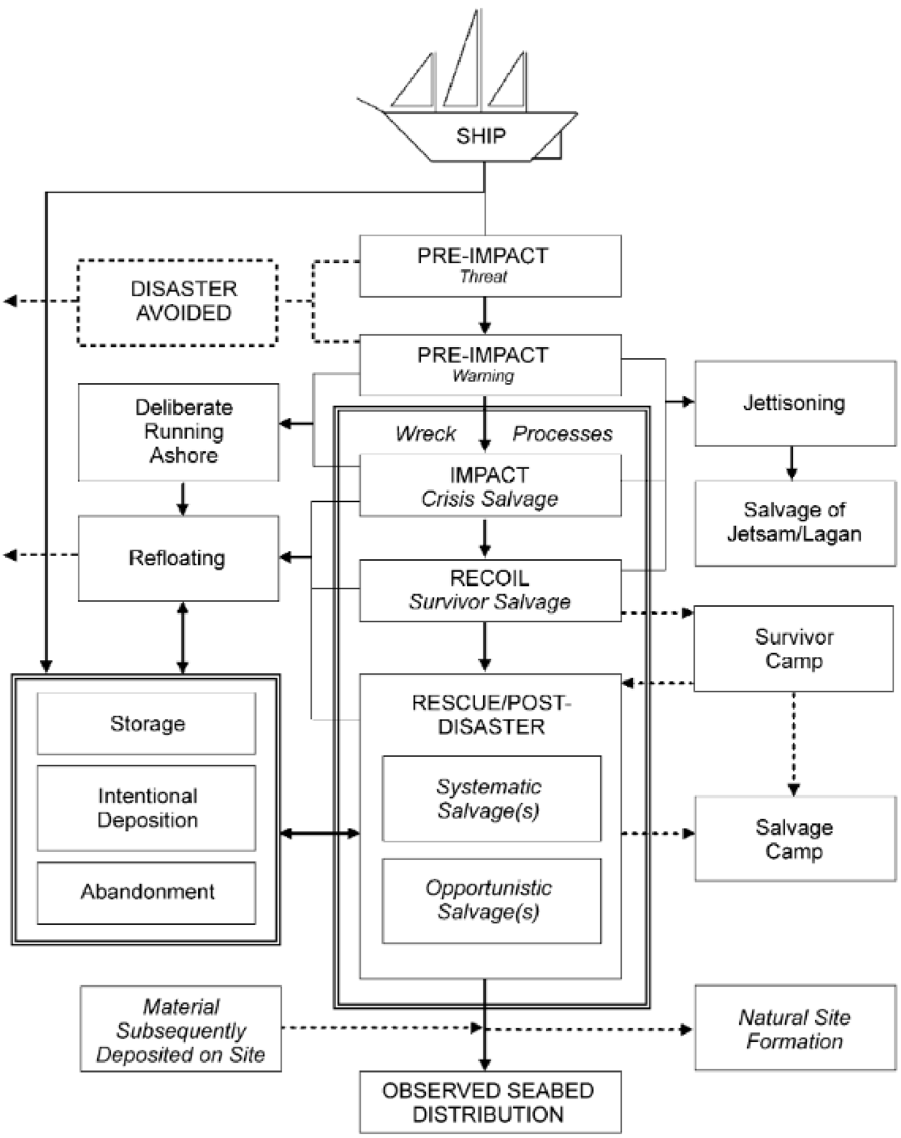


Figure 15. Site formation factors (Gibbs 2006:16).

In *Ships' Graveyards: Abandoned Watercraft and the Archaeological Site Formation Process* (2008), Nathan Richards also tackled the subject of site formation processes. In this work, Richards discussed some of the similarities between the theories of Schiffer and Muckelroy. Richards discussed how "Site formation theory is best represented by Michael B. Schiffer's and Keith Muckelroy's studies, which are similar to a degree" (Richards 2008:51). Richards also applies site formation theory to abandoned watercraft and focuses on several different types of transformation processes. *Reuse*, *discard*, and *abandonment processes* are all examples of cultural transforms which Richards applies to abandoned vessels. Richards discussed how abandoned vessels can be used by researchers to understand the events which caused a vessel to be abandoned in the first place (Richards 2008:178).

Systemic Context

These site formation processes can be explained through the hypothetical life of a coin. A coin, newly minted and made of silver, is sent off with many others like it to a bank for circulation. It is meticulously counted with the rest and placed into a cashier's drawer. A patron visits the bank and withdraws a sum of money and the cashier passes through the grate this new coin as part of the sum. The coin then spends the next several years being passed from person to person, slowly being tarnished and worn down by the handling. The time the coin spent in the possession of the people would be its systemic context. Eventually, some unlucky person places the coin in their pocket which has a hole and loses it quickly. The coin gets kicked to some corner of a street where it is forgotten and passed over, thus entering its archaeological context.

Similarly, a ship is often not pristine when it enters the archaeological record as a shipwreck. Before a ship ever becomes an archaeological site, there are factors which influence how it degrades as the ship is used and how the ship will degrade when it transforms into an archaeological site. While a ship is being used, it undergoes both transformations from cultural factors and environmental factors. According to Martin Gibbs, it is possible for the cultural transforms which might affect subsequent site formation to appear long before the ship becomes an archaeological site (2006:8). Figuring out those transformations which occurred before a wrecking or abandonment event can help archaeologists understand the site itself.

Pre-depositional evidence of Cultural Transforms

Schiffer showed that culturally artifacts are used in three major ways which include social, symbolic, and practical functions. Artifacts could also undergo changes from cultural transforms, or C-transforms, at any time after they are created and before they are completely gone (Schiffer 1987:14). Alan Sullivan came up with a system for showing the impact traces of use, or other activities, had on an artifact. He used this system to interpret how these traces could lead to a better understanding of how something was used and how the order in which events occurred to the artifact could change it (Sullivan 1978:208-210). In terms of a ship, cultural transforms from the systemic context include processes such as the actual construction of a vessel, the repairs, and reuse. A vessel made of wood will degrade in one way, a steel vessel another, and a composite vessel a different way. Marks made by tools during construction may also appear on vessels years later. For example, tool marks in timbers may be from the period of construction or could be salvage marks. Adze marks may be more likely to come from the period of construction or repairs, while saw marks could be from construction, repairs, or salvage; in which case, context is the best clue to understand its place in the site formation. If a ship has had a long or even a short hard life, then at some point it may become more beneficial to get a new ship rather than constantly doing expensive repairs. Or maybe the ship has some damage which makes it inoperable and is too expensive to repair. In this case, where does the old ship go? It could be broken down and scrapped for parts immediately or it may just be abandoned in some secluded spot or ship graveyard.

Depositional Evidence of Cultural Transforms

Abandoned ships are often overlooked archaeological sites in comparison with shipwreck sites, perhaps because deliberate discard (abandonment) and catastrophic loss are radically different (Richards 2008:4-5). Abandonment is a discard process which moves a vessel from its systemic context to its archaeological context usually once it has finished serving its designated purpose. This could be due to many factors such as damage which can't be repaired, general wear and tear, or technological obsolescence. An important note made by Schiffer relates to people's tendency to put their discarded items where others have already discarded things (Schiffer 1987:62). This means that once someone has abandoned a vessel in one spot, others are more likely to follow the first person's lead and a ship graveyard will form. Sometimes ships might even be abandoned right on top of each other. It is possible to also separate the type of discard sites into *primary refuse* sites and *secondary refuse* sites. When vessels are abandoned where they were used would be a primary refuse site, whereas a secondary refuse site would be if a vessel was abandoned in a place specifically used for the purpose of abandonment (Richards 2008:56).

Nathan Richards discusses specific behaviors within the context of abandonment processes: *de facto refuse* and *curate behaviors*. De facto refuse is a term which relates to still having use or the ability to be reused but are still abandoned anyway when people move on to other places. Curate behaviors occur when a vessel or parts of a vessel are taken from an abandonment site to be reused again. Curate behaviors are in direct contrast with de facto refuse, since people are taking from an abandonment site that has not been fully abandoned. Abandoned ships which are close to shore or in shallow water have a much higher chance of people returning to the site to acquire useful materials or parts (Richards 2008:57).

How a ship is abandoned is another important factor in site formation. A ship that is damaged by fire might be scrapped and abandoned in one location, while a ship that hits an iceberg might sink in deep water (O'Shea 2002:213). Burning a ship on purpose can also be a way of placement assurance, making sure that the remains of the vessel do not move from their intended resting place. This is particularly necessary for abandoned watercraft when a vessel left in the wrong place could cause damage to the environment or bring about fines for the owner. Nathan Richards writes about *placement assurance* being broken down into two factors, "Placement assurance takes many forms, but can generally be separated into two categories, the appropriate treatment of the hull and the choice of an appropriate environment" (Richards 2008:164). It is possible that the contents of a sunken vessel may not belong to the vessel itself but could be part of a filling process to make sure it does not move once disposed. Stones in "the wreck of stones" may have been a way to make sure that the vessel stayed put after sinking

(Richards 2008:169). Some of these cultural transformations can affect the environmental or cultural transformations which occur during the ship's archaeological context.

Archaeological Context

To continue the coin analogy from above, over time the coin that was lost is covered with trash and soil to the point it is buried in the earth. Being in contact with an acidic soil, the coin continues to tarnish and degrade. One day, an archaeologist excavating a once bustling city stumbles across this coin, dusts it off, and studies it. The coin is studied in its archaeological context, but the hope of the archaeologist is that the information gleaned from it illuminates its use within the culture under study, thereby helping to reconstruct the systemic context.

The archaeological context of site formation processes, the factors affecting a ship once it has found its resting place underwater, can also be broken down into cultural transforms and environmental transforms. The archaeological context of site formation processes is often studied more than those elements which affected a ship during its systemic context, and it is just as important to understanding a site. Ian Oxley and Matthew Keith wrote,

> Site formation processes consist of a wide range of both punctuated and ongoing events and processes that contribute to the condition of a shipwreck site at a given point in time. Formation on submerged sites begins with the initial deposition event and evolves depending on the subsequent effects of the natural environment and human activity. These processes are affected by deposition and depositional environment followed by the subsequent effects of processes such as wave action,

storms, bioturbation, pressure, salinity, temperature, chemical reactions, and human activity (Oxley and Keith 2016:1).

All these different processes come together to create an archaeological ship site. A better understanding of these processes is necessary to understand and preserve ships from chemical, biological, and physical damage.

Cultural Transforms

Cultural transformations can still take place even when a ship enters its archaeological context. Salvage can return parts of a vessel back to a systemic context while leaving destructive marks on what is left behind. Goods might be sought after to be returned to the original owner, or parts of a ship may be used to patch still floating vessels. Salvaging of a vessel might take place in multiple stages, making it more difficult to distinguish between them. *Primary salvage* usually occurs before a vessel reaches its final resting place, while *secondary salvage* most often occurs at the final resting place. The most recent salvage efforts on a ship often cover up any of the previous salvage efforts. During his research, Nathan Richards studied multiple different ship abandonment and graveyard sites around Australia and stated that determining what was a pre- versus post-depositional salvage was near impossible (2008:155-156). Sometimes parts of a vessel, such as the hull, might get in the way of salvage efforts and salvagers must remove the ship parts in some fashion. For ferrous hulled vessels, blowtorches might be used; however, for wooden vessels, burning off the wooden hull could be used to get at any useful internals or fastenings. The burning of the hull on ships like *Margaret*, *Redemptora*, *Day Dawn*, and *Glory of the Seas* show that it was a cost effective and a commonly used way to salvage or abandon a mostly wooden vessel (Richards 2008:160-161). Figure 16 shows the burning of several partially built wooden vessels which were scrapped before being completed since their need disappeared after WWI.

Figure 16. Before, During, and After the burning of partially built WWI ships (Tacoma Public Library, Chapin Bowen Collection).

Looting can also take place and affect the condition of a wrecked or abandoned vessel. Divers may take important artifacts off the wreck for their own collections, or looters may take "valuable" items off a wreck to sell for profit. A site may slowly disappear from being looted and damage may be done to "non-valuable" aspects of the site while trying to get to "valuable" artifacts.

Dredging and construction can also deeply impact a site. Dredged up sediment may be dumped on a site or a site might be cut into while undertaking dredging or construction. Fishing also has an impact on sites with fishing lines getting wrapped around vessel structures; or trawling fishing vessels getting nets tangled on protruding pieces, possibly ripping the ship apart, thus catching more than just fish. Just normal diving on a wreck may affect the site. Divers with poor buoyancy control may bounce up and down off the ship effecting the vessel.

Environmental Transforms

Environmental transforms also have a great effect on how a site forms over time. Some of the most prominent factors include marine life, currents, storms, sediments, and what natural chemicals a site is subject to. Different environments affect ships in different ways with some environments doing more physical damage versus others that do more biological or chemical damage (Ward et al. 1999:565). Marine life can come in two forms, microorganisms and macro organisms, both could cause changes in how a site breaks down. Microorganisms may colonize a wrecked or abandoned ship using the ship as a source of nutrients. When microorganisms move in other larger macro organisms follow to feed off the microorganisms and may make their own home on a site. Coral, as well as mussels and clams, can attach themselves to wrecks.

Muckelroy wrote about underwater archaeological sites and their environments in his book *Maritime Archaeology* (1978). In his work, Muckelroy noted that there are many generalized theories being thrown around by underwater archaeologists during and before his time. Since much of the work done during those periods was in the Mediterranean region, these generalizations rarely applied to sites outside the Mediterranean, due to the differences in site environments. To add more to these discussions about the effect of different environmental factors on sites outside the Mediterranean, Muckelroy gathered information about sites in English waters. The point of this study was to be able to show how the quality of archaeological sites changed based on environmental factors and to determine which of these factors had the most effect on the site's archaeological quality. A total of 20 sites were studied using 11 environmental factors (Muckelroy 1978:161). The 11 factors that were used are prioritized as follows:

1. Maximum offshore fetch, within 300 of the perpendicular to the coast.
2. Sea horizon from the site
3. Percentage of hours during which there are wind of force 7 or more from directions within the sea horizon.
4. Maximum speed of tidal streams across site.
5. Minimum depth of site
6. Maximum depth of site
7. Depth of principle deposit on site.
8. Average slope of the seabed over the whole site.
9. Underwater topography
10. Nature of the coarsest material within these deposits
11. Nature of the finest material within them (Muckelroy 1978:162)

From his research, Muckelroy was able to determine that the nature of the silt deposit was the most important factor in the preservation of archaeological materials. This result reinforced previously held ideas, but the most interesting thing was how highly factor two, Sea horizon from the site, placed on the list versus factor four, maximum speed of tidal streams across site. This suggests that having disturbances coming from multiple different directions had much more impact on a site than how forceful they were (Muckelroy 1978:163). It is important to point out that this study does not include flora or fauna of any kind and only focuses on wooden vessels without including iron vessels. The addition of fauna to the study might have changed the results and the results for iron vessels might look substantially different from those of the wood vessels.

Ocean currents are another way which ships, especially in shallow water, can be affected by their environment. Underwater currents have the power to slowly erode parts of a ship or even move around artifacts and distribute them in different areas. Currents generated by storms such as hurricanes can cause significant damage to sites, ripping them apart and redistributing parts of the site to new areas. Storms can also cover up exposed parts of wrecks or uncover buried parts, completely changing how the site will form from other factors in the future. Muckelroy discussed how current movement affected the site of *Kennemerland*, wrecked 1664 of the cost of Shetland. The currents shortly after wrecking scattered parts of the wreck and its cargo out from the initial wreck and then may have brought some of those pieces back over the site (Muckelroy 1978:174).

How much a site is covered in sediment and what type of sediment also plays a part in the process. If a site is covered, it may have more protection from other environmental and cultural factors. The type of sediment, and whether it is more muddy or more sandy, may change how fast parts of the ship degrade over time. Sediments can have different chemicals mixed in with different levels of acidity or alkalinity, thus affecting wood, iron, or other materials at completely different rates. The same thing can be true for the water that the site resides in. Whether the water is saltwater or fresh, and whether it is cold or warm all change how the site forms over time. One example of the effect of sediment on a site can be seen with *Dartmouth*, an English 1690 wooden shipwreck. The sediment which the ship lies in has two major substrates, a clay layer and a gravel layer that sits on top. *Dartmouth* is embedded in this sediment and though the clay may keep the wooden sections in this substrate layer well protected, the gravel above can be pushed around by current action and rub up against the wood in the top substrate to slowly erode it (Muckelroy 1978:177).

Case studies have been done by many archaeologists on environmental effects on shipwrecks. Andrew Wheeler discussed some case studies in one of his papers focusing on Irish Shipwrecks. Around the Kish Bank, Outer Dublin Bay there are a couple shipwrecks which are in very poor condition, but there is a lack of evidence of many other wrecks likely due to the conditions.

> The low preservation rate for shipwrecks in this area is probably due to two factors: the *high-energy conditions* causing physical destruction, and high chemical and biological degradation facilitated by constant exposure and re-exposure of shipwrecks in a mobile substrate. High-energy conditions on the banks come from both wave and current action that is capable of suspending sediment and creating bedforms indicative of mobile substrate (Wheeler 2002:1152-1153).

Another area that Wheeler looked at was La Surveillante, Bantry Bay. The wreck in that area is mostly buried in sediments which allowed very few harmful factors access to the wreck. This has created a much better-preserved wreck. Wheeler's studies show how massive differences in how well ships are preserved come from the environment in which they are deposited (Wheeler 2002:1157).

Conclusion

Understanding archaeological site formation theory is critical to determining how a ship went from construction to sailing to becoming the archaeological site it is when an archaeologist studies it. The work of Michal Schiffer (1972, 1987) and Keith Muckelroy (1978) were some of the most influential in building a foundation for site formation theory. Other archaeologists such as David Stewart (1999), Ingrid Ward et al. (1999), Martin Gibbs (2006), and Nathan Richards (2008) helped to build on that foundation and expand the understanding of the archaeological site formation process. To fully understand how a site is formed, archaeologists must study the cultural and environmental factors which effect a vessel, both before it enters the archaeological record and after. Events such as salvaging a vessel for useful parts would be a cultural factor to its development, while the habitation of a site by wood eating worms would be an environmental factor. Applying archaeological site formation process theory to the study of a site such as *Fraternité* will help in gaining a better understanding for how a wooden auxiliary schooner with many ferrous components went from a new vessel to its dilapidated state on the shores of Bermuda.

CHAPTER FOUR: METHODS

It is impossible to fully understand the site formation processes that produce an archaeological site without first establishing the historical context within which it was created. Historical and archaeological information were brought together in this study to create 3D models of *Fraternité*. These models were then analyzed to understand how elements of the vessel's design, including the extensive use of ferrous components, affected the site formation of the wooden-hulled ship.

This chapter focuses on the historical, archaeological, and model-building methodologies employed during research. The section on historical research shows the information on how wooden vessels were constructed during World War I, as well as explains the wider context of the transitional ship building period. During the historical research phase, both primary sources and secondary sources were consulted. The next section focuses on the previous archaeological work conducted by ECU in 2008 on the *Fraternité* archaeological site in Bermuda. The team conducted an extensive site survey using offset mapping, photographs, and video. The final section of this chapter focuses on the processes of using both the historical and archaeological material to create 3D models to better understand the site formation of *Fraternité*.

Historical Research

Before beginning work on creating 3D models of *Fraternité,* it was necessary to first understand the historical context of not only *Fraternité,* but also of World War I era wooden ships. Resources collected encapsulate the construction, lifecycle, and time period in which these wooden vessels were built. These historical documents can be divided into primary sources and secondary sources. The primary sources that were used in this study include information from the company who built *Fraternité,* books on the construction of wooden vessels which were written around the time *Fraternité* was built, and newspapers which discussed the wrecking event and salvaging efforts after the fact. Original plans for another vessel of the same type, *Commandant Rosin*, were also collected as primary documents. Secondary sources include books and articles which discussed the history around *Fraternité* and World War I, and the construction of vessels like *Fraternité* written years after the war was over. All this historical information was used to help in the reconstruction process of building the 3D historical model of the ship before it wrecked.

Primary Sources

Several primary sources were found in ECU's Joyner Library. Joyner Library has quite a few maritime history related books due to the maritime studies program present at ECU. Several books, such as Charles Davis' *The Building of a Wooden Ship* (1918), Charles Desmond's *Wooden Ship Building* (1919), and William Mattox's *Building the Emergency Fleet* (1920), contain information about the construction of wooden ships during the time period of World War I. Other primary sources found through internet searches for information related directly to The Foundation Company and *Fraternité*. These searches uncovered *The Foundation Shipbuilder* which was a newspaper released by The Foundation Company during World War I. A couple of the issues of *The Foundation Shipbuilder* (1918) held general information about the company that built *Fraternité*, as well as information about *Fraternité* itself, and the other five masted, steam assist schooners of its type. These include the 9 February and 3 April 1918 issues.

The Tacoma Public Library also proved to be a good location to obtain primary sources. Searching their online digital collections for anything having to do with *Fraternité* or the Foundation Company identified a general collection of photos from the Foundation Company dockyards, which constructed *Fraternité* and the other ships of its kind. Many of the photos were of the shipyard in Tacoma, Washington, the employees, the mechanical equipment, and facilities located on the large property. There were also a few photos of the slips where these vessels were constructed, both empty and with ships under construction. A smaller subset of photos showed one of the completed ships, *Gerbeviller,* which was the first ship of the same type as *Fraternité* to set sail. The photos of the shipyard gave important background information about the construction of *Fraternité*, while the photos of *Gerbeviller* gave important reference information for creating the models and better understanding the construction of *Fraternité* itself (Figure 17).

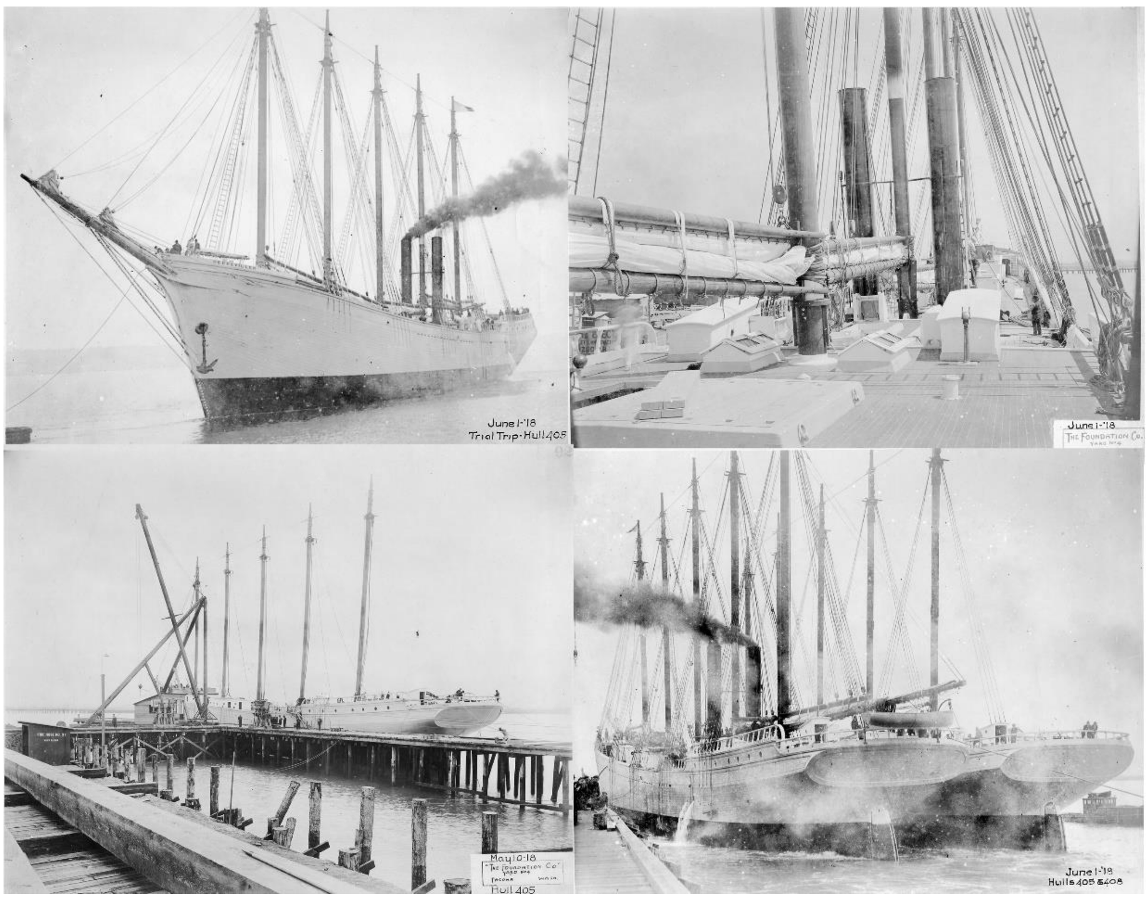


Figure 17. Photos of *Gerberville* used as reference (Courtesy of Tacoma Public Library).

Newspapers/Magazines

The largest batch of primary sources about the wreck and salvage of *Fraternité* came from Bermuda newspapers. *The Royal Gazette* reported multiple times on the condition of

Fraternité, shortly after its wrecking on 3 April 1919, until the burning of the vessel to help with salvage efforts near the end of May 1919 (*Royal Gazett*e 1919f). These newspaper clippings were acquired during the 2008 St. George's ship graveyard project conducted by ECU. The team went to the Bermuda Archives located in the Bermuda National Library in Hamilton to conduct much of their research (Richards 2009). Information regarding the salvage operations which some of these newspaper articles contain was very useful in understanding events between the tine of the wrecking of the ship and when the salvaging had finished at its final resting place in Meyer's Wharf. Without this information it would be impossible to determine that these exact cultural transformations took place the way they did. This information was incorporated into the modeling process to better show how the ship was broken down. Another primary source that had some detailed information concerning five masted, steam assist, schooners such as *Fraternité* came from *The Rudder Magazine for Yachtsmen*. In particular, *The Rudder* Volume 35, Issue 5 from 1919 had general information and specifications about the schooners, as well as some simple plans for that type of vessel (*The Rudder* 1919). This gave a high-level understanding of *Fraternité.*

Plans

To build the model it was necessary to find detailed plans of *Fraternité* or one of the other 39 vessels which share the same design. The search started with parameters on when the ship was built, and who designed and built it. The major repositories searched were those that seemed most likely to have ship plans within those parameters. The United States National Archives, Peabody Essex Museum, Washington State History Museum, and the Foss Waterway Seaport were all contacted regarding plans for *Fraternité* or one of its fellow ships. When this search failed to find the plans, it was necessary to search other places with a different method.

Looking online for any place that sold ship plans located several websites, but the one which looked the most promising was the Mystic Seaport Museum. By searching through Mystic's extensive database of ship plans, it was discovered that they had a collection of plans designed by Cox and Stevens, the same designers of *Fraternité* and the other five-masted schooners built for the French near the end of World War I. These plans were then searched by looking for the name of each of the 39 ships which shared plans with *Fraternité*. The only hit on this search was *Commandant Rosin* which shared the same overall length, build date, and builder with *Fraternité* in the museum's records. *Commandant Rosin* is likely a typo because in the list of 40 vessels *Commandant Roisin* is only one letter different. The Mystic Seaport Museum had 40 sheets of plans for this one vessel ranging from lines to detailed plans of the boiler system. Each sheet was priced at $40 so only six, specifically the ones most likely to help in creating a 3D model with the basic features, were purchased due to budget constraints. These plans included lines (Figure 18), midships (Figure 19), beams (Figure 20), long section (Figure 21), sail plan (Figure 22), and main deck along with a profile view (Figure 23).

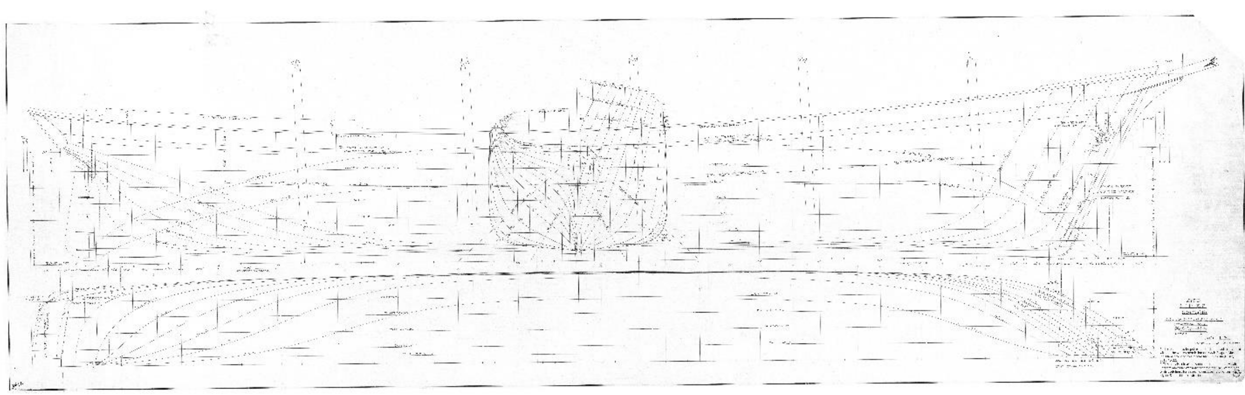


Figure 18. Ship lines for *Commandant Roisin* (Mystic Seaport Museum).

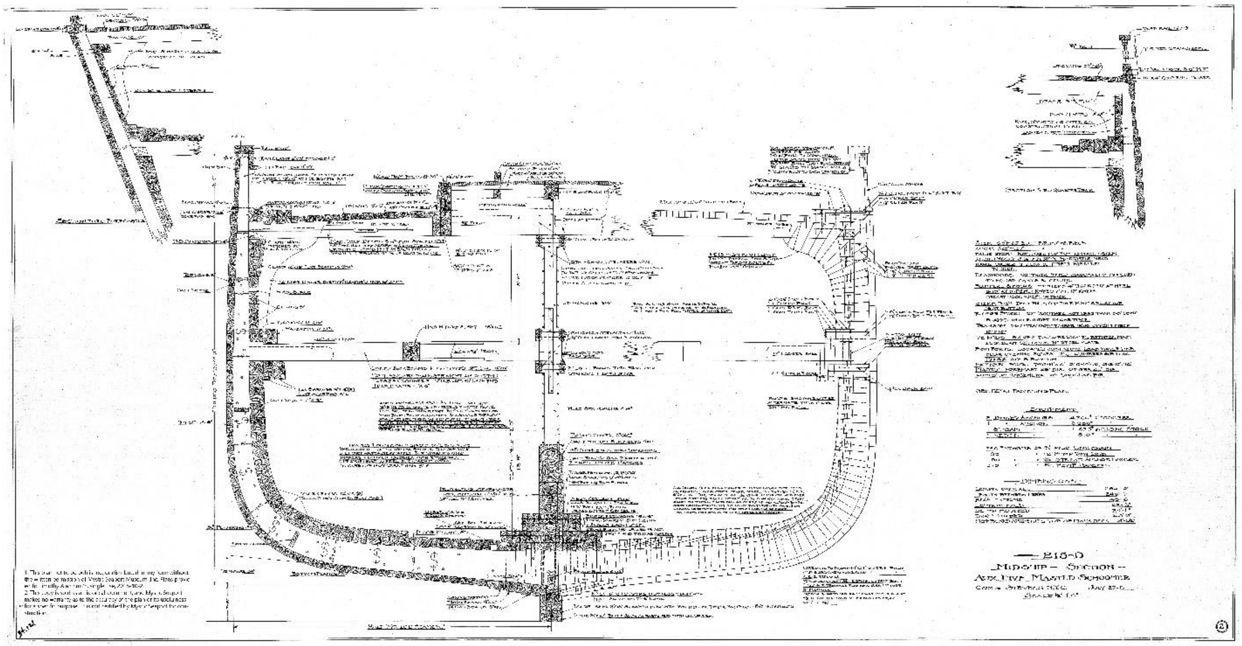


Figure 19. Midships section for *Commandant Roisin* (Mystic Seaport Museum).

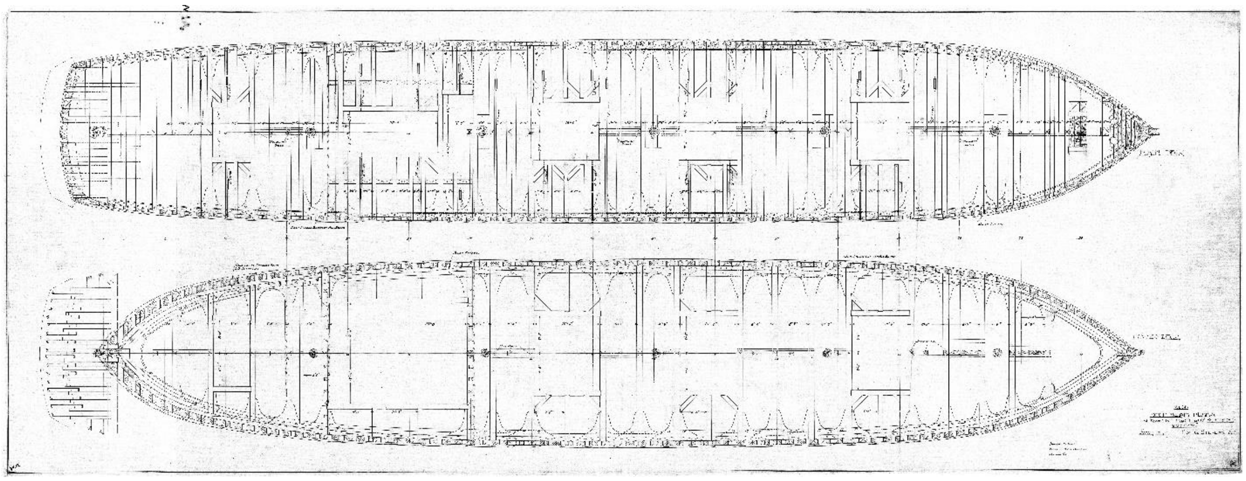


Figure 20. Deck beam plans for *Commandant Roisin* (Mystic Seaport Museum).

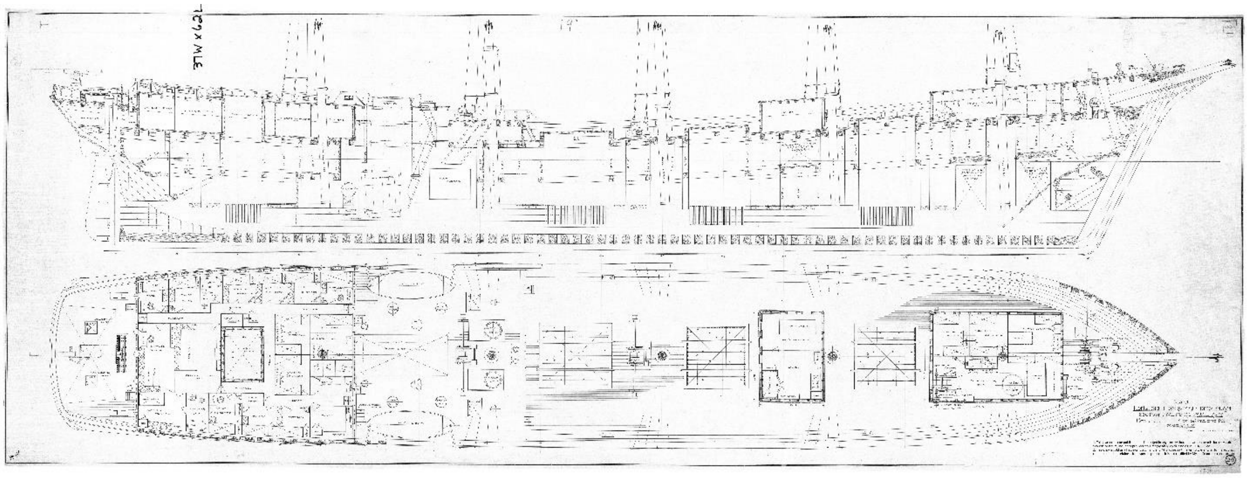


Figure 21. Longitudinal and main deck plans for *Commandant Roisin* (Mystic Seaport Museum).

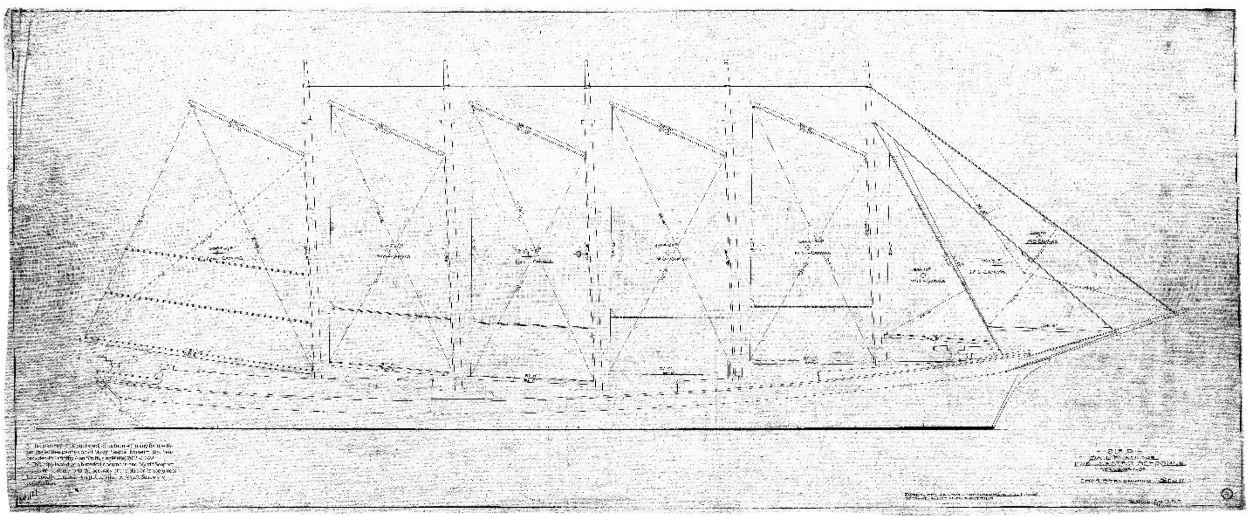


Figure 22. Sail plan for *Commandant Roisin* (Mystic Seaport Museum).

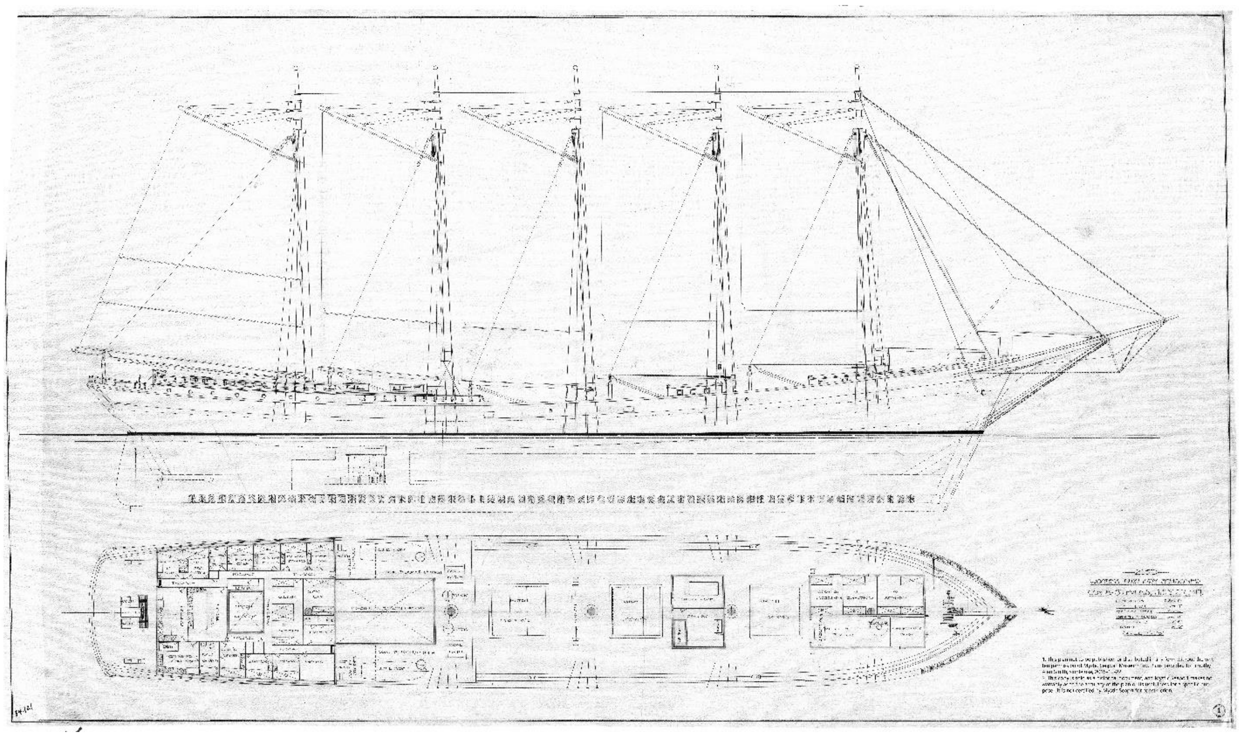


Figure 23. Profile and main deck views for *Commandant Roisin* (Mystic Seaport Museum).

Secondary Sources

Many of the secondary sources used for this project were found at Joyner Library at ECU. In Joyner Library, there was a great deal of information on World War I and the naval actions which took place leading up to and during the war. Books such as Tarrant's *The U-Boat Offensive, 1914-1945* (1989), Simpson's *The Lusitania* (1972) and the U.S. Navy department records (1923) on lost ships showed how the stage was set to create large wooden ships, such as *Fraternité,* which could carry large loads of goods quickly and be built cheaply and rapidly.

Joyner Library also has a collection of books on ship construction and its history. Following the history of wooden ships and their construction from a short time before WWI and during the war led to a better understanding of wooden ship construction of that era, and, by extension, of *Fraternité*. Chapelle's *The Search for Speed Under Sail, 1700-1855* (1967), MacGregor's *Merchant Sailing Ships 1850-1875* (1985), Marquardt's *The Global Schooner*

(2003), and Snow's *A Shipyard in Maine* (1998) all helped in understanding wooden ship construction of the late 19th century and early 20th century.

Along with all the helpful book resources that were found through Joyner Library, it was also possible to find articles relevant to World War I, ship construction, and archaeological site formation theory on the library's website. Through the Joyner Library website, it was possible to access many different academic databases throughout the country, thus allowing a wide net to be cast to bring in as much helpful information as possible.

Archaeological Research

Although no new archaeological field work was undertaken for this project due to cost constraints, it was still possible to rely on the work done previously. During 2008, ECU conducted several expeditions to study some of the shipwrecks and abandoned vessels that were located near the shores of Bermuda. Archaeological work was conducted in several locations around the islands, but the one of most significance to this thesis is the work carried out by Nathan Richards and David Stewart and their students. Funded by a National Geographic Grant, their work was conducted in the fall of 2008 around Meyers Wharf off St. George's Island (Richards 2009). They focused on creating an up to date list of underwater sites near St. George's as well as interpreting the ship graveyard. This project was carried out by conducting historical and archaeological research in multiple locations including the Bermuda Library and Archives, and field work through non-disturbance recording methods such as diarized observations, mapping, video, and photography (Richards 2018:43). All the information gathered by the ECU team would help in the construction of a 3D archaeological model of *Fraternité*.

2008 Field Expedition

As abandoned vessels were the focus of the research done in Bermuda by ECU possible abandonment and salvage sites close to the shores of Bermuda were those that received the most focus. As Richards notes,

> This project began the process of discovering the extent of ship breaking activities and their archaeological remains via historical research and archaeological search and survey in order to 1) study the role of geographical and economic factors in archaeological site formation, 2) create an inventory of a fleet of significant vessels currently at risk from development and, 3) provide management recommendations for the Government of Bermuda (Richards 2009:2).

The two main methodologies used to complete this research were detailed historical and archaeological research. The search for historical research took place both at ECU and in Bermuda at multiple locations. The archaeological research which was carried out used diver tow searches to help find new sites along with scaled mapping on some vessels. Notes were taken by the team members in field diaries documenting all the work done by each student (Richards 2009:7).

While doing research for this project, Nathan Richards and the ECU team came across many important historical records which were further utilized in this study. Newspapers mentioned above, which talk about the days following the wrecking of *Fraternité*, were uncovered by Richards. Richards also found the Haviland article which had information about the construction of vessels of *Fraternité's* type and a French article called "Liquidation de la Flotte d'Etat," ("Destruction of the state fleet"), which discusses the fate of the vessels of

Fraternité's type that did make it to France (Haviland 1972; Union Industrielle et Maritime 2012).

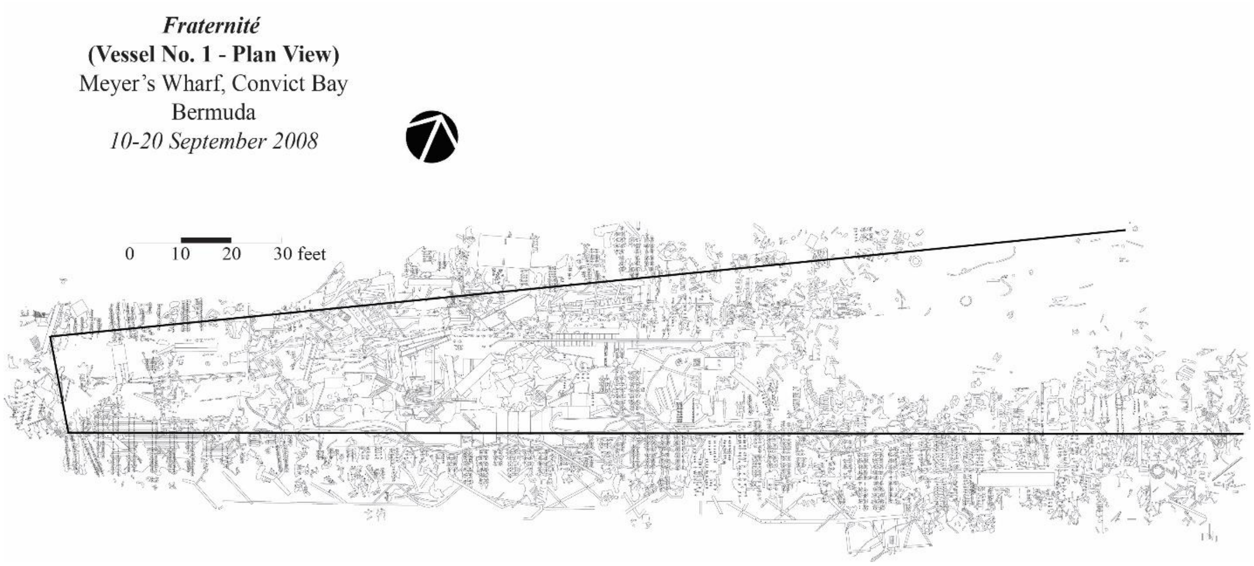


Figure 24. Modified *Fraternité* site plan with baseline (Richards 2018:50).

During this project, there were four clusters of ships observed. Cluster 1 was located at Meyer's Wharf (also known as Convict Bay). Nine sites were identified as residing within the cluster, Site 1 being *Fraternité*. Located at St. George's Boatyard was Cluster 2 with three total sites. Grotto Bay was the location of the third cluster that had the remains of two hopper barges and the debris of another un-surveyed craft. The last cluster located at Mullet Bay had three sites. Out of the many vessels examined, it was Site 1 in Cluster 1 that received the most attention. Site 1 was determined to be the location of a large wooden vessel. It was recorded using photography, underwater video, and scaled drawing to create a complete site plan which can be seen in Figure 24. The underwater video and photography helped to better understand the site and the site plan. The video was taken on one dive trip around the vessel showing major features up and down the site. Photos taken on site help to show some of these major features in a little more detail. The ECU team was able to easily identify this debris pile as the remains of *Fraternité*. Notable features which stood out and made the identification clearer included the overall length and breadth of the site as well as the presence of extensive steel strapping. Historical records and photos also helped point to this site as being the final resting place of *Fraternité* (Richards 2018:49).

Ultimately this project was able to gather and study some of the information about a lot of the abandoned vessels that lie in the waters around St. Georges, Bermuda. From this information, it has been possible for the ECU team to gain more insight about the salvage activities which have taken place around Meyer's Wharf. The economic and technological factors that influenced all the salvage and shipbreaking activities in this area might be able to be fully understood more with continued study into these wrecks through historical and archaeological work. Richards pointed out in a 2018 article that some vessels needed more detailed recording while others had the detailed recording and just needed to be further studied to be better understood (Richards 2018:76-77).

Field Notebooks

Some extensive field notebooks were kept by the students who worked on the 2008 ECU Bermuda field school. Peter Campbell, Jeanette Hayman, Morgan Mackenzie, Jacqueline Marcotte, Tyler Morra, Eric Ray, Lindsay Smith, Joyce Steinmetz, Matthew Thompson, John Wagner, and Lyz Wyllie all did excellent work in both recording *Fraternité* by keeping records on the work they conducted, and making observations about the wreck. Since there were multiple clusters of sites as well as multiple sites within each cluster, the team spent their time working on different sites on different days. What follows is a synthesis of information from the diaries will be from Cluster 1, Site 1, which is that of *Fraternité*.

The team started out work on *Fraternité* by snorkeling around the site and getting an idea for the location of where the baseline should go. The wreck is oriented southwest to northeast with some students saying that the stern was located landward. However, others pointed to the presence of full chain near the shore indicating that it might be the bow which is towards the shore. The site did slope downward the further southwest it went away from shore. In the shallowest areas near shore, the water was less than five feet deep; and at the deepest areas near the southwest, the water was only about ten feet deep. Near the large pile of ferrous debris at the center of the wreck, the water is also very shallow with only a couple of feet of water depth. Work was done in the deeper sections using diving equipment, while the shallower areas were surveyed on snorkel. The original plan was to run the baseline in a U or V shape, but the 230-foot tape was not long enough. As a consequence, the baseline was laid out from west to east along the length of the vessel and was moved using trilateration once the first area was surveyed (see **Error! Reference source not found.**). The teams were divided to survey the grid in 30-foot sections which were then broken down into 10-foot units to make surveying more accurate. To record the site, tapes were run out from the baseline at 90-degree angles in the 10-foot units and then notable features were marked down and sketched onto mylar noting their location relative to the baseline. It took about 10 days of work, spread out over the course of the project, to finish mapping *Fraternité*.

Throughout the time spent mapping *Fraternité,* many of the students made important observations about the site. One student noticed that seeing only the bottom bolts on the frame pairs from the knees could show that the vessel was burned to the water line. Fasteners could be seen to have corroded, permeating into the wood surrounding the fasteners, creating concretions. There was also still enough evidence of the fasteners to determine their pattern showing where some wooden parts such as the frames and planking once were. It was also noted that the shallower sections of the site tended to have a larger spread of debris in a much more unorganized way. A few students noticed that there was a large collection of iron plates located on top of the wooden vessel. Two different theories were proposed as to what these iron pieces might be. Some suggested that these ferrous pieces were possibly the remains of another vessel which had been placed atop *Fraternité*, while others thought they might be the remains of the engine room. Other useful observations included noting the location of what might be significant finds for interpreting the site. Some students made notes about the location of things such as brick, piping, catwalks, wire, possible knee bolts, as well as other objects. Knowing where these objects are located might help in determining what belongs to *Fraternité* and what belongs to a possible vessel that was placed on top of *Fraternité*. If some of these objects do belong to *Fraternité*, it will help to understand how *Fraternité* degraded.

Model Building

The 3D modeling for this thesis was created using Robert McNeel & Associates computer aided design software *Rhinoceros* (versions 5.0 and 6.0). Computer aided design programs, or CAD programs, are software programs which are used to create and share designs. These programs can be used to design anything, but most often they are used for designing architecture or mechanical engineering. Through the use of points, lines, surfaces, and objects within a CAD program any three-dimensional object can be created. There are many of these programs on the market which require purchase or subscription like, *AutoCAD*, *Rhinoceros 3D*, and *SketchUp*, and some that are available as open source, like *FreeCAD* or *SolveSpace*. *Rhinoceros* (*Rhino*), was originally chosen for this thesis due to the ease of use, the wealth of features and depth provided, and a previous familiarity with the program. It was not difficult to learn some of the more in-depth tools and mechanics of the program to create objects for *Fraternité*. *Rhino* also has a plugin specifically for nautical engineering called *Orca 3D*, which makes analyzing the properties of a vessel easy, although the feature was not used much for this thesis. Part of the way through the project a switch was made to *Rhino* 6.0 due to its new release and upgraded capabilities.

Historical Model

To start the process of modeling, the plans acquired from the Mystic Seaport Museum were placed into *Photoshop* to adjust for small amounts of distortion which occurred from the scanning process. These photos were then placed into *Rhino* as picture frames and lined up in the positions that they represent and scaled to the appropriate size. This process and a workflow series can be seen in Chapter Five. The long section was placed where the center of the ship would be. Using this method, it is possible to draw lines directly on the plans and then manipulate them as necessary.

The *Fraternité* historical model was created using a shell first method. This model started out by using the lines from the lines plan and creating an outside surface first. From this surface, lines for the frames were then extrapolated. This created the skeleton of the vessel upon which every other feature was slowly created by placing lines, extruding them into surfaces, then extruding those surfaces into three-dimensional shapes. Throughout the process of creating the entire model, thousands of elements, including lines, points, and surfaces, were created to make the model as detailed and accurate as possible. All these elements were organized into different layers, making it easier to build and view each part of the vessel, as well as making it easier to later deconstruct. For example, turning off the planking layer would give a view of the frames underneath and make them easier to create or edit. Each layer which ended up in the final model was also given a rendered surface to make the model look more accurate; layers that contained wooden features received wooden surface renders which made them look like real wood, while layers with metal received iron surface rendering to make them look like iron or steel. Other layers still used different color coding to make it obvious as to what layer they belonged and that they were not meant to be present in the final model. *Rhino* 6 also allows for specific viewing angles and intermediate states to be saved so that the vessel can look partially deconstructed and then whole again with the push of a button. Expanded modeling methodologies for the steps in the buildup of the historical model can be seen in the chapter 5. Figure 25 offers a view of the final product of the historical model. Chapter 5 goes more in depth into the construction of each model and shows more detailed figures.

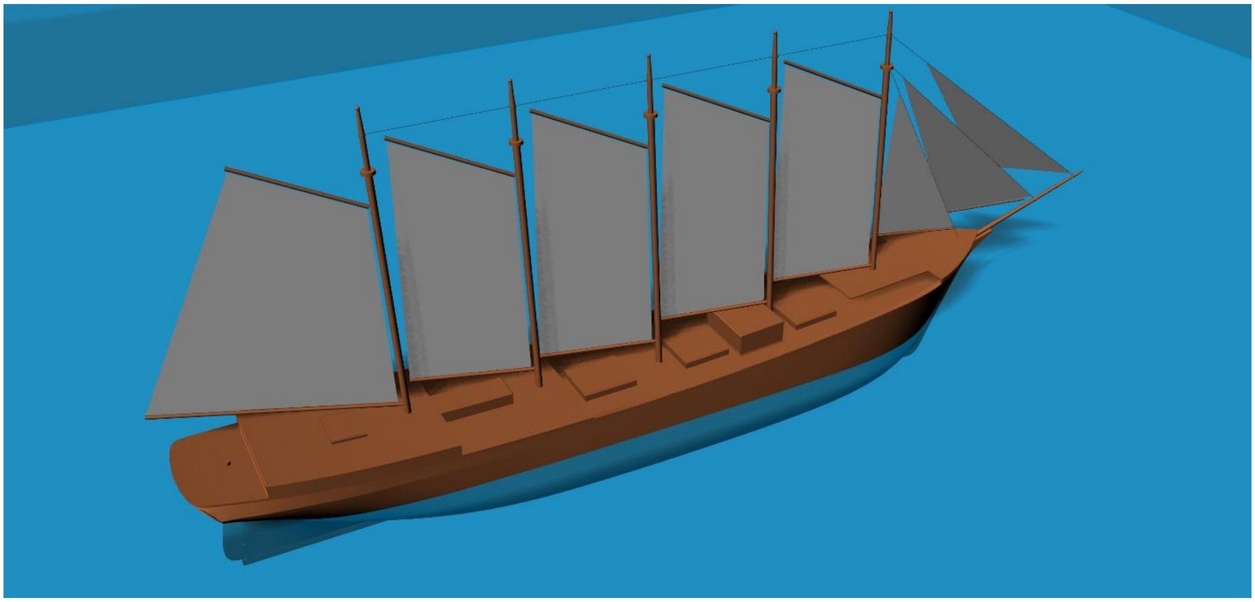


Figure 25. Example of historical 3D model of *Fraternité* (Image by Tim Smith).

Archaeological Model

Creating the archaeological model was different from creating the historical model. Instead of creating the archaeological model from scratch from the site plan, it was created by using the site plan as a guide and deconstructing the historical model. To start the process, the historical records were consulted and used to systematically remove the parts of the vessel from the model that were noted to be removed in the wrecking event and salvage efforts. For example, since the newspapers mentioned the masts falling before the ship left its original wrecking site, the masts were removed first, and a view was saved of the vessel without masts to show this step in the life of the vessel. Similar steps were taken for other parts of the vessel such as a part of the hull which was left at the original wreck site and the burning of the vessel at Meyer's Wharf.

After making these recorded changes to the historical model, it was time to make what was left look like the current archaeological site. To accomplish this, pieces were slowly taken apart and moved into place with the purpose of ensuring they lined up with the site plan, the observations made by students during the 2008 field school, and the video which was taken during 2008. Some parts were bent into new shapes while others were cut into more pieces to best match the site plan. This process has not created a hundred percent accurate model of the current site, but it is as close as possible with the information available. Once the debris of the historical model was lined up correctly, it was then necessary to add some components that were not present in the original model. The large iron plates that are located near the middle of the site do not appear to be from *Fraternité*, so new objects had to be created to represent them in the model. Figure 26 shows an example of the completed archaeological model of *Fraternité*. Further figures that show the models can be seen in more detail in Chapter Five.

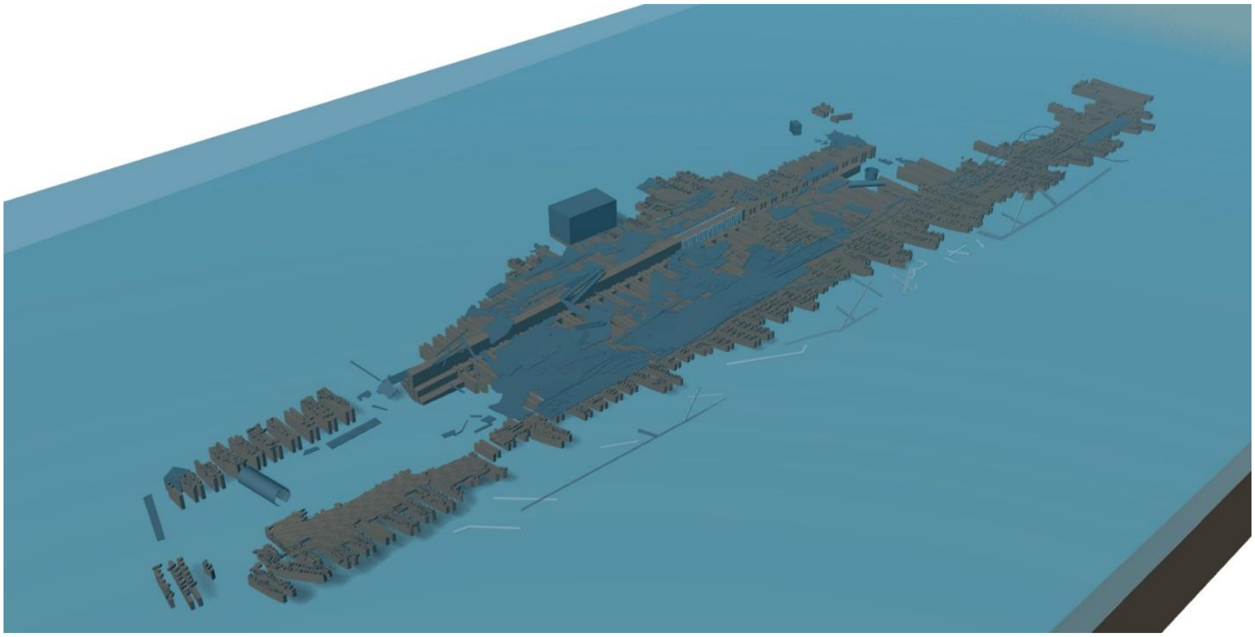


Figure 26. Example of archaeological model of *Fraternité* shipwreck site (Image by Tim Smith).

Analysis of Models

After the completion of the archaeological model based on the historical model, the work done on the 2008 expedition, and historical research, the next step was to study the model and complete a site formation analysis of *Fraternité*. The way that the archaeological model was created using the historical model made this part easier since, in a way, the deconstruction of the historical model closely mimicked how the actual vessel has been deconstructed over time by both cultural and non-cultural transforms. Using the historical and archaeological data, a full series of models were created to show how *Fraternité* deteriorated.

As previously stated, models were created to represent each major documented step the vessel went through after its wreck to its current state. Masts were removed to show that they fell from the ship and were detached. A section of hull was removed to show the hull section which broke off on the reef. Parts of the vessel were removed to show the salvaging of materials from the vessel as it sat in Meyer's Wharf. A large part of the vessel was removed from the model to show the burning to the waterline that occurred at the site. Using all these separate models along with the archaeological model, it was possible to show some of the factors which led *Fraternité* to its current state as well as make educated guesses on other factors. More on the creation of each model and their interpretation in relation to the site formation is discussed further in Chapter Five and Chapter Six respectively. These models include,

- Historical model
- Initial wrecking model
- Further wrecking/salvage model
- Falling of the masts model
- Burning of the ship model
- Archaeological model

Conclusion

This chapter focused on the how, where, and why historical and archaeological research was gathered as well as the general process used to create the historical and archaeological models for the project. The historical information gathered helped in understanding the background for the construction of *Fraternité*, as well as helping to create the computer models of it. The newspapers, as well as other similar primary sources, were crucial in helping to build the timeline of the vessel's life and understand as much as possible about what happened to *Fraternité* while it remained in the historical record. Vessel plans were indispensable in creating the historical model of *Fraternité*. Secondary sources related to wooden ship construction and World War I helped in better understanding how and why *Fraternité* was constructed the way that it was, as well as when and where it was built. The archaeological research conducted by ECU in 2008 such as research, videography, photography, and the creation of a site plan led to a better understanding of the *Fraternité* site's current condition. The detailed diaries kept by the team gave an informed view of what exactly transpired during the expedition and the important features on the site which helped with interpretation. Using all this gathered data, it was then possible to create both a historical and an archaeological model of *Fraternité*. Along with several other models, these helped with the visualization of site formation over time. The next couple of chapters go more in depth on these models, showing in more detail how the models were created and how they were interpreted to better understand the site formation of *Fraternité*.

CHAPTER FIVE: MODELING RESULTS

This chapter goes into details the use of historical and archaeological records with the methods discussed in the previous chapter to create the three-dimensional models of *Fraternité*. The models created for this thesis help in better understanding the site formation processes of the wooden *Fraternité* and the role the extensive ferrous components played in those processes. A historical model was created to better understand how the ship was originally constructed. The wrecking and salvage models were created to get an idea of the recorded steps that transformed the ship *Fraternité* into the archaeological site that it is today and to interpret the changes which took place per the site formation theory discussed in Chapter Three. The archaeological model shows the site as it was when it was surveyed in 2008 by ECU.

The *historical model* was built based entirely off historical research using plans, photos, and ship construction literature (Mystic Seaport Museum 1918; Tacoma Public Library 1918; Desmond 1919). The base for the first *wrecking and salvage model* was the historical model and historical records of the wreck and the damage caused. Each subsequent wrecking and salvage model were then based off the model which came before it. The wrecked model turned into the *post-wreck model* showing more damage from the environment, that model then was used to show the falling of the masts, and lastly the model with the fallen masts was cut down to show the damage from burning it to the waterline. This last wrecking and salvage model was then used to create the final *archaeological model*. Basing the next model on the previous one gave great insight into how each event was affected by the one that came before it, showing which parts of the vessel could not be present in the next model and how they may have changed.

The first section discusses the creation of the historical model and the steps taken to create as accurate a model as possible given the information that was gathered for this project.

The next section shows how each of the wrecking and salvage models were created, the ever-increasing damage to the ship, and how the extent and location of this damage was determined. The last section discuses the creation of the archaeological model, taking apart and moving the pieces of the model to create as accurate a representation as possible of the last surveyed condition of the site. It also shows what parts of the archaeological site came from *Fraternité* and the parts that likely did not. The next chapter discusses the analysis of these models and what conclusions can be drawn from them about site formation at the wreck.

Historical Model

Extensive historical research was required before work could begin on the historical model of *Fraternité*. As discussed in the previous chapter, acquiring the plans to *Fraternité* proved to be somewhat difficult. After searching for the plans in multiple different museums and archives, a set were found which belonged to *Commandant Roisin*, a ship like *Fraternité* and built in the same location, by the same people, using the same designs. These extensive plans that had a total of 40 pages were crucial in creating the historical model with as much accuracy as possible. Out of the 40 pages of plans only 6 were selected to be used due to the constraints as was discussed in Chapter 4.

The scanned plans received from Mystic Seaport Museum were slightly edited in *Photoshop* to remove small amounts of distortion. Once the plans were edited, they were uploaded into *Rhino* as picture frames to provide an easy reference guide when creating objects in that software. Scaling the plans up to the size of the vessel made modeling easier so everything could be on a one to one scale. The plans were also lined up in their correct positions so long section, midships, main deck, and lower deck, as well as the others, would be in the correct positions as the corresponding parts on the vessel. It was necessary to keep in mind that the top down plans were orthographic projections, so the curvature of the decks and other objects were not forgotten. These plans can be seen in Chapter Four Figure 18 toFigure *23*. Figure 27 shows the major steps of the process and timeline of creation, with more individual details discussed later in this chapter.

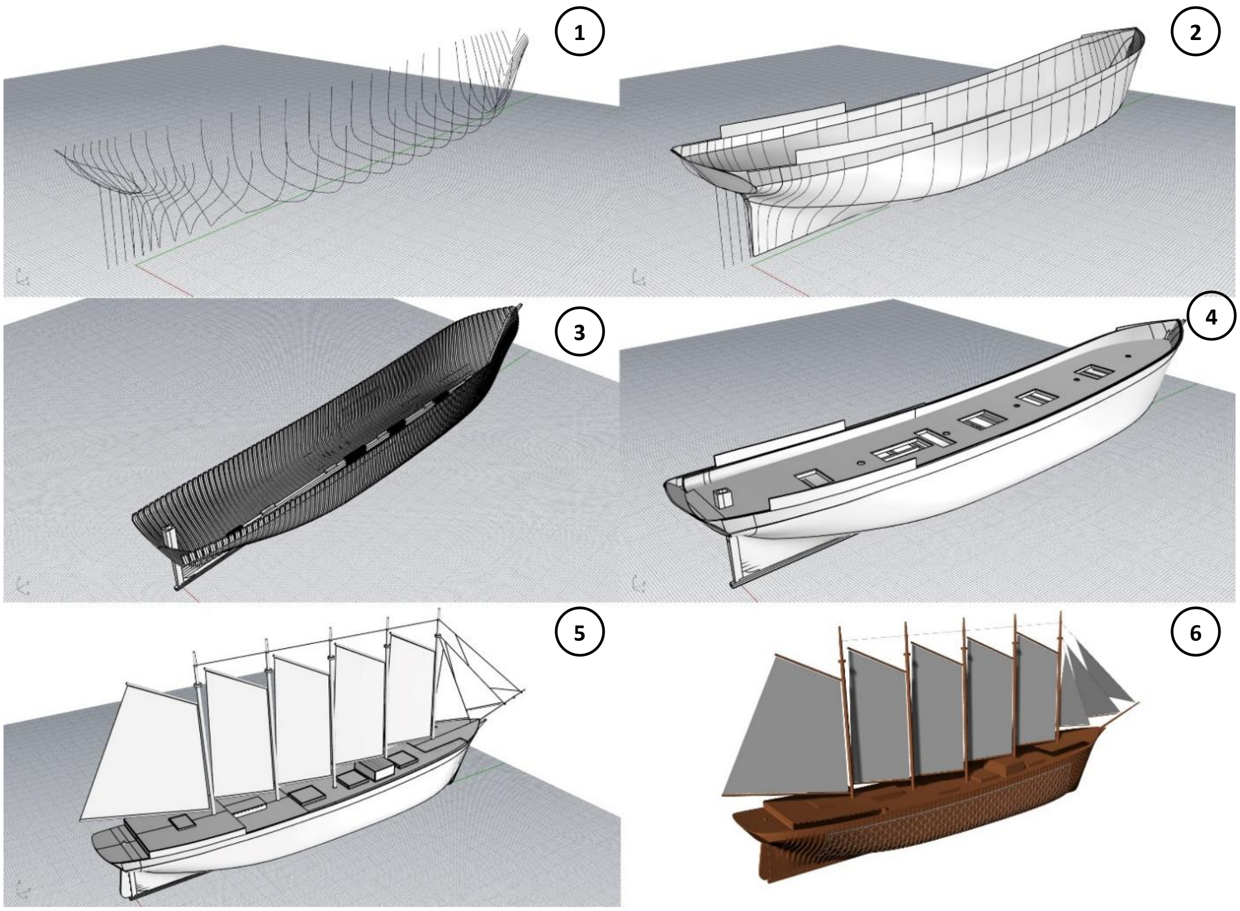


Figure 27. Process and timeline of creation of historical *Fraternité* model (Image by Tim Smith). 1. shows the lines of *Fraternité* moved into their 3D locations, 2. shows the outer surface of the hull, 3. shows keel assemblage, stem, stern, and frames, 4. shows decks and planking, 5. shows masts, cabins, and rudder, 6. shows hull strapping and the model color coded based on material.

During the construction of *Fraternité* in 1918, builders started by setting the keel, building the frames up, and then adding the planking and other components. This is known as using a frame-based system where the frames determine the shape of the vessel (Desmond 1919:44). A slightly different direction was taken in creating the historical model. Since there was no plan set with detailed information on the frames, a frame-based method could not be used. Instead a curvature of the hull needed to be established first and this was done using line drawings. Using the lines drawings, it was possible to create a skeleton for the outer surface of the hull, which can be seen in Figure 28. An accurate outer hull surface was then created by lofting a surface onto these lines, which can be seen in Figure 29.

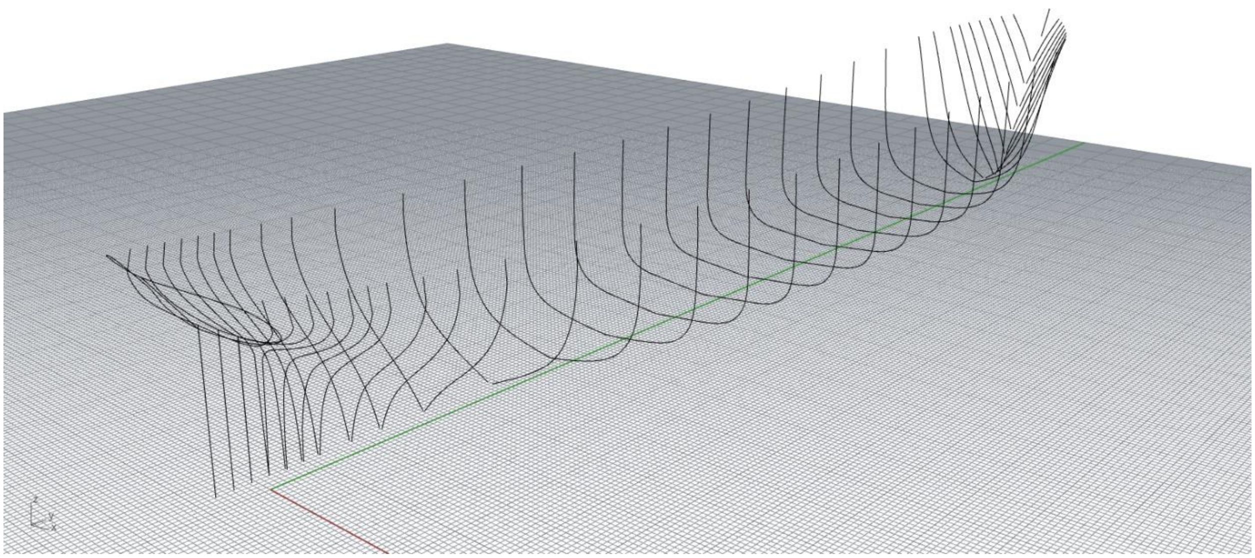


Figure 28. Example of *Fraternité* lines (Image by Tim Smith).

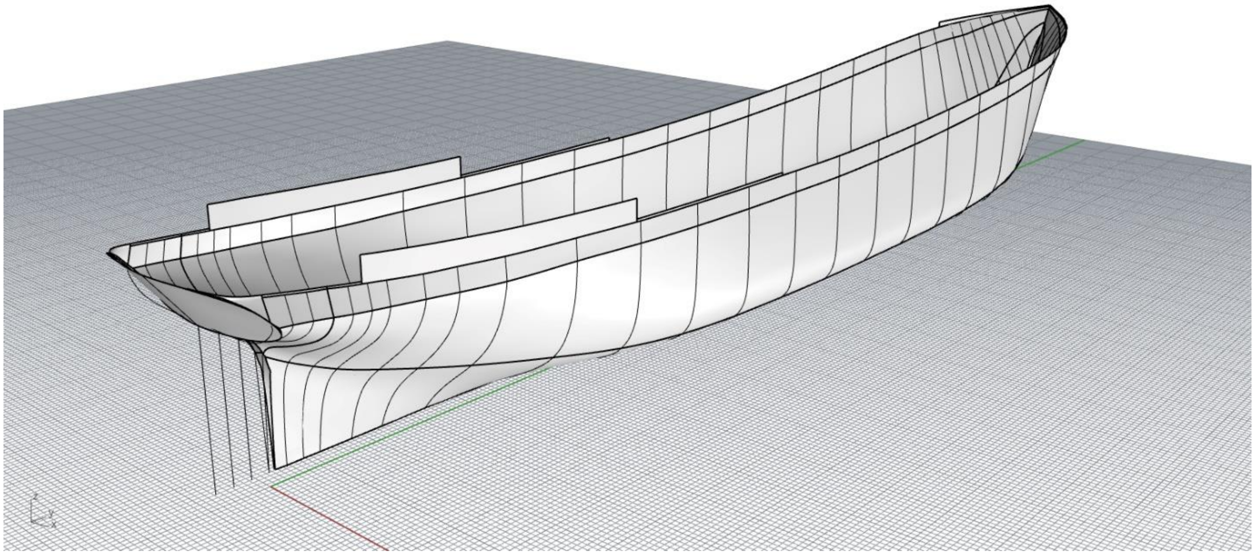


Figure 29. Example of *Fraternité* lofted lines (Image by Tim Smith).

After creating this outer surface, it was possible to begin adding real structural components of the vessel starting with the keel followed by the stem, stern, and frames. The only details that any of the plans had on the dimensions of the frames was on the midships plan, and it only gave the details for the frames at midships. Therefore, the largest discrepancy between *Fraternité* and this historical model was the dimensions of the frames. All the frames were based off the midship frame dimensions which were slightly altered to fit the curvature of the hull depending on where the frames were positioned along the length of the vessel (Figure 30). Desmond discussed how the frames dimensions changed based on where they were located along the ship (Desmond 1919:89). There were also some liberties taken in constructing the stern section of the ship. The plans helped to give an idea of the shape of the stern and historic photos of a vessel of the same type were also used to make it as accurate as possible.

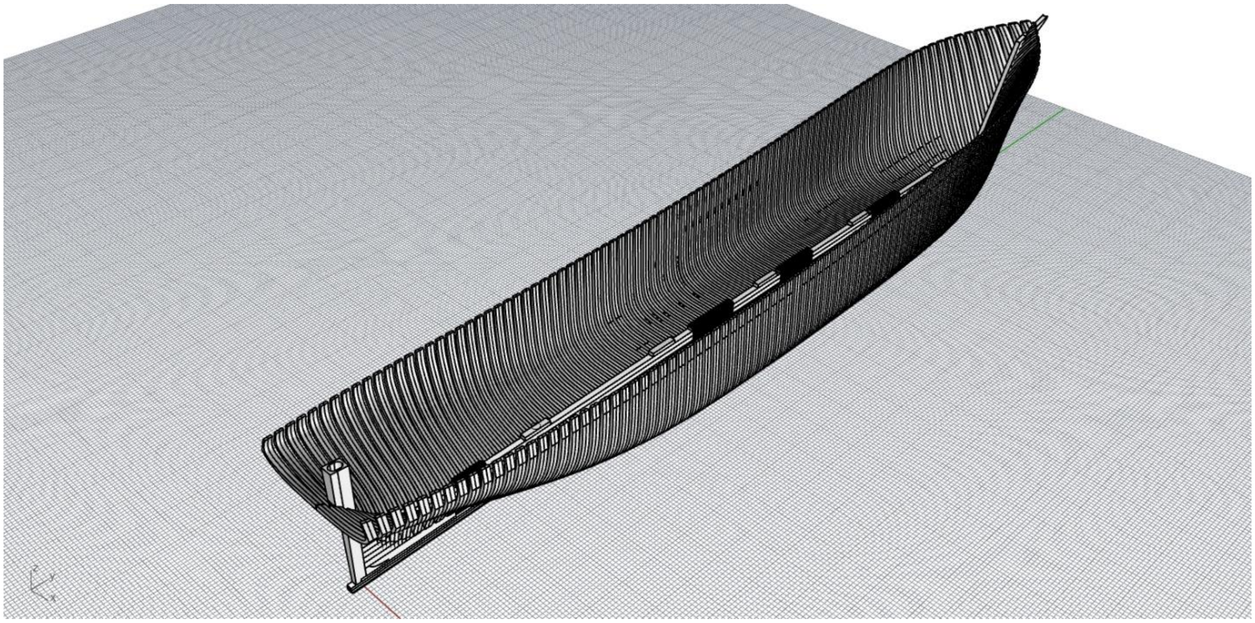


Figure 30. Example of keel, stem, stern, and frames for *Fraternité* (Image by Tim Smith).

After creating the frames, more structural components were added including the deck beams, stanchions, and decking. The deck beam plan along with the long section plan helped guide the creation and placement of the stanchions and beams. All the information for the dimensions and locations for those timbers could be easily taken from the plans which were imported into the software. From that point, it was straightforward to create the decking by using the main deck plans and longitudinal profile to get the curvature and location of the decking. Adding on a polysurface to represent all the planking for the outside, inside, and decks was done by lofting the curves from the frames and beams and extruding them to the proper distance. These added features can be seen in Figure 31. With these basic aspects in place, it was then possible to add more details to the model.

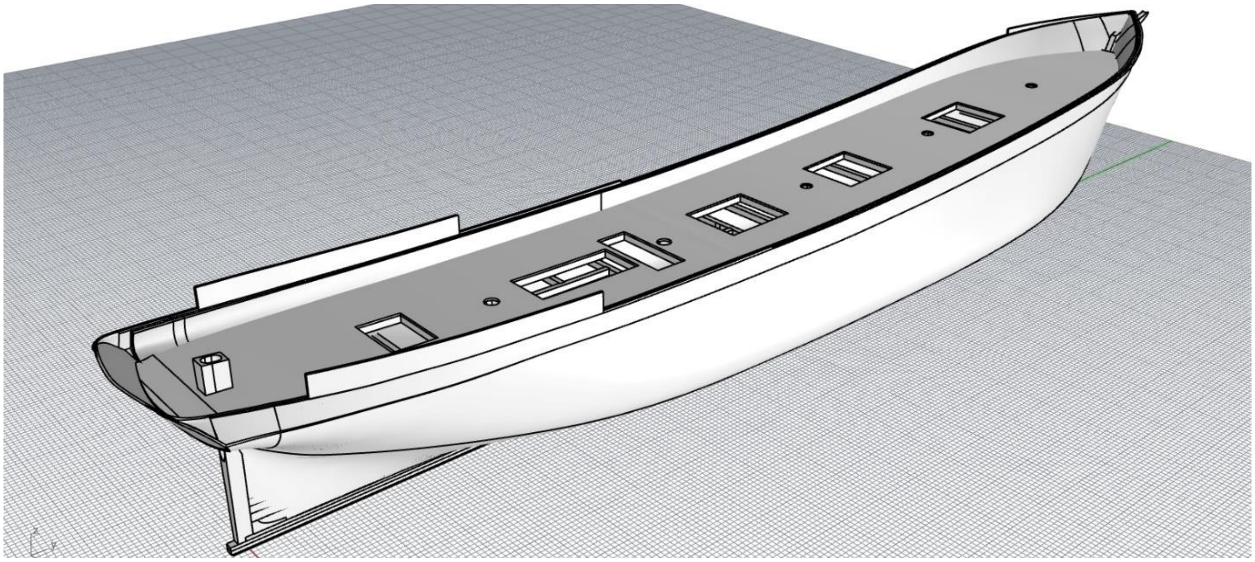


Figure 31. Example of decks and planking added to rest of model (Image by Tim Smith).

The next features added included the cabin structures on the main deck, some of the bracing below decks, the rudder assembly, and the masts. The structures on the main deck included the rear cabins which are mostly made up of crew quarters, the galley and messroom, and the donkey boiler room with more crew quarters, as well as the anchor system. The crew cabins at the back included space for 22 crew members and the space at the front had room for another 13 crew members (Haviland 1972:16-17). The main deck also had three access hatches down into the lower deck and cargo area of the ship along with one cargo hatch which went through the stern cabin area for a total of four cargo hatches. A cannon is located on the stern of the vessel in the main deck plans; however, this feature was not added to the historical model. Originally these vessels were expected to be working when the war was still going on, but the ships did not enter service until after the war had finished as discussed in detail in Chapter Two. As there was no longer a need for these ships to carry guns, they were left off the model. The few photos which remain of these vessels show no guns on the stern of the vessel. The masts and rudder assembly were added following the longitudinal plans and the sail plans. Figure 32 shows all these features added to the historical model. There are features of the original ship which are not depicted in the final model due to not having all of the detailed plans and not having the time to add intricate parts.

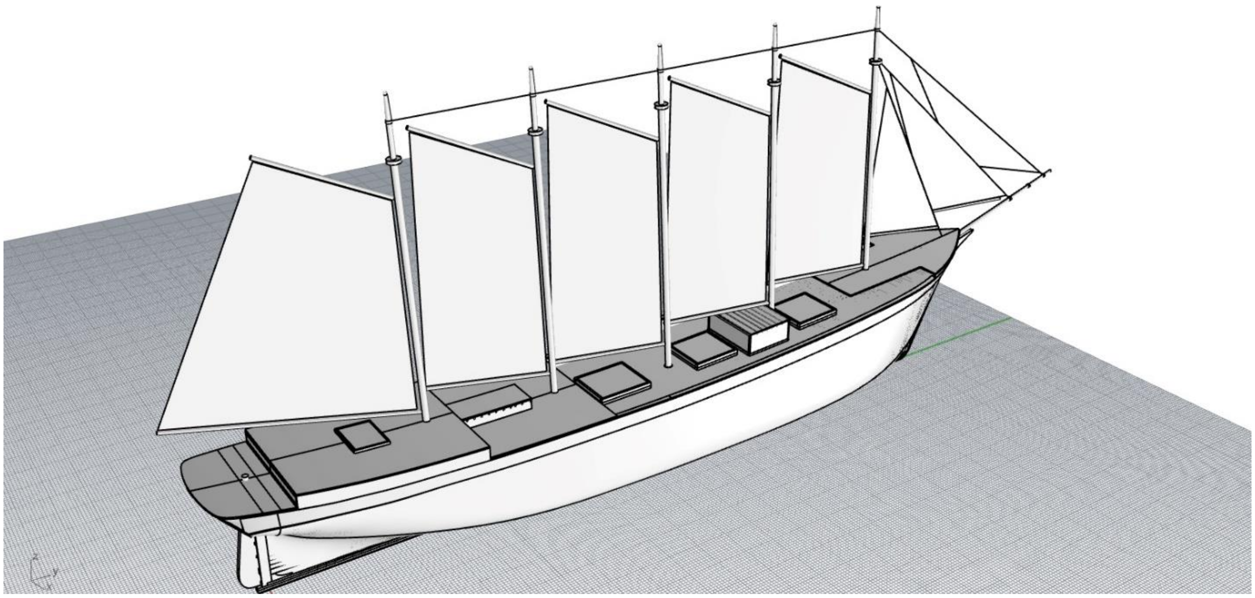


Figure 32. Example of masts, cabins, rudder, and other small details added to *Fraternité* (Image by Tim Smith).

The final major step in the construction of the historical model was the addition of the iron strapping located between the frames and the outside planking. None of the plans purchased for this project had any illustrations of where the strapping was located and how it looked. The only information about the strapping came from the midships plans, which state (exactly):

> Iron strapping for about 2/3 length amidship 3/4”x8” belts connected by treble riveted butt laps fastened to each frame by 1”x10” countersunk head blunt bolts staggered diagonal straps 1/2”x4” at 45^0 let into frame 8c to meet top belt in every other fame space connected with 2-7/8” rivets, 1” rivet at crossing 1-1”x10” bolt to each frame diagonal straps overlap floor timbers (Cox and Stevens 1918).

Although this short paragraph gives some information on the dimensions and location of the strapping, it does not give enough to make the strapping one hundred percent accurate. To supplement this information, Charles Desmond's book, *Wooden Ship Building,* was referenced for more details on iron strapping (Desmond 1919:62,99). Figure 33 shows a rendered version of the model showing the strapping.

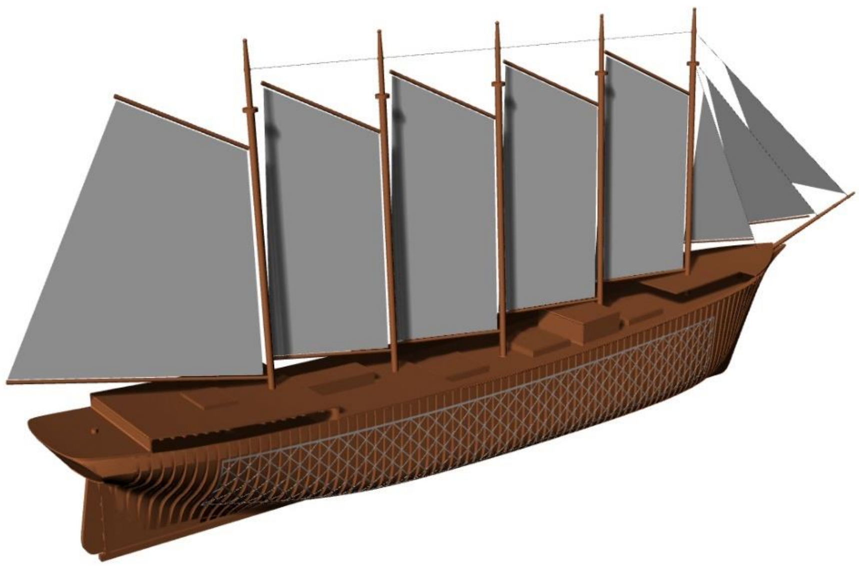


Figure 33. Example of rendered *Fraternité* without planking to view strapping (Image by Tim Smith).

The final historical model is made up of a little over 1000 polysurfaces, which are what *Rhino* calls *solid shapes*. To create all these various parts for the model over 5,500 points, lines, and surfaces were used throughout the modeling process. Not every single detail of the original ship could be added due to not having a complete set of plans. The time to create this level of detail on the 3D model was of considerable utility for gaining a better understanding of the ship over what can just be gleaned from two dimensional plans and historical records. What was put into this historical model is enough to understand how the ship was originally built and then used to deconstruct it to represent the ship in its current archaeological site.

Wrecking and Salvage Models

After creating the historical model, the next steps involved systematically destroying it. To fully understand how the historical ship became the archaeological site and to understand the site formation, it was necessary to understand as much as possible about the steps which brought the former to the latter. The historical record mentions a few major events which drastically altered *Fraternité* since its wrecking. These events include damage to the ship when it first wrecked, continued damage where it first wrecked during first salvage, fall of the masts, and burning of the hull to the water line. To illustrate these events, models were created for each one. These models were created using the historical model and data from the corresponding historical record. Figure 34 shows all the models which make up the major documented events pertaining to *Fraternité* from its wrecking to before it reached its current location.

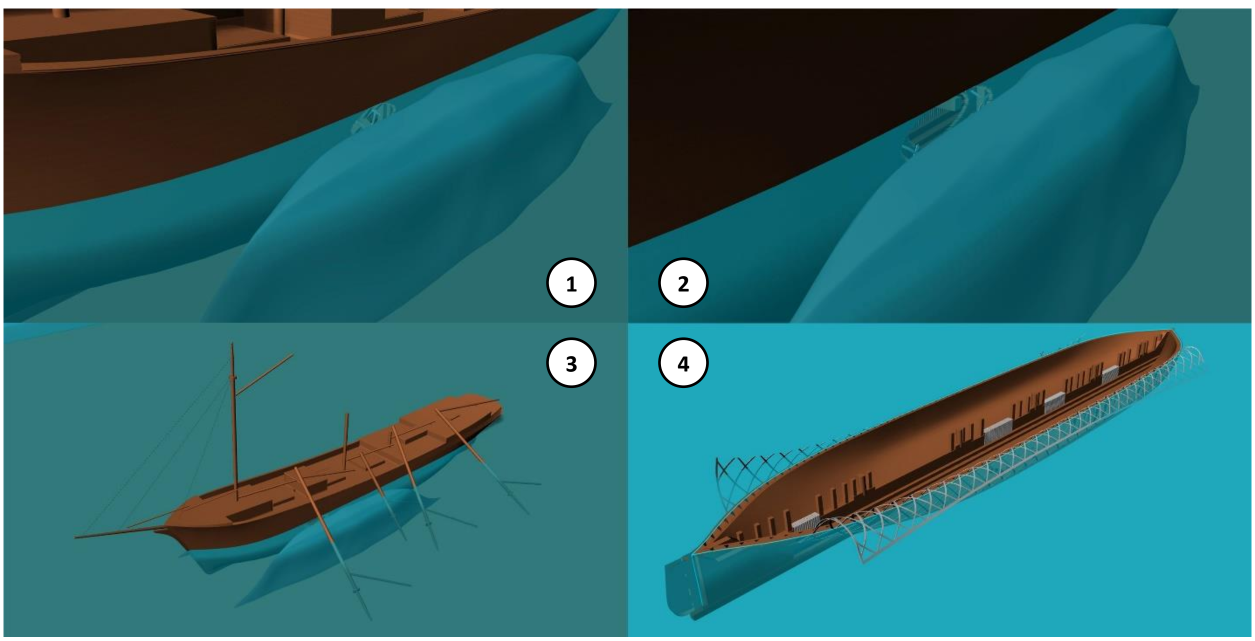


Figure 34. Series of damage from wrecking to burning of *Fraternité* (Image by Tim Smith). 1. shows the initial wrecking site with estimated original damage - small hole to hull, 2. shows the expanded damage after one week working against the reef, 3. shows the masts broken off at or above the main deck, 4. shows the remnants of *Fraternité* after it was burned to just below where the lower deck beams were located.

The first model is that of the initial wrecking event and an estimate on the damage received from driving onto the reef system. *The Royal Gazette*, a Bermudian newspaper described the wrecking event in the following account:

> According to her engineer, Mr. J.J. Leonard of Savannah, Georgia, she was making about 8 knots when she struck. She seemed to bounce over the edge of the rock and then her impetus drove her on hard and fast between two projections of the reef which the sea hardly covered. The schooner's keel astern was driven out by force of the impact and presently her cargo of lumber began to float out as the torn planking of her hull spread apart (*Royal Gazette* 1919a).

Since this is the only known description of the wrecking event, the exact amount of damage and where it was located on the hull were ascertained through educated guesses. To create this model, the historical model was placed in-between two sections of reef to show how the vessel was stuck. Part of the aft section of the keel was removed to show the part which was driven out. A section of planking was also removed to show where some of the cargo may have floated out of the hull. Figure 35 shows *Fraternité* at its projected wrecking site with the estimated post-depositional damage.

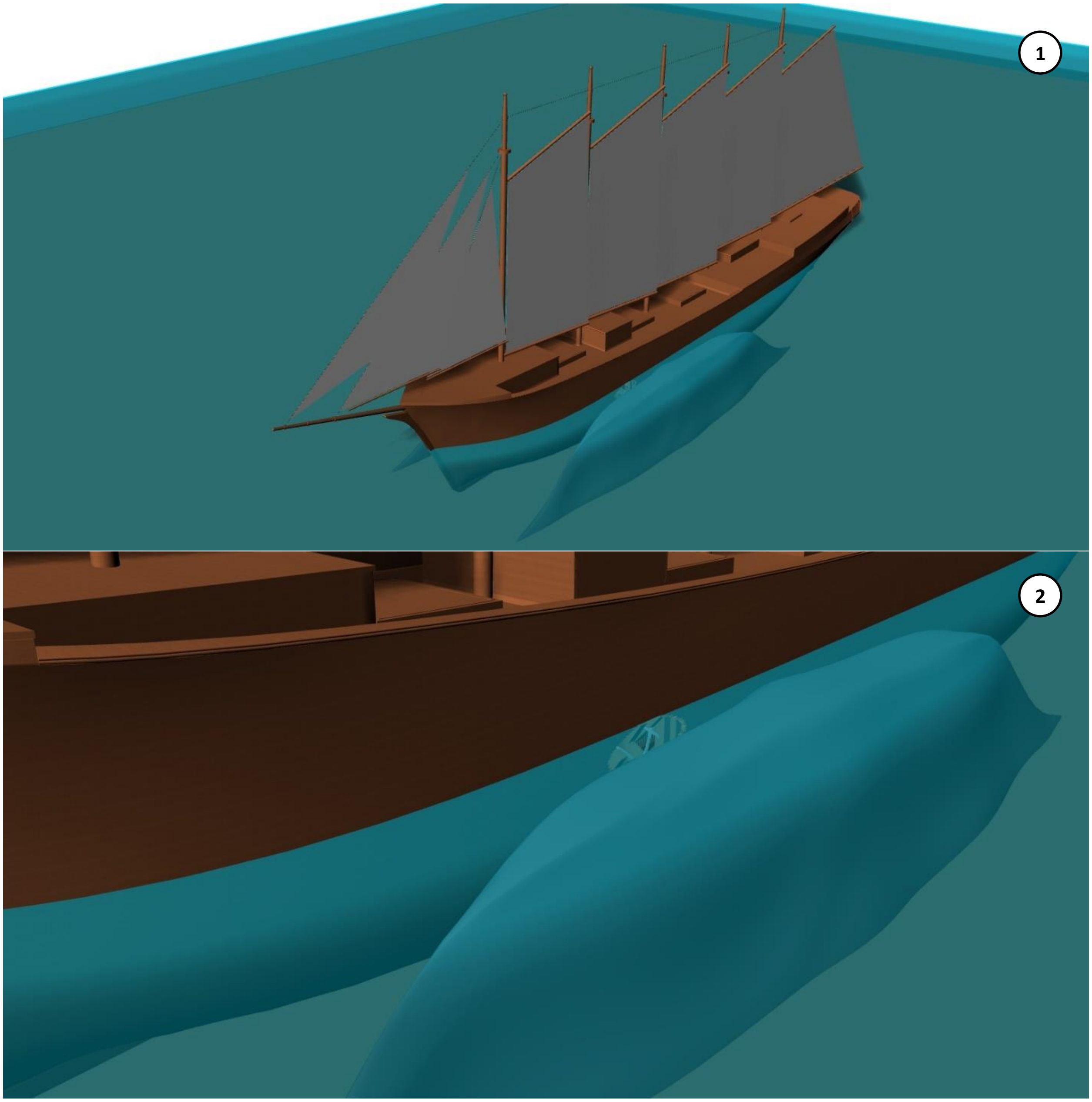


Figure 35. *Fraternité* initial wrecking site with estimated original damage (Image by Tim Smith). 1. shows the *Fraternité* wrecked between two sections of reef, 2. shows the approximate initial damage from wrecking with damage to planking, frames, and strapping.

Next, the model of the initial wrecking was changed to display the damage which took place thereafter , but before *Fraternité* was moved to Meyer's Wharf. Once again, the damage to the vessel was briefly described in a *Royal Gazette* article:

> Capt. Foggo on Monday afternoon went out to the stranded schooner only to find that she was past pumping out; a large portion of her bottom had been knocked off by the working of the ship against the rocky bottom. Our informant, who was one of the men on board the salvage boat, said that both ends of the vessel were working, each independently of the other and that there was no possibility whatever of saving her (*Royal Gazette* 1919c).

This is not very descriptive and again leaves the exact location and extent of damage up to interpretation. Since the vessel was eventually able to be moved roughly 12 miles from its wrecking site to a ship scrapyard, it can be conjectured that the damage was not too extensive damage. It is possible however that with the ship working against the reef like it did that part of the keel had snapped. The damage to *Fraternité* must have been small enough that a temporary patch could be used to secure the hull enough to refloat it and tug it the entire distance, which still could have been completed with a broken keel. Alternatively, some of the damage could have been just below the waterline; and once most of the cargo was removed, the vessel was able to ride high enough in the water to facilitate it no longer letting water in when it was pumped out. Based on the historical record from the newspapers and the current state of the archaeological site, it was determined that this damage occurred on the port side just below the fully loaded water line. Nearly all the salvage of the cargo took place at the wrecking site and once removed, would have allowed the wreck to ride high enough in the water to be tugged and pushed to Meyer’s Wharf. Figure 36 shows the expanded damage to *Fraternité* after spending a week working against the reef.

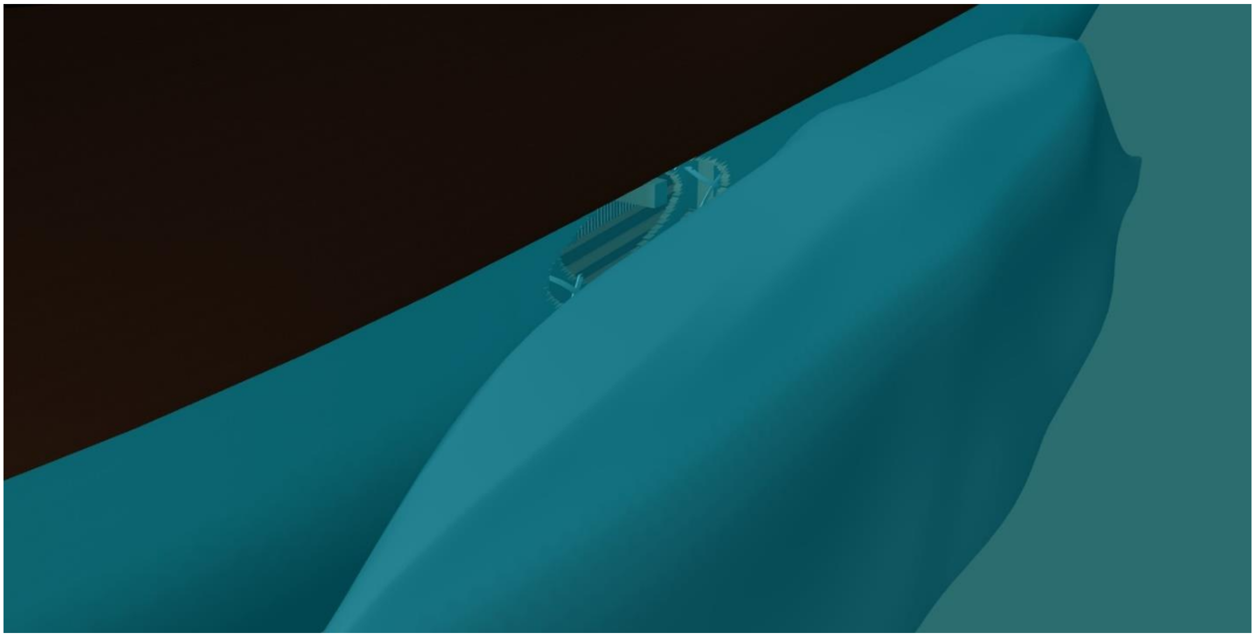


Figure 36. *Fraternité*, estimated extended damage at one week after wrecking, original damage seen in Figure 35 (Image by Tim Smith).

The falling of the masts is the next major event concerning the changing of the vessel in the historical record. According to the *Royal Gazette*:

> At 3a.m. yesterday the four after masts of the French Schooner '*Fraternité*' which lies stranded on the reefs, fell with a crash. The vessel had been going to pieces fast under the impact of the recent heavy weather and it was only a question of a few days or even hours, before her top hamper was bound to give way (*Royal Gazette* 1919d).

A model was generated to illustrate the masts broken off at or above the main deck. To create this model, the previous model was again used, with the new damage added to continue to show the progression of ship to wreck. Figure 37 shows the new model with the masts broken off, splayed across the deck and in the water.

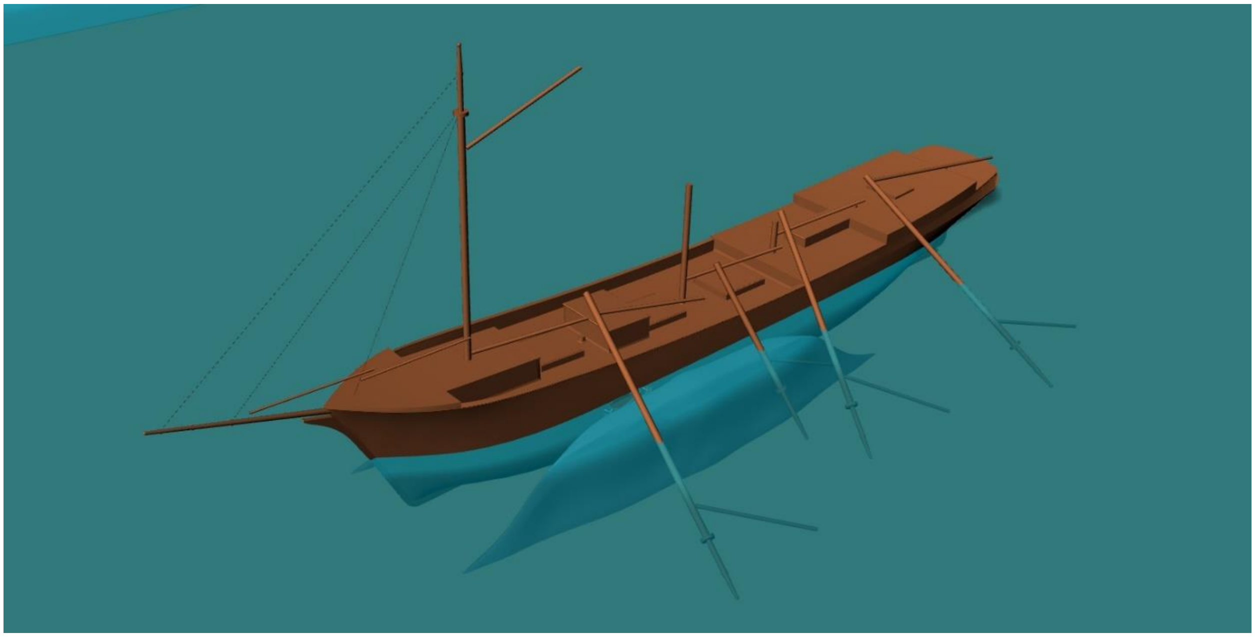


Figure 37. *Fraternité* without masts (Image by Tim Smith).

After nearly two months of salvage efforts on *Fraternité,* it was finally moved from the site of its wrecking to Meyer's Wharf. Before *Fraternité* made it to its final resting place, the vessel was set on fire with parts still burning while it was moved. The *Royal Gazette* does not give too much information on the burning:

> With the assistance of all three tugs the yet burning vessel was brought through the channel up the harbor and anchored off Meyer's Electric Welding Works… A visit to the *Fraternité* was interesting, the remains were yet on fire on the starboard side, the bottom of the ship was strewed with canvas, cottons, piping, bolts, spikes, engines, boilers, machinery, etc. estimated by the local surveyors to be worth a lot of money (Royal Gazette 1919f).

As mentioned in Chapter Three, this was a method of making salvage easier. The newspaper mentioned that there was still some cargo left as well as the engines and other valuable ship components. Burning the ship to the water line would have allowed for much easier access into the hold of the ship, making it faster and more straightforward to remove the rest of the cargo and the large, heavy components such as the engines and boilers. The way the newspaper worded the information about the burning implies that it either started at the original wreck site or it was tugged closer to shore before it began.

The version of the model with the fallen masts was used as the base for one model showing the vessel no longer at the original wreck site, riding higher in the water, and burned down to the new water line. The extent of the burning is based on observations about the amount of material still visible on site today. Archaeological evidence points to the burning of the ship to just below where the lower deck beams were located. Figure 38 shows the remnants of *Fraternité* after it was burned.

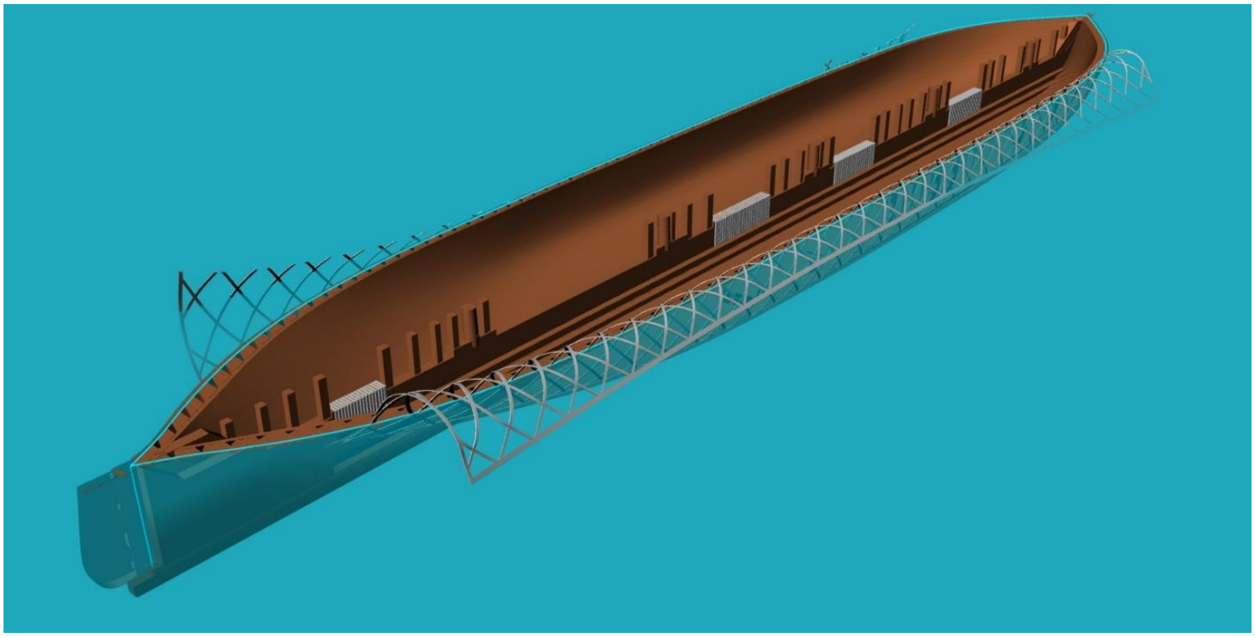


Figure 38. Remnants of *Fraternité* after it was burned (Image by Tim Smith).

Archaeological Model

The archaeological model was by far the hardest to create, as there are only a few resources which could be used. The first major component was the model of *Fraternité* with all its previous damage, including everything from its wrecking to the burning of the vessel down to the waterline. The next major component was the site plan created by the ECU team in 2008. Overall, it is a well surveyed site and well-drawn site plan, with only a few notes in some of the field diaries of students which mentioned possible mistakes or inaccuracies. Some small changes were required to make up for discrepancies between the site plan and model. The site plan is also an orthographic projection, which required consideration when working to create the model on the sloped ocean floor. The only other information that was utilized to make the archaeological model was a few photos which were taken during the survey process in 2008, as well as a video taken of a dive through of the site at the same time. To reference the video, it was necessary to slowly scan through it until the most diagnostic parts were recognized and the time in the video was marked on a copy of the site plan when they appeared. This could then be used to create the dive path that was taken and be able to understand what parts of the site were being shown at the corresponding time in the video. All this material was compiled to make as accurate a model as possible. A plan view of the archaeological model is shown in Figure 39. The major steps of the process and timeline of creation can be seen in Figure 40, with more individual details discussed later in this chapter.

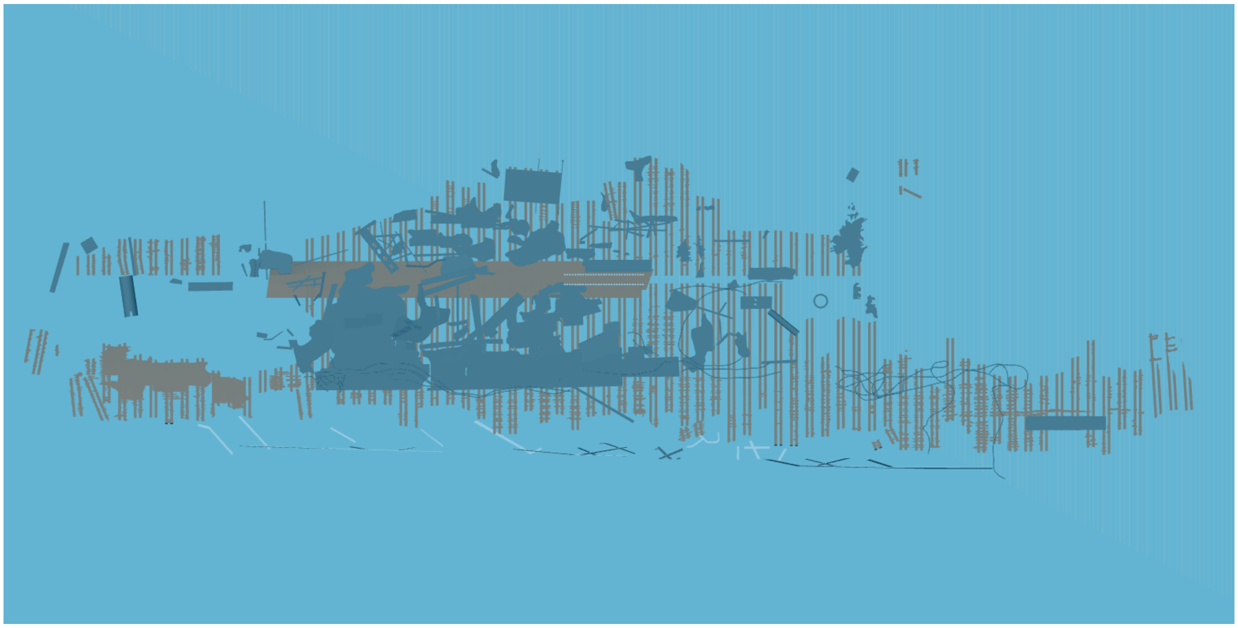


Figure 39. Plan view of final *Fraternité* archaeological model (Image by Tim Smith).

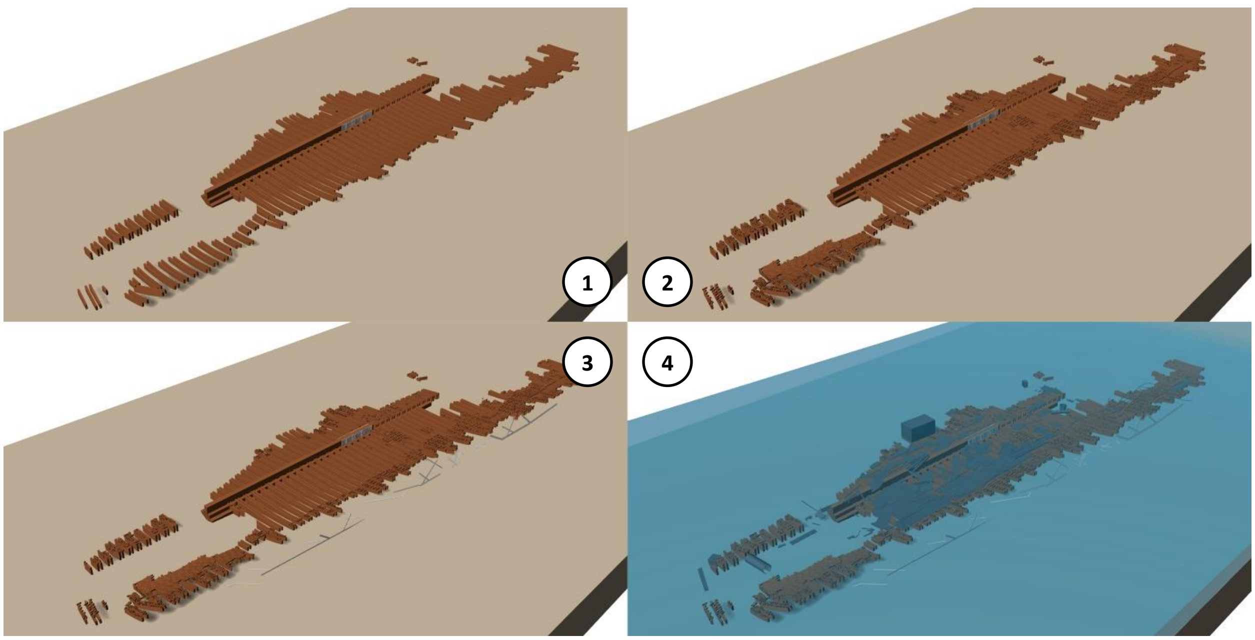


Figure 40. *Fraternité* archaeology model creation timeline (Image by Tim Smith).
1. shows the rough-cut frames in place on the ocean floor, 2. shows the frames with the addition of planking, 3. shows the model with the frames, visible surviving planking from the site plan, and the iron strapping remains, 4. shows the final archaeological model

The first step in building the archaeological model was to create the ocean floor where the site is located. Some of the students who worked on the project in 2008 took notes about the depth of the water in multiple different locations on the site, however the tide level was not noted when they took them. The data for depth was then loosely used to develop with a general idea of what the ocean floor looks like. As it is close to shore, water depth is very shallow on the northeastern side of the site and slopes down towards its southwestern side (Figure 41). After creating the ocean floor, the model was moved and rotated to line up with the site plan and the slope. Lining up the model was based on the placement of frames and the small part of the keel which are visible on the site plan.

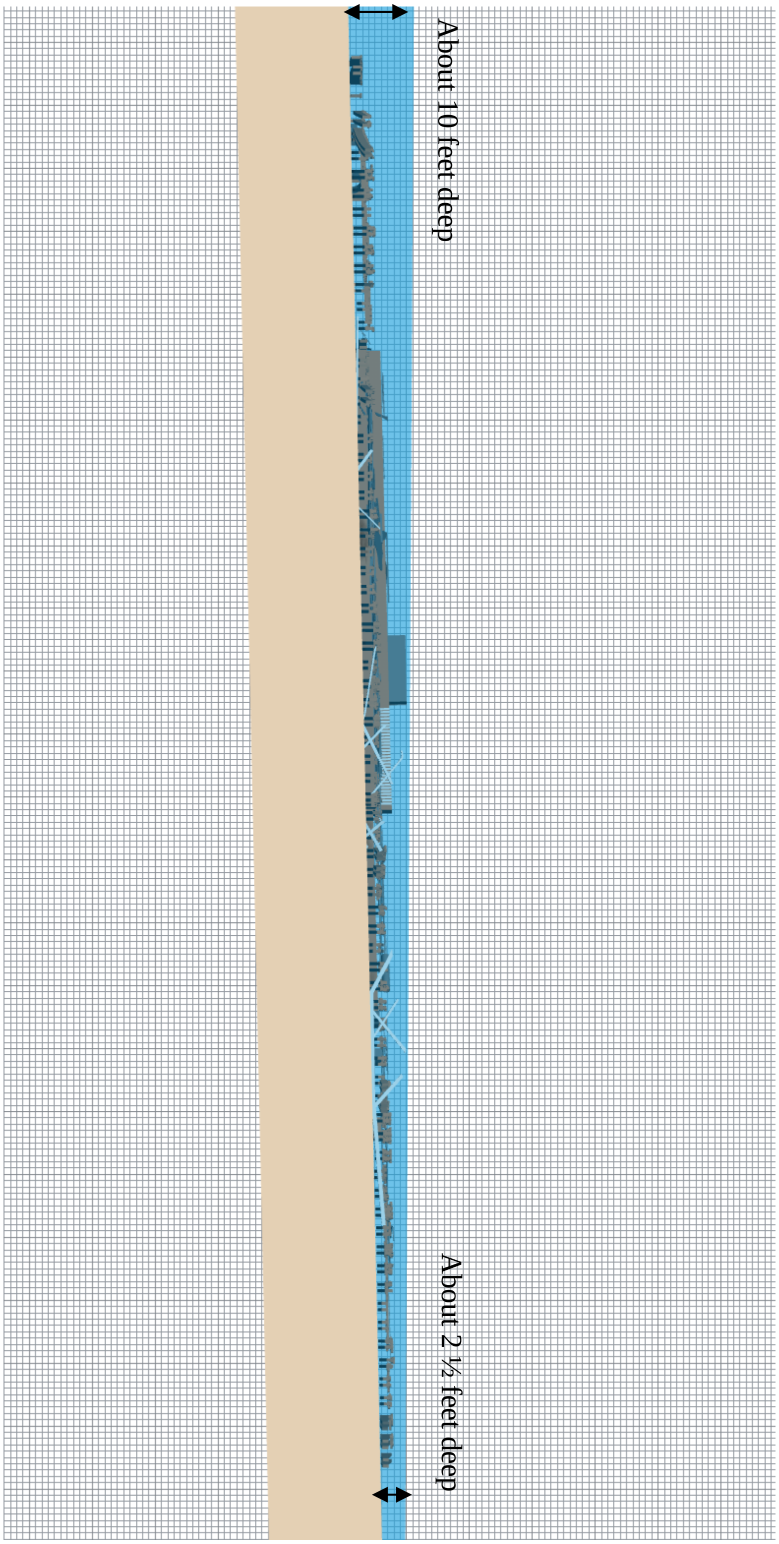


Figure 41. Profile view of archaeological model showing depth and slope of site (Image by Tim Smith).

Since the *Fraternité* wreck has been submerged for over 100 years, it has changed drastically, and the frames have not maintained their shape. To get the frames to line up to their current shape, they were bent using the bend tool in *Rhino*. Frames were also cut to the right size based on the information from the site plan. Some frames were broken into multiple fragments and moved to match the site plan showing broken frames. They also had to be shaved down to show how the frames have degraded overtime. Figure 42 shows the rough-cut frames in place on the ocean floor.

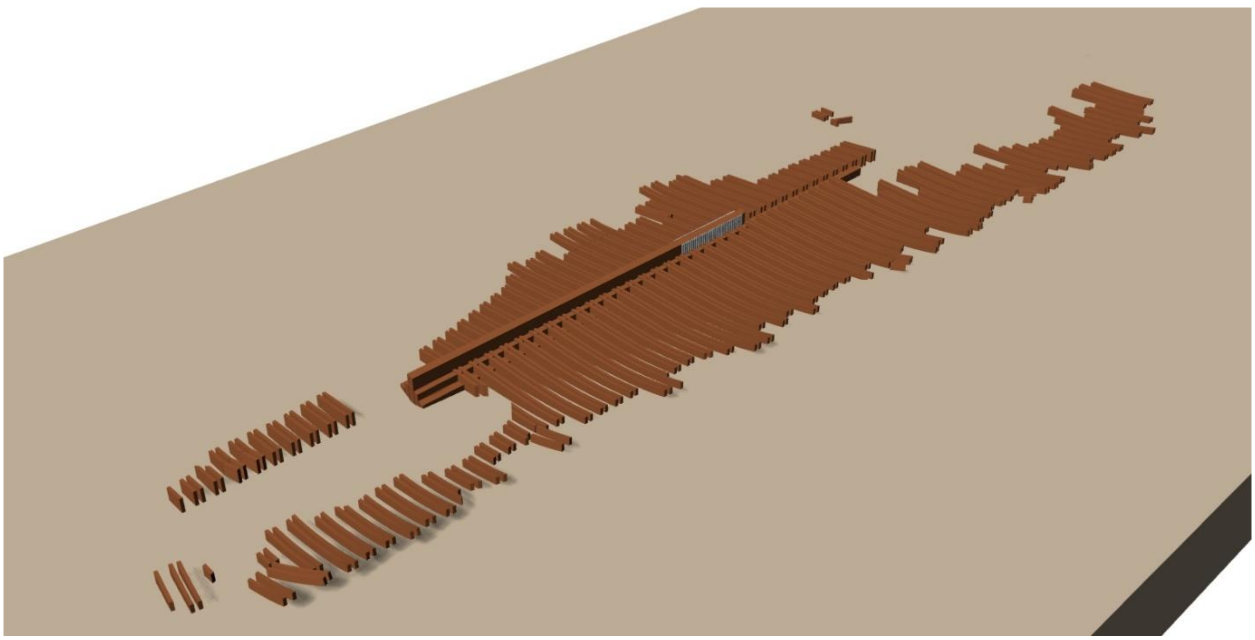


Figure 42. Degraded Frames of *Fraternité* (Image by Tim Smith).

To show the planking remains on the frames, it was not possible to bend the planking from the original model. As such, it had to be reconstructed onto the newly shaped frames. The planking surface was created the same way as it was when making the historical model, by lofting a surface onto the curve of the frames and then extruding that surface. This new planking polysurface could then be split into the correct shapes using a Boolean split and the extruded curves from the site map. This planking can be seen in Figure 43. This is one instance where the site map and the model do not line up perfectly, so it became necessary to move some lines around to make sure that everything made sense when put together.

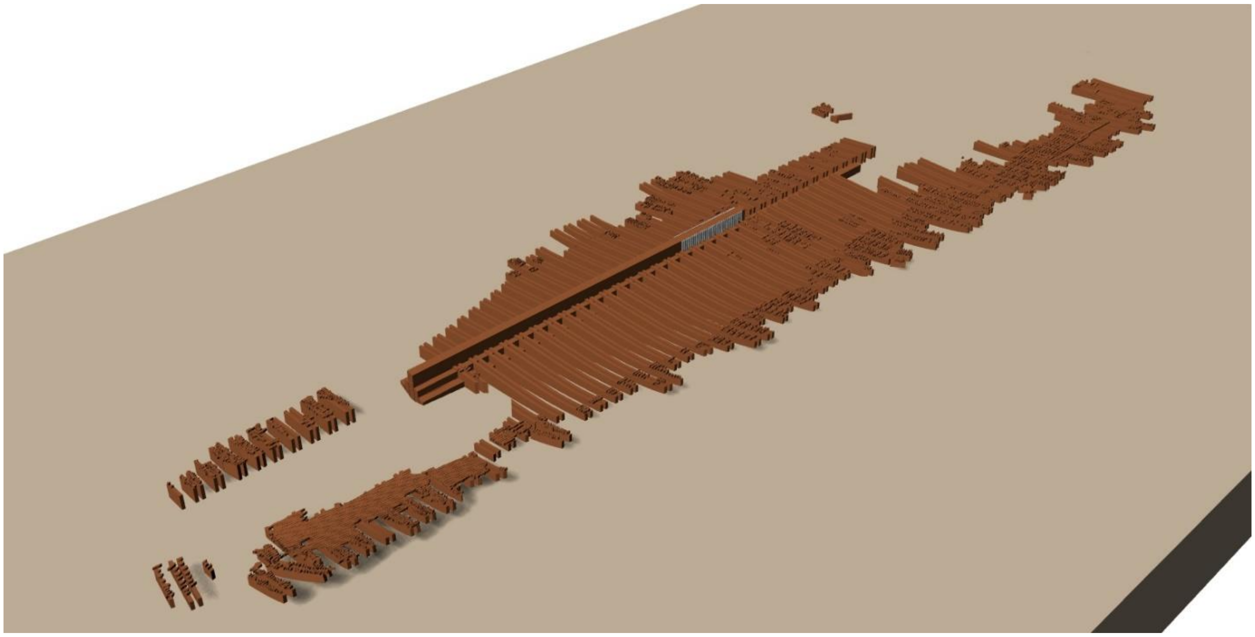


Figure 43. *Fraternité* archaeological site with planking (Image by Tim Smith)

The next part of the model creation was the iron strapping on the outside of the frames that can be clearly seen on the south eastern side of the site. The video of the wreck showed that a lot of what was left, which could be seen past the extent of the remains of the frames, was bent down and broken in ways that made it difficult to use the strapping from the base model. New strapping pieces had to be created from scratch, but still using the same basic measurements from the historical model. Strapping was also added underneath the frames since it is very likely that strapping has survived mostly in place. Figure 44 shows the model with the frames, visible surviving planking from the site plan, and the iron strapping remains.

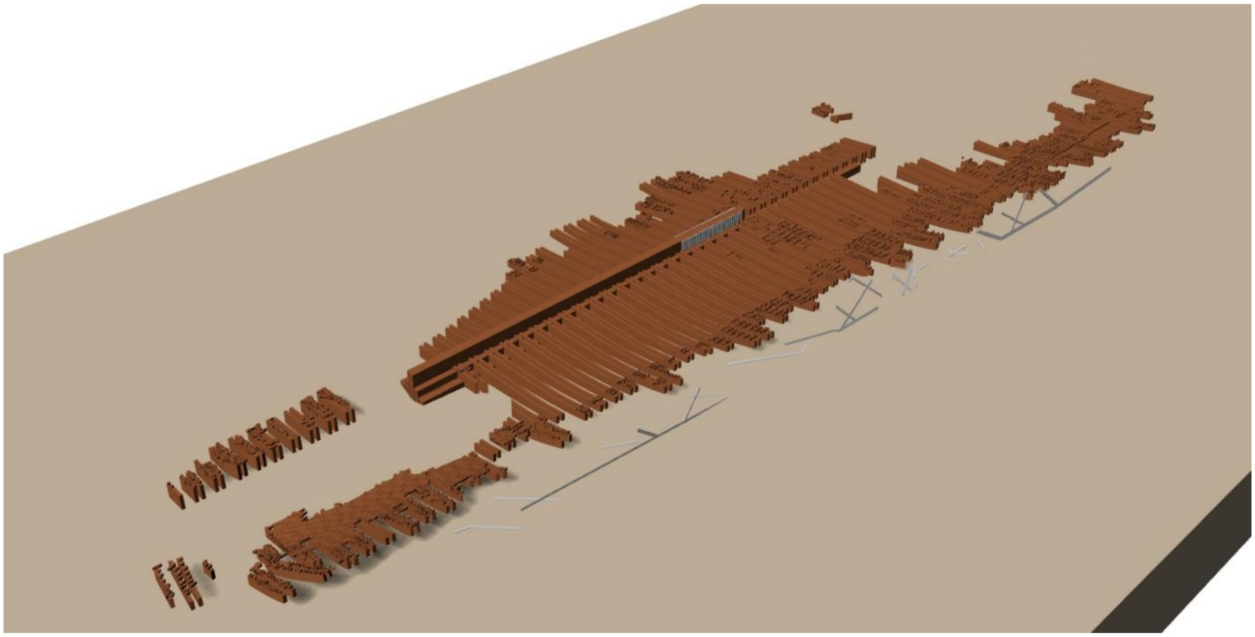


Figure 44. *Fraternité* frames, planking, and iron strapping (Image by Tim Smith).

After adding all these features to the archaeological model, it became evident that very little of what was left on the site plan probably originally came from *Fraternité*. This will be discussed further in the next chapter. The rest of the metal plates, beams, boxes, piping, and other scattered remains were all modeled in on top of the rest of the vessel remains. A great deal of this material lacks much information or reference, so some of the material dimensions had to be estimated from the site plan with some of these materials left out of the final model. Since there was also so much debris sitting on top of other pieces, some of the shapes of what could not be seen on the site plan, or the video and photos, had to be estimated as well. The video showed that there were some locations where some of the debris nearly stuck up out of the water. Better information could have been gathered about this part of the site if it had been possible to physically study the site during the project. Figure 45 shows the final archaeological model.

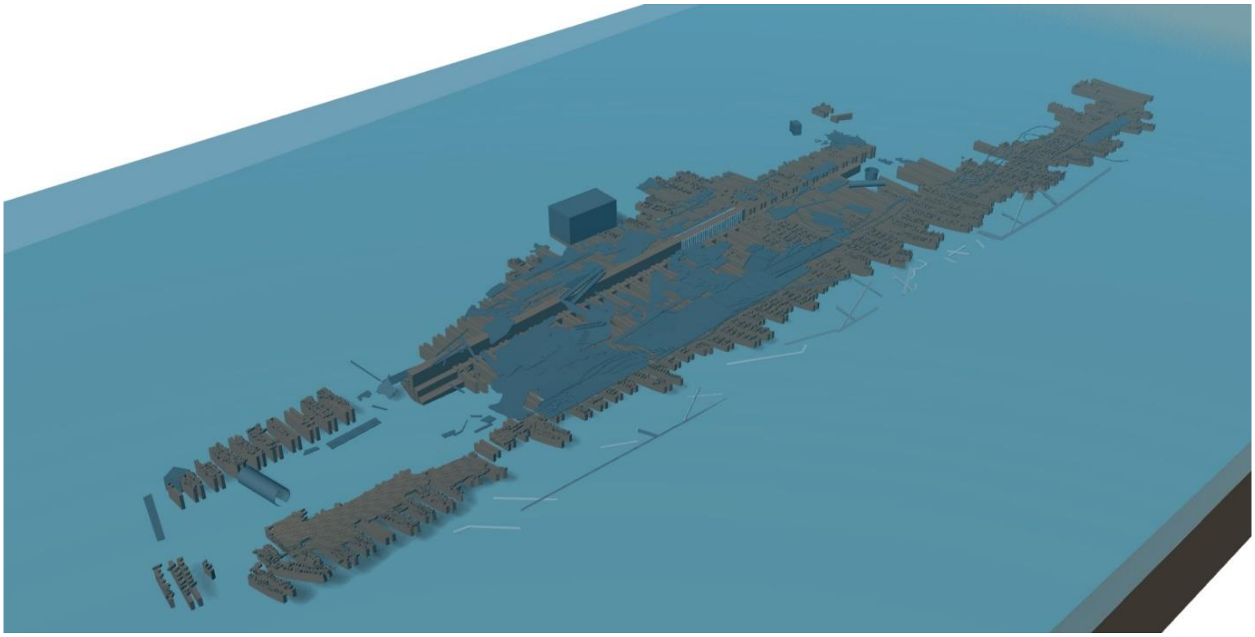


Figure 45. Final archaeological model of the *Fraternité* (Image by Tim Smith)

To help visualize the parts of the site that are believed to have come from *Fraternité* and those that did not, the site plan and archaeological model were color coded to make it more obvious. The site plan, Figure 46, shows the site in three colors; black representing parts of the site which were part of *Fraternité*, blue representing fragments that might be part of the ship, and red representing fragments which are most likely not part of the ship. The 3D archaeological model, Figure 47, shows the fragments that were part of *Fraternité* in their original color while parts of the model which were most likely not part of the ship are colored in red. Chapter Six will go into more detail about how it was decided which parts belonged to which categories.

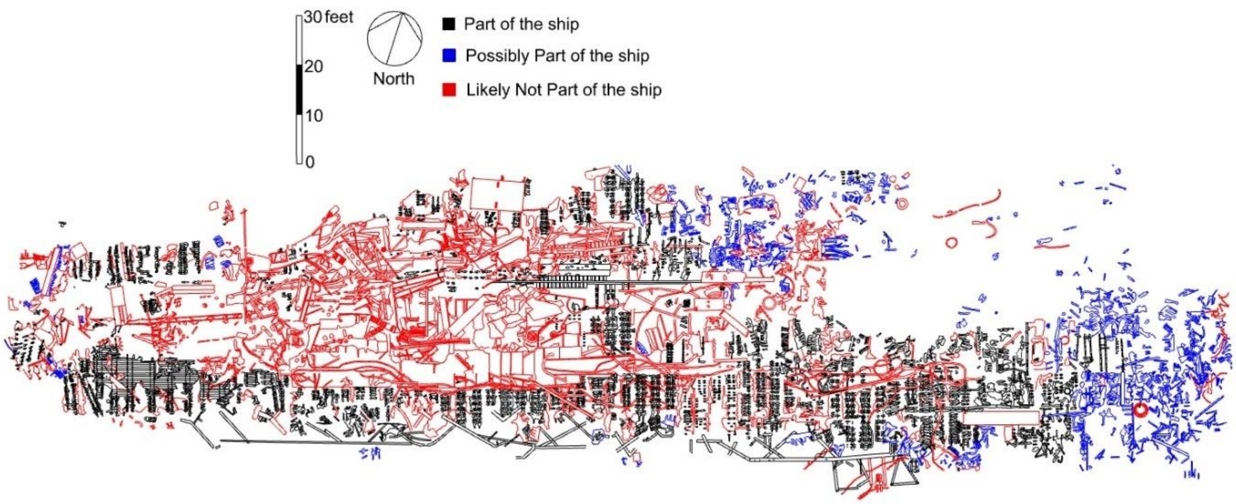


Figure 46. Color coded *Fraternité* site map (Image by Tim Smith).

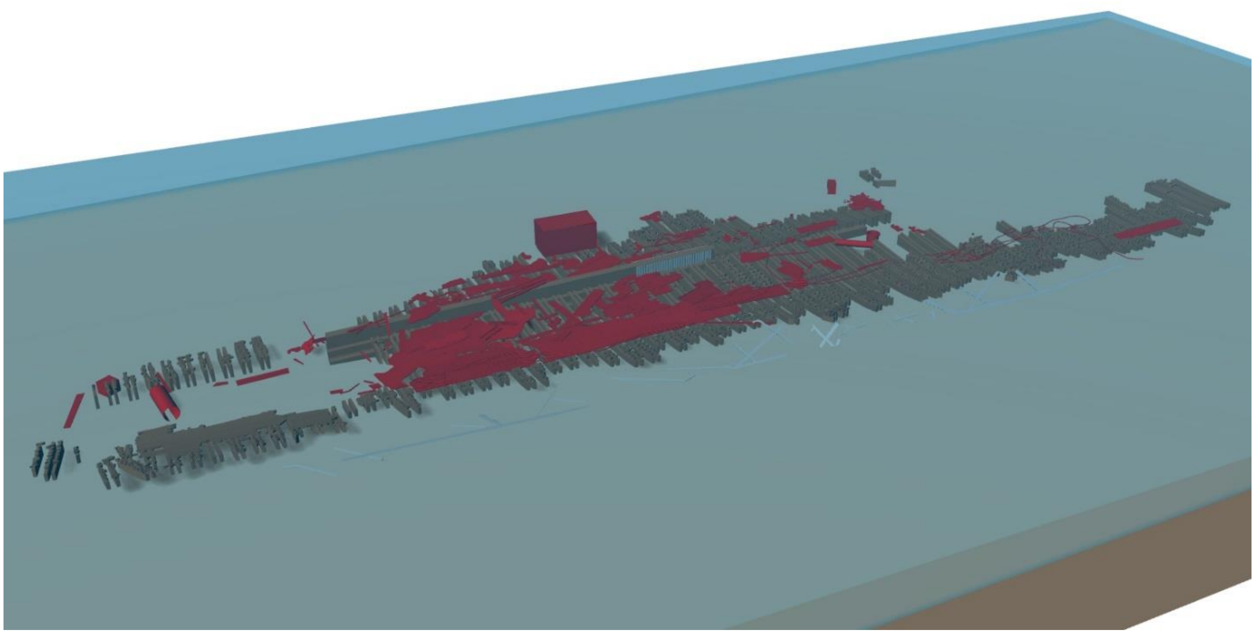


Figure 47. Color coded *Fraternité* archaeological model, red represents parts likely not part of the ship (Image by Tim Smith).

Throughout the model building process, the video and photos were referenced to help get an idea of the three-dimensional nature of some of the parts of the site that can’t entirely be gleaned from the two-dimensional site plan. Importantly, not every single fragment from the site plan was added into the archaeological model, as it would have taken far more time than it was worth to map in every piece. Furthermore, mapping in this debris would not have helped in answering the research questions listed in Chapter One. The idea that most of the debris is contamination from other ships will be discussed in Chapter Six. The most important information to model was the confirmed structural data which could be connected to the historical fabric of *Fraternité* with a high degree of certainty. Some small unidentifiable fragments were excluded for the sake of time and the perception that they provided nothing substantial to the site's interpretation. Enough was modeled to be able to answer the questions posed for this thesis, like how the *Fraternité* transformed from a ship to the derelict mess it is today and how the vessel continues to disintegrate.

The methods used in this thesis for creating an archaeological model only partially follow the way that archaeological models have been created by others. For instance, Fox's 2015 site formation study of *Caribsea* incorporated a combination of a site plan with 3D multibeam data to create each piece of the wreck (Fox 2015:107). Originally, this is the route that modeling would have taken for this thesis, but instead of multibeam data it would have been photogrammetry data. Ultimately, it was helpful to create the archaeological model directly from the historical model with historical record damage incorporated into it. This helped with identifying how the vessel became the archaeological site. This modeling process helps to redefine *Fraternité* and changes its interpretation from just the site mapping performed by the 2008 ECU team. This information will be further discussed and analyzed in the next chapter.

Conclusion

This chapter has displayed the use of historical and archaeological records to create models for site formation interpretation. The historical model, based entirely on historical records, gives insight into the construction of *Fraternité*. The wrecking and salvage models, each one based on the historical record and the model created before, shows the cultural and non-cultural transforms which took place between the wrecking and the vessel reaching its final resting place. The archaeological model, based on the historical record, the previous models, and archaeological field work, depicts the site as it is today. Each model was made as accurate as possible based on historical and archaeological information with a few estimates made based on facts. The structure of basing each model on the one that came before it help to show the transformations overtime and how they affected the transformations that came next. The following chapter discusses how these models can be used to learn about the site formation processes which have affected *Fraternité*, especially the ferrous material on site.

CHAPTER SIX: SITE FORMATION ANALYSIS

This chapter addresses the four research questions that were posed at the beginning of the thesis. The primary question, "How has *Fraternité* transformed from a ship to the derelict mess it is today," is the basis for this entire study. This question is answered by addressing the three secondary questions: How is the site formation of this wooden, steel strapped wreck different from a wholly wooden or wholly steel vessel? How will the vessel continue to disintegrate? What can this wreck teach us about early 20th century ship building?

It is through bringing together all the historical and archaeological resources coupled with an understanding of site formation theory, especially cultural and non-cultural transforms (c-transforms and n-transforms, respectively), that it becomes possible to answer these questions. This was done through the creation of the historical, wrecking/salvage, and archaeological models of *Fraternité*. This chapter will discuss how these models were analyzed utilizing site formation theory to answer the primary and secondary questions.

The historical model, showing the ship in its systemic context, has the potential to give insights into the c- and n-transforms which affected the ship before it wrecked, as well as to provide a better understanding for early 20th century ship building. For c-transforms, understanding the historical model can give insight into the building materials, methods, and designs of *Fraternité*. From historical records it is possible to understand pre-wrecking damage which could have affected the ship. For n-transforms, it may be possible to understand the environmental damage that could have been caused to the ship by studying the historical records and model. The wrecking and salvage models, showing the ship in its wrecked state and salvage stages, can also be broken down into the c- and n-transforms which affected the wreck before it ended up at its current location. C-transforms for these models can give insight into the reasons for wrecking and what original salvage damage was likely done. The archaeology model, showing the state of the wreck during the ECU survey in 2008, can show how archaeological context c- and n-transforms have changed the wreck. C-transforms, including later salvage, and n-transforms showing effects like corrosion of ferrous aspects and degradation of wood, can give a better understanding of how the vessel might continue to disintegrate. Each model can be compared to other similar wooden and steel vessel sites to add to the understanding of how the site formation of *Fraternité* is different from those types of wrecks.

Historical model

To understand how *Fraternité* went from the ship to the archaeological site that it is today, it is necessary to understand the vessel in its systemic context and the early 20th century building techniques used to create it. The creation of the historical model was an excellent way to do this. Decisions made in the design and construction process had a great effect on how the ship has degraded over time. This section of the chapter will discuss the result of the chosen building materials, ship design, and building methodology on the site formation of *Fraternité*. It is also important to consider any previous damage done to the vessel while sailing. Typically, systemic context n-transforms should have at least a small outcome on a vessel's site formation. Given the little time *Fraternité* spent sailing, it is possible that these standard n-transforms did not really impact the ship structurally. Even if they did, these transforms would be difficult to distinguish from the post wrecking n-transform damage. This mirrors Richard Steffy's discussion of how ships can give us information about everyday life and trade, but this information is then slowly stripped away after the sinking of a vessel and the damage done to it by the sea (1994:189-190).

When analyzing the historical model, it is important to understand its limitations. The historical model is not a perfect model of *Fraternité*, and this was explained in both Chapter Four and Chapter Five. Since the model was created from only a few pages of the ship plans, it does not have all the details it possibly could. Computer modeling also is not one hundred percent accurate to real world conditions. It is also possible that not everything in the plans made it into the final ship, for example the gun in the plans never made it on to Fraternite or any other of the ships of its kind. There are aspects of the design which had to be modeled based on educated guesses made from studying the plans because not all of the information was present. For example, the exact dimensions and location of the iron strapping is estimated based on a general description. The model is also lacking some aspects due to the time it would have taken to add more details. It took well over 100 hours to create the historical model and adding more details was unnecessary for the amount of time it would have taken to include. Fittings and equipment of the ship that are missing from the model include the engines, the smokestacks, propellers, internal cabin details, and other small components. These parts were not necessary for the model to understand the historical ship. The plans and photos are referenced for these details as needed during this analysis.

C-transforms

In this study, the following pre-wrecking c-transforms were identified: the construction of the ship including material choices, method and design; and the engine failure with the corresponding necessary repairs. The c-transforms of the site, and therefore the site formation process, begins with the choices made by the ship's architects and designers before the *Fraternité* even left port. An architectural design combining wood, iron, and steel components fundamentally changed the cultural and non-cultural site formation processes and the evolution of the ship from its original state to the current *in-situ* archaeological remains. The historical model shows some extent of wood and some of the iron and steel used in construction while the archaeological model shows how these materials warped and changed over time by later transforms (Figure 48-Figure 50).

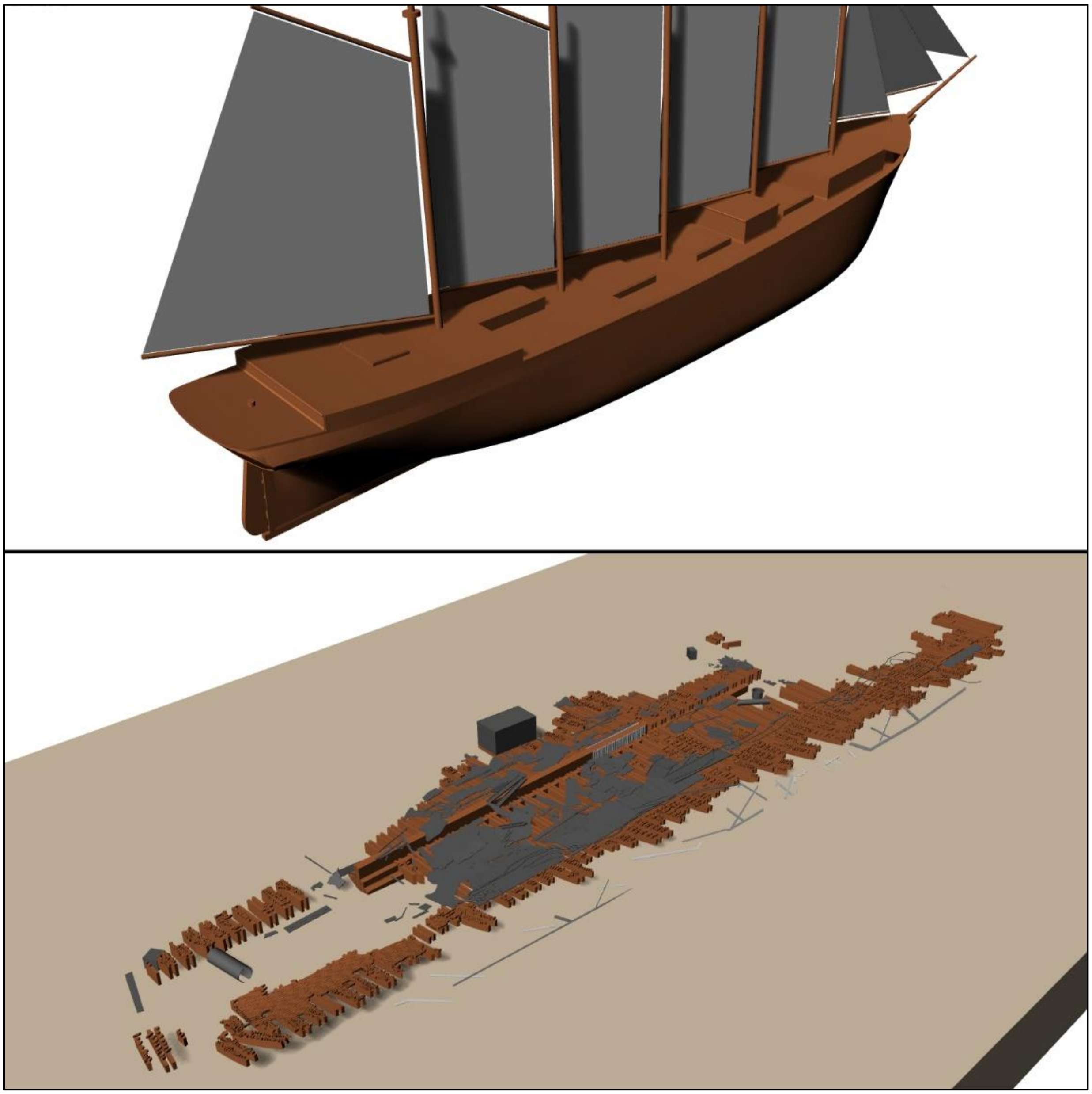


Figure 48. A side by side perspective view of the historical model and archaeological model (Image by Tim Smith).

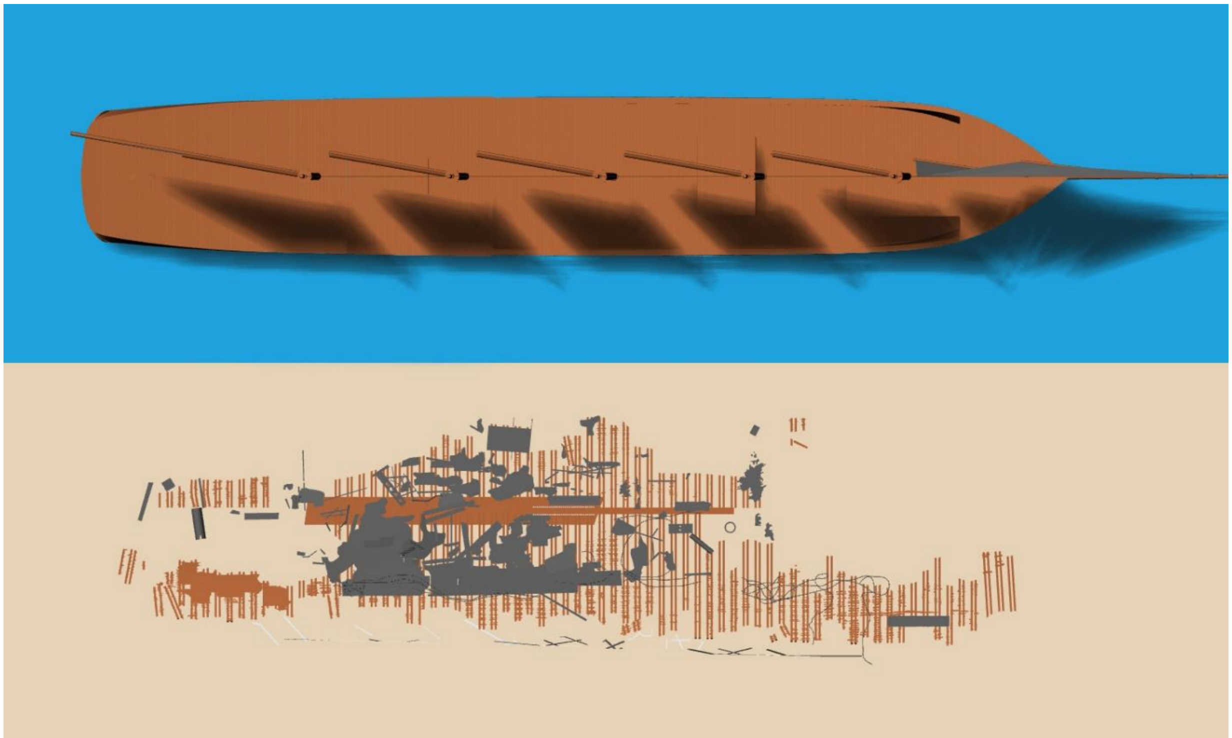


Figure 49. Plan view of historical and archaeology models (Image by Tim Smith).

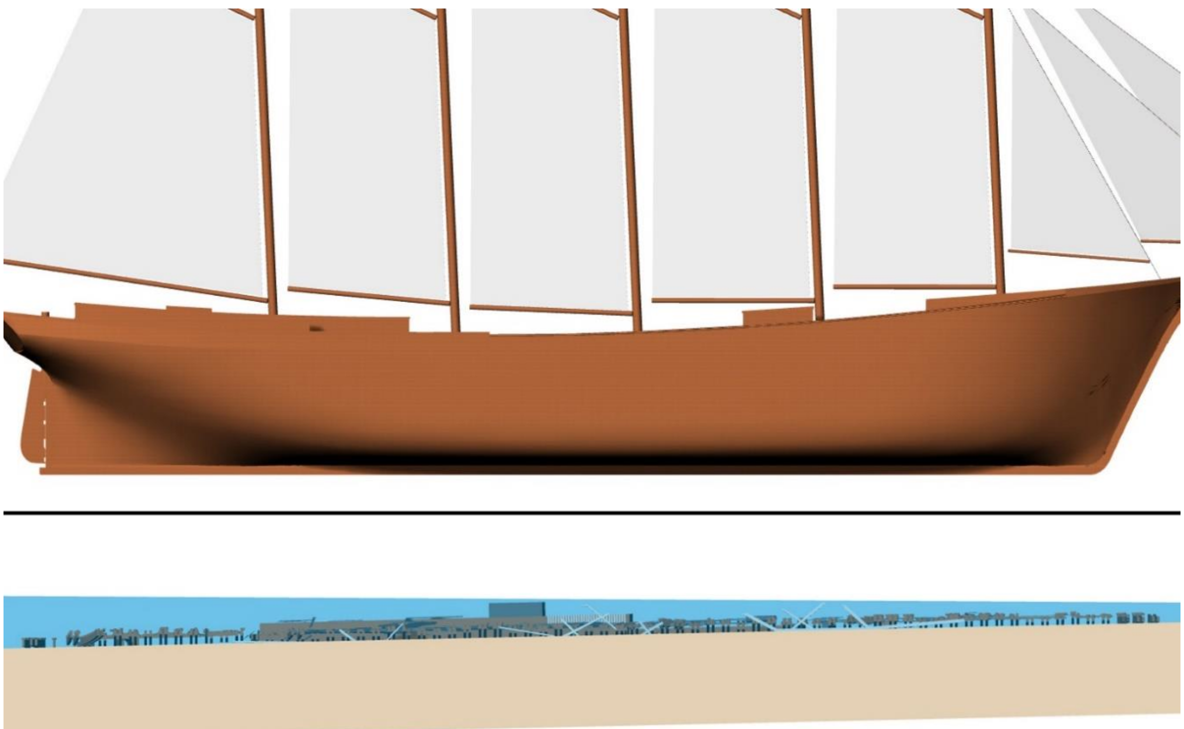


Figure 50. Profile view of historical and archaeological models (Image by Tim Smith).

A ship made of wood with less steel components or an entirely wooden ship would have somewhat different transforms taking place during site formation, and the same can be said for a vessel made with more steel or an entirely steel ship. Wooden ships would typically have flayed outward while steel ships would be more likely to fall in on themselves more than the *Fraternité* site (Steffy 1994:190; Watts 2014:254). Ward et al. state:

> Iron wrecks are more likely to deteriorate as a result of physical and chemical processes, whereas wooden wrecks are more influenced by physical and biological processes. In-situ corrosion studies of iron and composite wrecks indicate a clear correlation of the extent of degradation (measured from corrosion potential) with the oxygen flux (associated with the amount of water movement) at the wreck site. For wooden wrecks there appears to be no correlation between the age of the ship and the extent of biological degradation measured as loss of carbohydrate carbon. However, there is a significant difference in degradation between aerobic and anaerobic environments (Ward et al. 1999:564).

This explains why steel ships corrode over time and leave behind rock hard concretions, whereas wooden ships tend to disintegrate based on their environment. Although *Fraternité* was not a composite vessel like HMS *Ready* (which also sits nearby in Convict Bay), in terms of site formation it still falls somewhere on this spectrum between wooden ships and steel ships due to its makeup. These differences between wood and steel will be further explored in other sections of this chapter.

Fraternité's design is another c-transform which affected later archaeological site formation. For example, if the ship was made to withstand an impact like the one *Fraternité* took when it wrecked, it would likely have gone on to France and likely served a short term of service or set off in a harbor where most of its sister ships sat unused before being scrapped for parts. Obviously, had it not wrecked on the reef, the result would be no site left whatsoever. As mentioned in Chapter Two, these ships were made fast and cheap to replace those lost during WWI. They were not made with great longevity in mind similar to many the vessels that ended up in Mallows Bay (Shomette 1996:234). A short or borderline nonexistent career at sea points to the vessels being poorly designed for their intended purpose during the era in which they were constructed. It was written by the French that the ships of *Fraternite's* type which made it to France were poorly made with green wood, bad caulking, defective pipes, and several other issues. The ships had such a short life span and were in the docks so often that they were nicknamed the "Flotte aux pieds nickeles" (fleet with nickel feet) because they were so often stationary (Union Industrielle et Maritime 2012). Of the 40 ships, 3 sank before 1921, 24 were laid up by the end of 1922, and 13 were sold by the end of 1923. By the end of 1924 all but 10 were demolished for parts, with all but 1 ship demolished by the end of 1927. *Gerberviller* was the only ship of its kind to last until 1931 (Union Industrielle et Maritime 2012). Also in terms of design, the addition of the much needed strapping for longitudinal support likely helped in holding the ship together longer then if it did not have the strapping. The strapping provided substantial power to hold the ship together (Desmond 1919:94-95).

Another possible c-transform which could have had an impact on *Fraternité's* outcome is the pre-wreck damage of the faulty engines. It is unlikely this had too much effect on later transforms, but it is at least worth mentioning that this was a historically noted cultural transform of the ship while still in its historic context. This transform is most likely covered up by the later c-transform of the salvaging of those components from the site (*Royal Gazette* 1919f).

N-transforms

Since *Fraternité* was on its maiden voyage when it wrecked near Bermuda, there was not much time to get the normal wear and tear which comes with a ship which has been in service for many years. Non-cultural transforms are constantly affecting a ship while in its systemic context, just like they are in its archaeological context, since the ship is always being subjected to environment impacts (Richards 2008a:52). However, evidence of these transforms does not often make it to the present after many years of transforms during the archaeological context (Gibbs 2006:8). This is certainly the case for *Fraternité*; the bulk of the c-transforms and all the recognizable n-transforms, such as environmental degradation of the wood and steel, took place post-wrecking. These transforms are often not studied or considered as can be seen in Chapter 2 with the diagrams shown in Figure 13-Figure *15*.

Wrecking and Salvage Models

Upon wrecking, *Fraternité* did not immediately enter an archaeological context. The wreck did, however, continue to undergo cultural and non-cultural transforms. As stated in Chapter Two, it was quickly determined that the wrecking of *Fraternité* made it no longer seaworthy due to substantial damage sustained from hitting the outer reef system around Bermuda (Haviland 1972:16). Salvage crews from Bermuda immediately set to work salvaging the cargo before moving on to salvaging the ship itself. The environment also impacted the wreck by damaging it further when currents worked the ship against the reef, as well as wind eventually knocking down the masts (*Royal Gazette* 1919c, 1919d). Further c-transforms affected the wreck, as stated in Chapter Five, when it was refloated, burned to the waterline, and moved to a ship salvage location and graveyard.

Like the historical model, the wrecking and salvage models are not 100 percent accurate. These renderings were created based on the historical model and the primary resources of the Bermuda newspaper, *Royal Gazette*. The *Royal Gazette* provided only basic information on damage to the wreck, so it was necessary to use the limited details to extrapolate the exact location and extent of damages to *Fraternité*. For some of the damage, it was possible to use the current archaeological site and work backward to gather more information create a more robust model.

C-transforms

In terms of the wrecking and salvage models and the c-transforms they represent, the process begins with the reason for wrecking. As discussed in Chapter Two, *Fraternité* wrecked due to the lack of crew familiarity with the waters and reef system around Bermuda. They did not have a map or a pilot to help them navigate the treacherous waters filled with numerous shallow reefs (*Royal Gazette* 1919a). This is certainly one of the most influential c-transforms to take place. With navigational aids in place the site would likely have not even been created. The danger of Bermuda's waters was well known far before this time. Bermudians have endeavored to lessen the danger to ships as much as possible in multiple ways before *Fraternité* encountered them. Lighthouses were erected in attempts to stop ships from running into reef systems (*Royal Gazette* 1830). Bermuda also signed into law the Pilot Act which provided pilots for vessels attempting to navigate Bermuda's waters (*Royal Gazette* 1843). Naturally, the immediate wrecking damage is a direct result of the crew's unfamiliarity with the area (Figure 51).

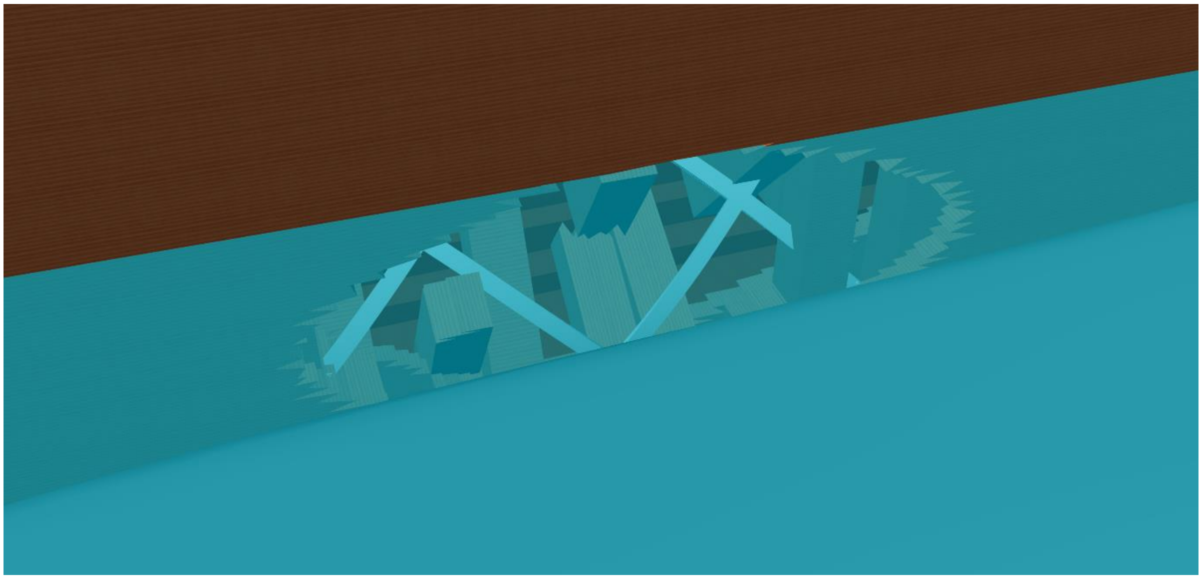


Figure 51. Close up view of hypothetical initial wrecking damage (Image by Tim Smith).

The damage that is shown in the initial wrecking model is hypothetical in terms of size and location on the ship because there was very little historical information about this damage. It is possible that these fragments of the ship which were knocked off during the wrecking are still located at the original site (Government of Bermuda 2020a). It is also possible that the damage was located further down on the vessel with the breaking of the keel and part of the bottom coming out like what is describe in the Royal Gazette (*Royal Gazette* 1919a). With more extensive damage it becomes likely that the steel strapping played a larger role in keeping the ship together while it was salvaged at its wreck site and on its journey to Meyer's Wharf.

As mentioned in Chapter Two, *Fraternité* flooded very quickly and sustained enough damage that the ship was beyond saving. Work began on salvaging the cargo soon after the wrecking due to its value (*Royal Gazette* 1919b) The culture and economy in Bermuda at the time was based around the salvaging of wrecks. "In Bermuda, wrecking, or salvaging, goods from sunken vessels, was as old as settlement itself, dating back to the salvage work done on *Sea Venture* in 1609" (Jarvis 2012:81). Due to the construction of the ship with four large hatches, it is possible that little, if any, of the main deck was removed at the initial wrecking site to get access to the cargo (Figure 52). The larger fixtures and fittings that would have needed deck removal were still present on the vessel when it was burned (*Royal Gazette* 1919f). The salvaging of the cargo served a twofold purpose: the recovery of the goods and the lessening of the ship's load so it could later be moved. The entire process took about one month to remove as much of the cargo as possible. The cargo was, therefore, quickly returned to its systemic context.

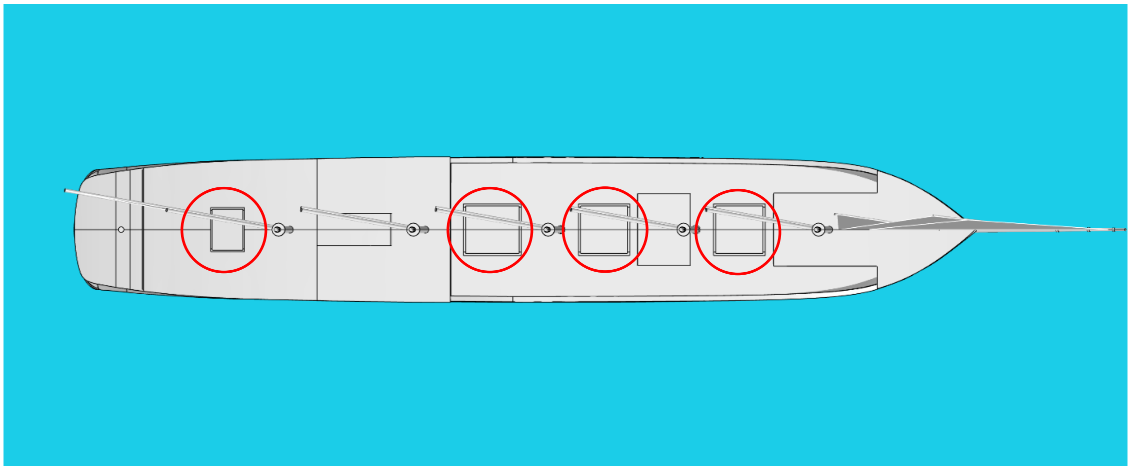


Figure 52. Plan view of main deck of *Fraternité* with hatches circled (Image by Tim Smith).

Not only was the cargo made up of valuable materials, so was *Fraternité* itself. These included the engine assembly, steel strapping, and other metal components. The ship was sold to a salvage company in Bermuda, but due to its wrecking location it would likely have been more trouble than it was worth to salvage it at its original location. The salvage company which purchased *Fraternité* was able to refloat the wreck enough to bring it into shore near its salvage yard where they could recover whatever they wanted from it easily.

A common practice in salvaging wooden ships, which was mentioned in Chapter Three, was the burning of the vessel down to the waterline. In Australia, ships like *Margaret*, *Redemptora*, *Day Dawn*, and *Glory of the Seas* were burned to facilitate salvage (Richards 2008:160-161). *Fraternité* was put through this process shortly before it reached its current location as evident from studying the models. As was mentioned in Chapter Five, the historical model shows the ship was raised up to make it possible to refloat t, which is the only feasible way to remove it from its original location wrecked between two reefs. From the wrecking model, it was clear it would have had to sit high enough in the water to lower the waterline to below the wrecking damage. Studying the archaeological evidence and knowing that the ship had been burned determined a likely place where the new waterline would have been and is shown in the salvage models. This waterline is still too high to allow the ship to be pushed into its current location and still had the amount of remaining unburned wood. This indicates that the ship was burned and then pushed into shore (Figure 53).

The burning of *Fraternité* down to the waterline and grounding the remains of the ship in shallow water meant that it was easy for the salvage company to get as much material as they could. The burning of the ship also points to the fact that they were likely not interested in its wooden components and instead aimed to salvage as much of the steel as possible. In the United States at that time, many ships similar to *Fraternité* were burned at Mallows Bay. After trying several different methods to quickly salvage material from a couple hundred composite ships, it was decided that burning would be the most cost efficient and quickest method of getting to the desired metal components of the ships (Shomette 1996:242-243). This can be backed up by the archaeological evidence shown in the archaeological model and site plan showing how little of the metal from *Fraternité* is left on the site, which is discussed later in this chapter.

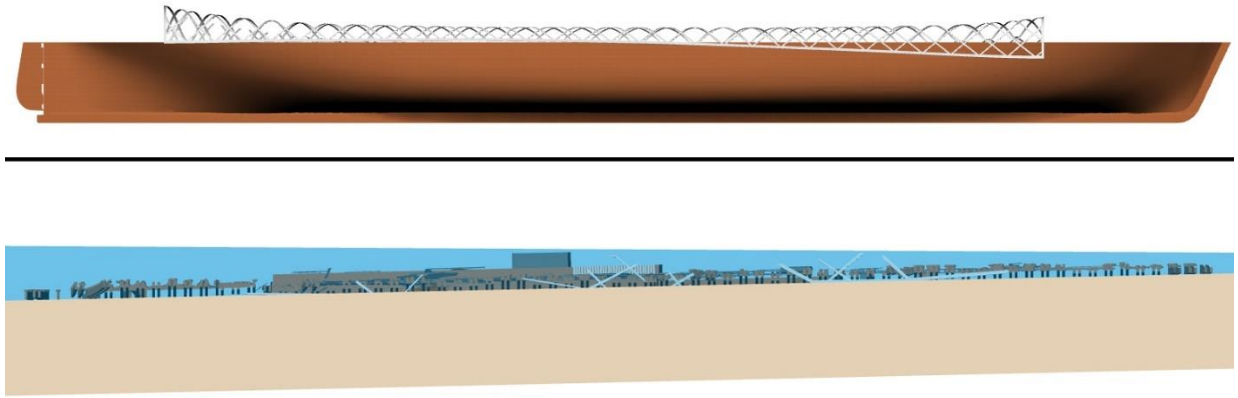


Figure 53. Profile view of burned ship model and archaeology model (Image by Tim Smith).

N-transforms

C-transforms from the wrecking and salvage are not the only transforms to have substantially changed the wreck during its wrecking and subsequent salvage period. N-transforms were also present and noted throughout the historical records working alongside the various c-transforms to change the ship. If the lack of crew knowledge about the waters around Bermuda is one of the primary the c-transforms which caused the wreck, then the dangerous shallow reef system is the n-transform which also played a significant part in the wreck. The natural shallow reef system around Bermuda has been a factor in the wrecking of ships around the islands since it was discovered. Bermudians were salvaging from their earlies days when *Sea Venture* wrecked and when the first colony was established (Watts 2014:14). Salvaging wrecks provided a good source of much needed materials which would have had to come from far away at the time (2014:16). Bermuda has since accrued many more wrecks with somewhere close to 400 shipwrecks around the island chain due in large part to the reef system (2014:28).

Throughout the time after the wrecking event (i.e. before it was moved to its current location), *Fraternité* was subject to the environment of the outer reef system of Bermuda. The major n-transform events which occurred during that period were mentioned in Chapter Two and include the working of the wreck against the jagged reef due to currents and the falling of the masts due to wind (*Royal Gazette* 1919d). The historical narrative discussed how, with the ship stuck between two sections of reef, the currents in the area were strong enough to work the ship against those reef projections to quickly increase the damage done during wrecking (*Royal Gazette* 1919c). This damage is represented in the wrecking and salvage models and includes the expansion of the hole caused by striking the reef (Figure 36).

The other major n-transform to take place in this period was the falling of the masts. In the historical documents it is stated that this was caused by heavy winds. The winds, in combination with how the vessel was stuck, would have caused great stress on the masts and would have been the reason they fell (*Royal Gazette* 1919d). Once again, this n-transform is shown in the wrecking and salvage models (Figure 54). It is possible that the masts, which fell due to this, are still located at the original wrecking site. The government of Bermuda has noted that there are still remnants of some of the cables and hardware from *Fraternité*, still located at the original site, but there is no mention of the masts themselves (Government of Bermuda 2020a).

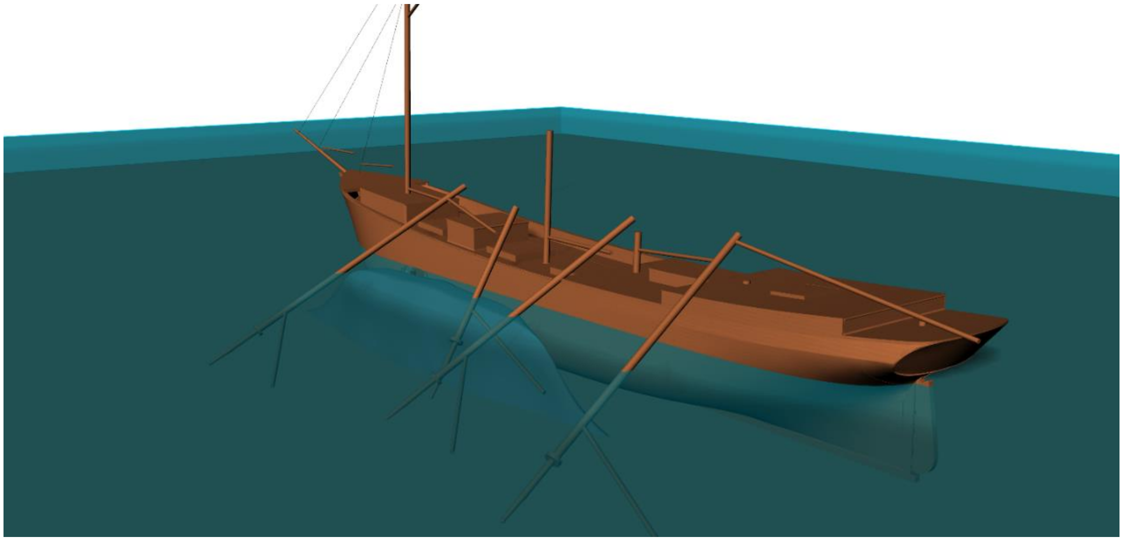


Figure 54. Perspective view of hypothetical falling of masts (Image by Tim Smith).

Archaeological Model

Just like the other models, the archaeological model also helps in understanding the current state of the site, how it got to its current state, and how it might degrade in the future. By analyzing this model, it is also possible to show the continued differences between the site formation of this ship versus a wholly wooden or wholly steel vessel. This model can also be analyzed using site formation theory and show the cultural and non-cultural transforms that took place after *Fraternité* entered its archaeological context. C-transforms include the use of the wreck for further salvage as well as a dumping site for either another vessel or parts from multiple other vessels. N-transforms include the corrosion of the ferrous features of the ship and the degradation of the wooded aspects.

The archaeological model has similar limitations to those discussed earlier in this chapter in regard to the other models. As stated in Chapter Five, this model was created from the previous models, the site plan, photos, and video taken in the 2008 ECU expedition. The site plan only shows the plan view, and the photos and videos only show some details of parts of the wreck which are not in measurable detail. Many aspects of the archaeological site had to be created from these details using approximation and educated guesses to fill in the missing information. Time was again a limiting factor; with the time spent already on the model, it became gratuitous to spend more time adding small details. The archaeological model does not show every single piece of the wreck. It was decided that not every piece was needed since there was not enough information on every fragment and it would have taken hundreds of more hours to add, with a greatly diminishing return on usable information. This is also why a color-coded version of the site plan was created to supplement this lack of full detail. It was not possible for new information to be gathered from the site directly. Time and money were limiting factors in any attempts to travel to Bermuda to get more data from the site. A new field session would have been helpful in not only gathering more specific data for features of the site, but also seeing how the site had changed since it was studied in 2008.

C-transforms

It is known from the historical documents that once *Fraternité* reached its current location further salvage took place. Having been sold to a salvor and brought to Meyer's Wharf, a common location for ship salvaging, denotes these further c-transforms. The engine assembly including the boilers, the propellors, and the engines themselves would have been the most valuable steel components and were, therefore, likely salvaged first (*Royal Gazette* 1919f). As can be seen in the archaeological model, there is no evidence of these components left on the site today. There is also a substantial portion of the iron strapping missing from the port side of the ship which can also be noted in the archaeology model. This strapping was also likely salvaged during this initial period. It is possible that some of the iron fasteners were salvaged, since there is not nearly the number of fasteners identified at the site which would be expected for a ship this large. However, it is also possible that some were scattered during the fire and are located somewhere else or were removed in some other way. The outer elements of thin metal shown on the archaeological model without any wood around them are likely evidence of parts of the iron strapping. There is no wood nearby because of the burning of the ship to the waterline and other environmental factors such as shipworms and storm activity (Figure 55).

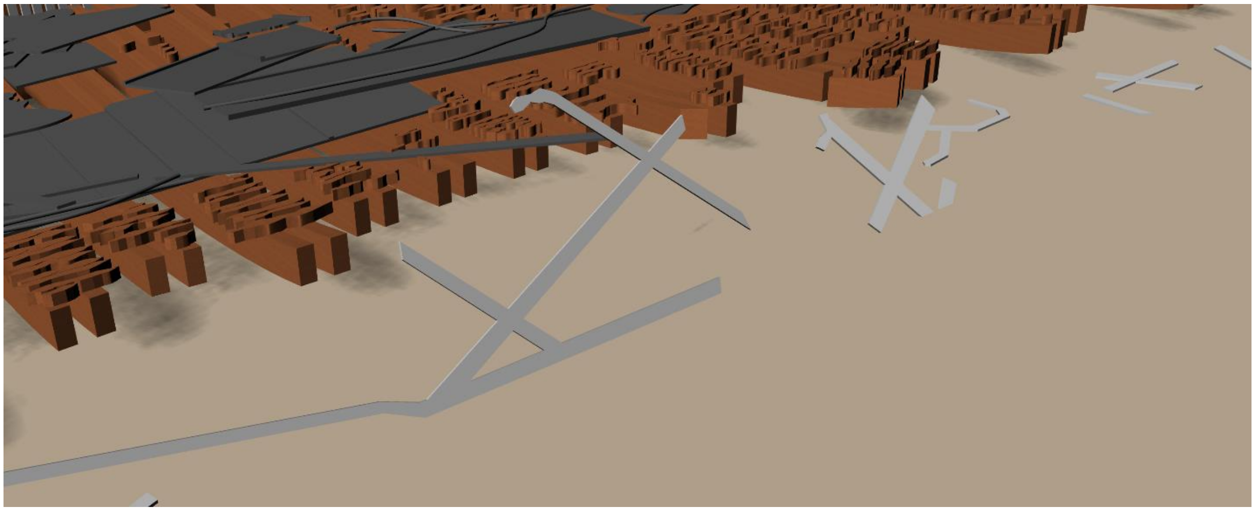


Figure 55. View of steel strapping on outskirts of the *Fraternité* site (Image by Tim Smith).

The burning of the ship would have likely removed all the wood that surrounded the upper part of the strapping which can be seen bent over in Figure 55. What was once the top of the strapping is now laying on the sediment with the parts closer to the bottom now sticking up. This is likely because the steel was weakened when the ship was burned, and the strapping peeled down towards the outside of the ship. The burning of the ship would have taken a long time to complete. Other similar burning of vessels such as those at Mallows Bay took between 18 and 26 hours to burn. This also created a lot of scrap metal that would fall off of those ships and later collected (Shomette 1996:245-246).

In terms of later salvage, it is possible that some salvage took place during World War II. The salvaging of various types of metals from shipwrecks around Bermuda was commissioned by the government to help the war effort and replace shortages caused by the war (Government of Bermuda 2020b). There is no documentation on salvage during the war but due to the widespread nature of salvaging and how close the site is to the shore; it would have been easy for people to salvage *Fraternité* to meet the needs. The *Royal Gazette* had several advertisements placed about supporting the war effort by salvaging metals and other materials (*Royal Gazette* 1942, 1943, 1944).

There was also some salvage which took place at the original wrecking site. Teddy Tucker, a famous Bermudian treasure hunter, inspected the original wrecking site and discovered a few ingots of cargo left behind. Figure 56 through Figure 58 show Teddy Tucker diving on the wrecking site, as well as copper and lead ingots from the cargo of *Fraternité*.

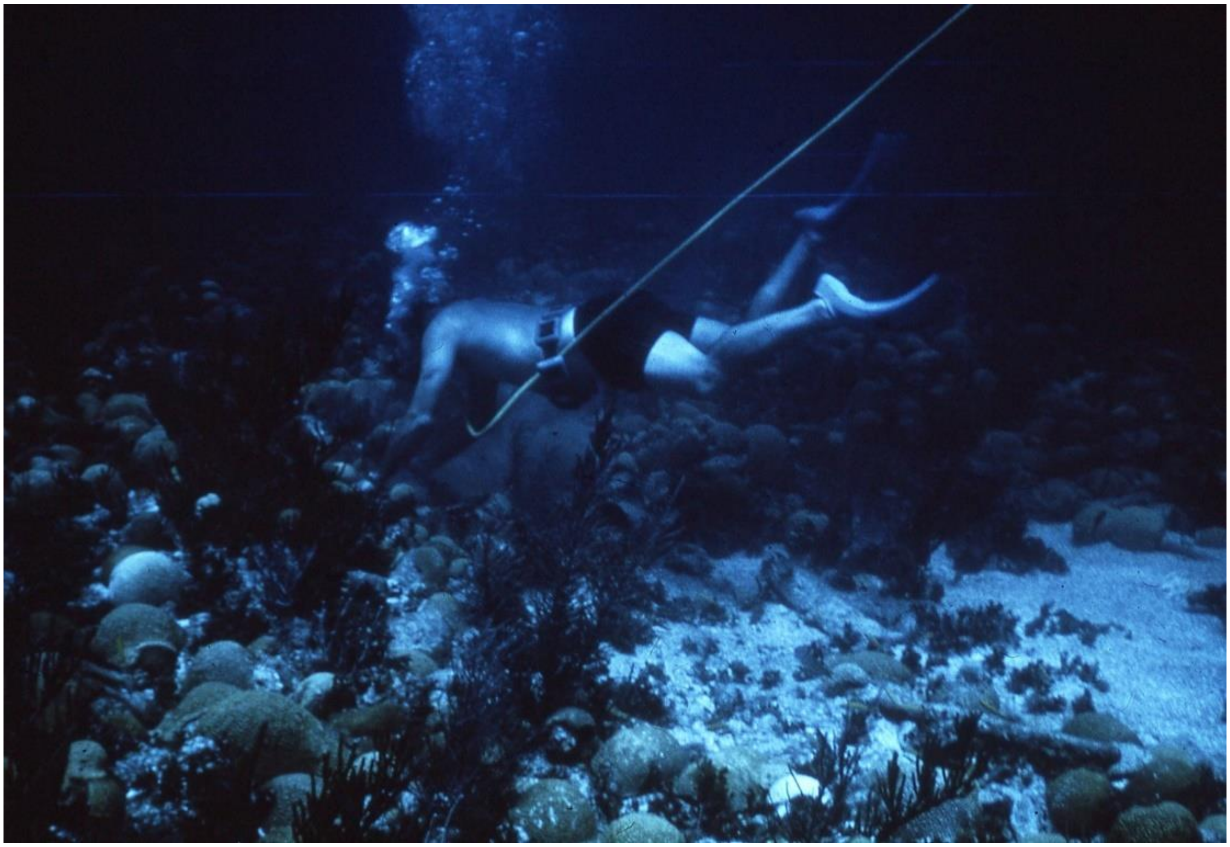


Figure 56. Teddy Tucker diving on the original wrecking site of *Fraternité* (Tucker 2020).

Figure 57. Lead ingots recovered from original wreck site of *Fraternité* by Teddy Tucker (Tucker 2020).

Figure 58. Copper ingots recovered from original wreck site by Teddy Tucker (Tucker 2020).

In terms of future salvage, recreational divers or swimmers could interact with the site; however, there are a couple mixed variables that would affect this. *Fraternité* is one of only a handful of wrecks that is on Bermuda's list of restricted sites. This means that to visit it would require permission from the Bermudian government. The reason this site is restricted is due to the danger it could pose to those who visit. The site is shallow and has a large amount of jagged metal aspects which visitors to the site could fall and hurt themselves on (Government of Bermuda 2001:3). This restricted access is easy to enforce due to how close it is to shore and the area being a high boating area. However, this proximity to shore and a heavy trafficked area could also have the opposite effect. People who do not know about the site being restricted, like tourists, might just decide to snorkel around the site. Being near so many other ships could also draw attention to it.

It was not until the late 1950s that Bermuda started to really turn away from salvage and more towards protecting historically significant wrecks. In 1959, legislation was passed which gave a little more protection from salvage to historical wrecks. However, it was not until 2001 when the Historic Wrecks Act was passed, that all shipwrecks within Bermuda's waters were provided protection from anything being removed from a site without the proper state issued license (Government of Bermuda 2020b).

Another important note regarding c-transforms in the archaeological context is that there are so many steel plates, other steel artifacts, and other out of place objects located on the site. From building the historical model and then going through the process of breaking it down through the wrecking and salvage models to the archaeological model, it was evident that most of the steel on this site did not belong to *Fraternité*. As was mentioned earlier in this chapter the major iron and steel components of the ship included the fasteners, steel strapping, anchors, and the engine assembly. There was other metal onboard, but only in small components, which did not appear to be on the site when surveyed and were likely salvaged at some point throughout the site's history. The massive amount of metal which can be seen in the archaeological model, on the site plan, and the photos taken during the site survey do not show up in the plans. When the ECU team first studied the site in 2008, there was some discussion among the students that the large pile of metal present was not part of *Fraternité*, but in the end it was all considered part of the ship (Richards 2009:6). By building and breaking down the models of the ship to show the site formation processes, it was possible to prove that much of these metal components were not associated. Figure 59 shows which parts of the site were determined to be part of *Fraternité* (normal colors in archaeology mode/black), which fragments are possibly not part of the ship (blue), and which fragments are most likely not part of the ship (red). Figure 60 Shows how there is very little metal represented in the burned model plan versus the archaeological model.

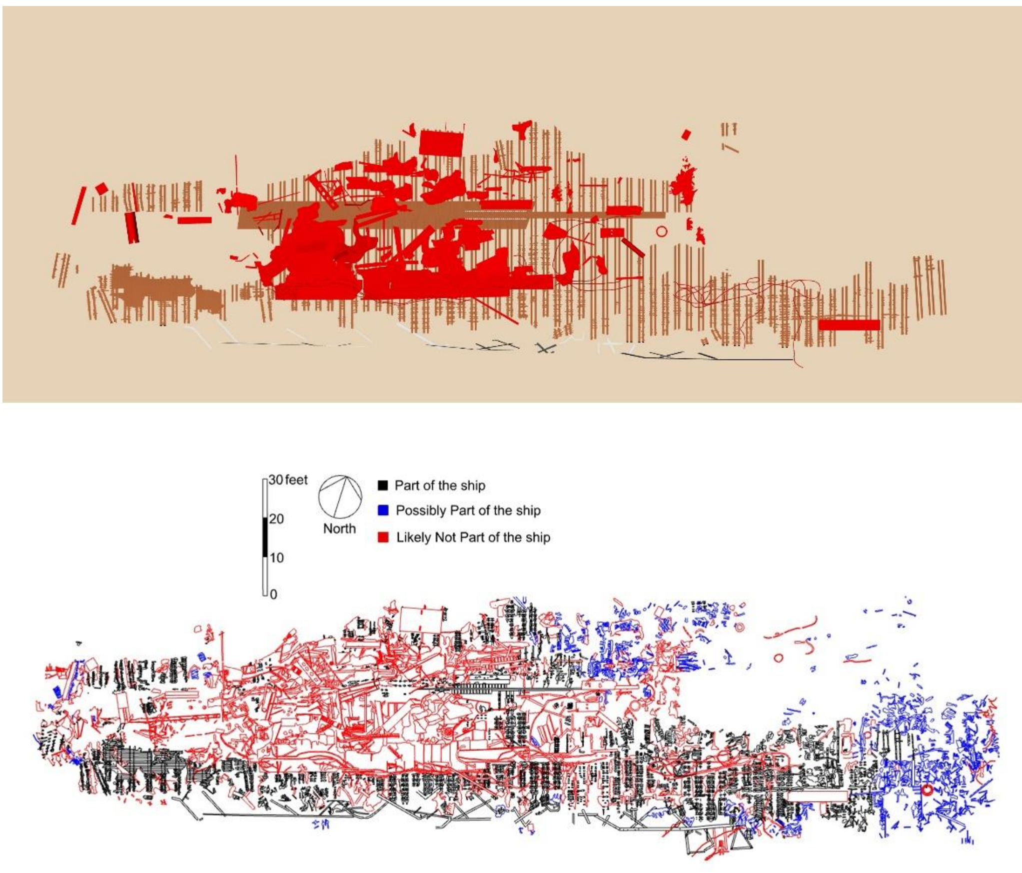


Figure 59. Plan view of color-coded archaeology model and site plan (Image by Tim Smith).

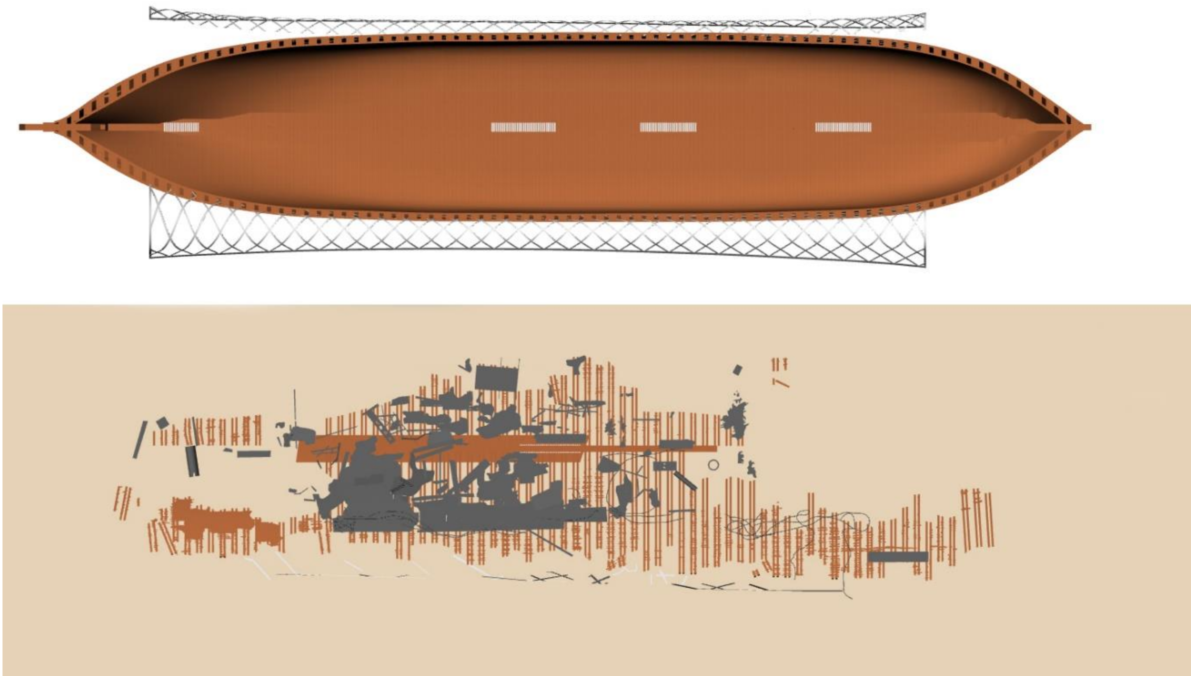


Figure 60. Plan view of burned and archaeology models (Image by Tim Smith).

It is likely these metal scraps were placed on the site when they were taken from other ships. As was mentioned in Chapter Two, Meyer’s Wharf was commonly used for shipbreaking and was part of the Meyer’s Salvage yard. Since not every aspect of a ship is valuable to salvagers, whatever is deemed of no value or not worth the time and effort it would take to salvage is left behind or thrown away (Richards 2008a:148-149). In a similar fashion to the burning of *Fraternité* to get to its more valuable engine assembly, on a steel ship later in the 20th century it would have been better to remove the unwanted steel decking to get to the engines. To save room when salvaging, it makes sense that salvagers would dump what they did not want on the remains of already salvaged vessels. This is likely what happened to *Fraternité* and why there is so much metal on the site which does not belong to the original ship. It is also possible that this metal is placement assurance to make sure the vessel did not move after being burned and sunk. However, since they were removing much of the metal when *Fraternité* was originally salvaged it is unlikely they would waste so much metal to keep the vessel in place. More likely, in this case, it was garbage dumped on *Fraternité* to save room (Richards 2008a:169-170).

N-transforms

As a wooden ship with extensive iron components, wood and iron are the materials which have been affected by n-transforms while the ship has been in its archaeological context. All the metal on the site is encased in a substance known as concretion. Concretions form over many years from iron corrosion mixing with sand and sea life to form a substance around a ferrous artifact which is as hard as concrete. These concretions can spread to incorporate other artifacts or aspects of a site that are non-ferrous (Page 2017). This has certainly happened to this site and can be seen in the photos taken by the 2008 ECU team (Figure 61).

Figure 61. Concreated fasteners on *Fraternité* (Image from 2008 ECU archaeological survey).

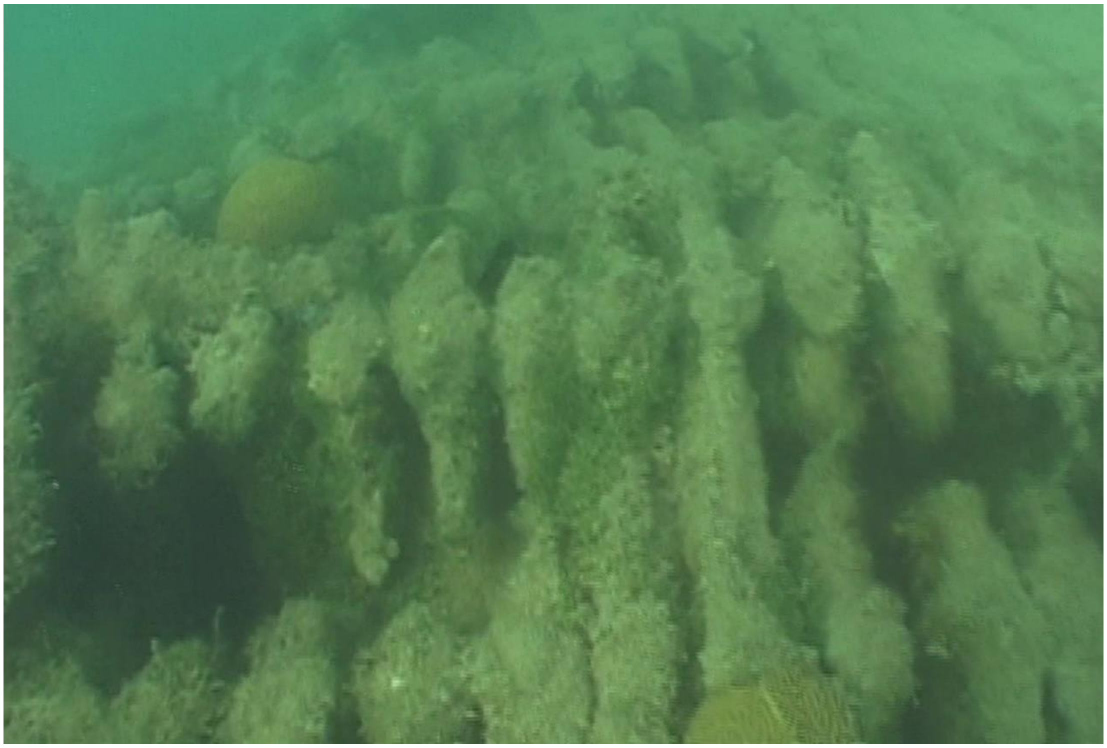


Figure 62. Corrosion from fasteners encompassing remnants of planking on Fraternité (Image from 2008 ECU archaeological survey).

Since this corrosion has only been taking place for about the past 100 years, it has likely not grown too thick and most of the iron beneath the concretion likely exists. It is also possible that some of this concretion is helping to protect the wood that it encompasses from other n-transforms that want to degrade the wood (Page 2017). This can be seen in certain areas on the archaeological model and in photos where planking remains (Figure 62).

Another factor protecting the wreck is that much of it is covered from copious amounts of steel plates and other metal artifacts from other ships. These metal artifacts can help to protect the remnants of *Fraternité* from further damaging c- and n-transforms. With all the metal on the site, some of *Fraternité* is protected from the removal of artifacts which remain by people without taking a fair amount of effort to remove the metal on top. The metal also helps protect parts of the vessel from the effects of storms disturbing the site. It does a similar job as the sediment that might cover other wrecks such as those buried on the outer banks of North Carolina. A protective layer of material covering a site helps limit its exposure to the elements (Jones 2018:146).

The n-transforms affecting the degradation of the wood while the vessel rests in its archaeological context are heavily dominated by the marine life that flourishes around Bermuda. *Fraternité* is in warm shallow water with a soft fine sandy bottom on the north end of the island chain. These are the perfect conditions for marine life like burrowing crustaceans and marine worms. Fauna like these seek out and breakdown organic material such as the wood from ships for their own sustenance as well as releasing nutrients back into the environment (Steffy 1994:190; Government of Bermuda 2014:7). *Teredo Navalis*, or the ship worm, may be good for the environment, but they also make quick work of archaeologically significant wood. These creatures consume the wood and create little tunnels and burrows behind. If given enough time they would consume all the wood left behind on a site. They also thrive in an aerobic environment like the one *Fraternité* sits in within Bermuda's waters (Eriksen et al. 2016:117). This is certainly one of the reasons there is so little wood remaining on the site and explains the state of the wood that does remain. Figure 63 shows that in some areas of the site there is little to no wood remaining. Planking in most areas is completely gone and the size of the frames that are left are reduced.

Figure 63. Fasteners that once held planking to the frames (Image from 2008 ECU archaeological survey).

Storms, as n-transforms, have also likely played a large role in changing the site of *Fraternité*. As mentioned in Chapter Three, storms are an n-transform which can be a scrambling device for a site (Muckelroy 1978:174). Hurricanes and tropical storms create large gusts of wind, as well as wave and current action. The shallowness and proximity to shore of *Fraternité* increase the impact storms could have on the site. As the site map and archaeological model show, the site is a scattered mess of archaeological remains especially in the very shallow area near the shore. Some of this is likely due to the c-transforms of salvage actions, but some is likely the cause of the many larger storms which have impacted Bermuda since the wrecking of *Fraternité*. There have been many severe recorded hurricanes and tropical storms to impact Bermuda in some way since 1919 (*The Bermudian* 2020). Many of these storms have the potential to impact the site with their high winds and the changes which can be wrought under the ocean. It is not possible to determine which storms did and did not impact the site since there is no historical documentation on the subject, but it is safe to say that some did, and these storms likely scattered much of the debris which can be seen around the site today. Other wrecks such as *Altoona,* that was close to shore, was both uncovered and broken up by the action of storms. Storms also affect wrecks by scouring out sediment that surrounds buried aspects putting them in danger from other transforms which is the case for wrecks such as *Howard W. Middleton* (Jones 2018:146-150).

Comparison to other vessel types

Fraternité and its site transformation can be compared to other different types of vessels like wooden, composite, and totally iron or steel ships. There are similarities and differences to each of these vessel types with *Fraternité's* site transformation. *L'Herminie* was a wooden French frigate that wrecked in Bermuda after encountering heavy weather in 1838. Like *Fraternité,* salvaging of the wreck was quickly carried out. The wreck was forgotten for a while before being rediscovered in the mid-20th century. This is when further salvage occurred, and many different groups excavated or studied the site throughout the later part of the 20th century. Most anything of value has been taken from the site leaving behind a small amount of the hull and many of the cannons (Watts 2014:206-209). The amount of hull left is likely due to some of the same reasons why *Fraternité* has lost much of its wooden structure, due to n-transforms such as shipworms. Shipworms combined with wood erosion and other n-transforms to quickly eat away at any exposed wood. Continued stress from the weight of cargo, cannons, or other material slowly put strain on the weakening ship structure and cause it to collapse (Steffy 1994:190). The wooden aspects of *Fraternité* are also likely to end up like *L'Herminie* in the next 100 years as destructive n-transforms continue to degrade the wood.

A composite ship in very similar circumstances to that of *Fraternité* is HMS *Ready*. *Ready* was constructed only about 40 years before *Fraternité*, and wrecked about 20 years after *Fraternité*, however it was constructed as a composite vessel. This means the ship had metal frames, but the hull was made of wood. The current site of the HMS *Ready* is in Meyer's Wharf very near *Fraternité*, meaning that many of the transforms which affected *Fraternité* likely affected HMS *Ready*.

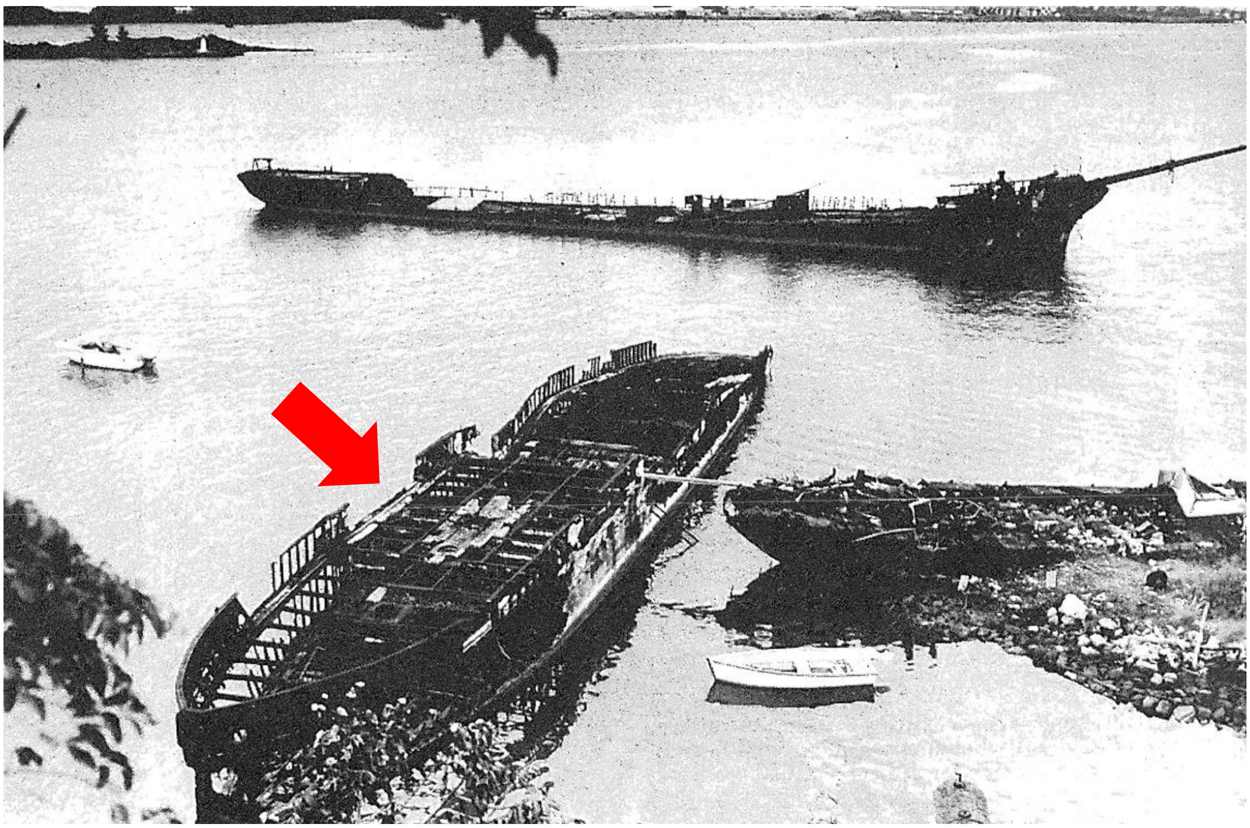


Figure 64. Image of HMS *Ready* in Meyer's Wharf (Robb 1975).

Figure 64 shows HMS *Ready* as it was in 1975 and it has only continued to degrade, as seen in Figure 65. As can be seen from these figures, much more of the structural components of the ship are remaining. This is due to the difference in the design with the stronger metal frames. Very little of the wooden hull remains; however, like *Fraternité*, this is likely due to the same n-transforms. HMS *Ready* had several new lives after it finished service. The ship was used as a barge and lighter until it was abandoned as a breakwater in the 1940s instead of being broken down like *Fraternité*, which is another factor in why it still retains much of its upper structure (Watts 2014:254; Richards 2018:70).

Figure 65. View of HMS *Ready* in 2008 (Image from 2008 ECU archaeological survey).

North Carolina was an iron barque which was constructed about 40 years prior to *Fraternité* and wrecked in Bermuda only a few years after construction. The durability of the iron vessel allowed it to survive one wrecking and almost survive a second time before having its hull pierced, which ultimately resulted in its sinking during refloating attempts near Bermuda. Due to the nature of the iron vessel, like many others of its type, it has survived better than its wooden and composite counterparts. Large sections of the vessel remain intact including the bow and stern sections. The middle section has collapsed in on itself likely due to the weakening and weight of the metal in that area. The entire ship is covered in concretion just like the concretion which has formed around the metal artifacts of *Fraternité* (Watts 2014:216). Even though *North Carolina* has been submerged for 40 more years than *Fraternité*, there is still much more of the ship remaining. This is due to the strength of the metal as well as its location far from shore making salvage of the site much more inconvenient.

Conclusion

By bringing together the historical documentation, archaeological research, theoretical ideas, and the models which were created for this project, this chapter has illustrated the many various c- and n-transforms that have affected *Fraternité* during its systemic context and archaeological context. The 3D models that were created immensely helped in understanding the site formation and how *Fraternité* went from an active ship to the site it is today. The historical model gave insights into the systemic context transforms. The wrecking and salvage models, along with the archaeological model, gave insights into the archaeological context. This chapter also discussed some of the similarities and differences between site formation at *Fraternité* and that of other vessel types like wholly wood, composite, and steel. Understanding the models also helped in understanding more about early 20th century shipbuilding at a time when vessels were transitioning from wooden to steel construction.

CHAPTER SEVEN: CONCLUSION

This study started with four research questions related to the site formation of the French schooner *Fraternité*. These questions were answered using historical and archaeological research, employing archaeological site formation theory, and utilizing model building as an analytical tool. The historical and archaeological research that had been done was crucial in understanding the degradation of *Fraternité*. This information was used to create a series of 3D models to help in the interpretation of theoretical site transforms. Through studying these models, the research questions were answered, and new light was shed on the nature of the *Fraternité* site that other methods of study might have missed. This study can contribute to the wider archaeological understanding of how a vessel in a transition time period between wooden and steel ship building deteriorates over time. It is also a good case study in how 3D modeling can help to better understand archaeological sites.

To understand the site formation of *Fraternité* it was first necessary to understand the history of the ship itself and its background. Chapter 2 presented the background of *Fraternité* focusing on the time period of the ship, the history of ship construction during that time, and the history of the ship itself. A lot of this historical information was key in constructing the historical, wrecking and salvage, and the archaeological models. These documents also helped to interpret the transforms which took place in the systemic and archaeological contexts of the vessel.

Along with understanding the history of *Fraternité,* it was also necessary to lay out and understand the theory behind site formation especially the principles laid out by Muckelroy (1978) and Schiffer (1987). Chapter 3 presented these theoretical principals that are the base for this study. The main theoretical concepts used in this study are the c- and n-transforms that affected the ship and breaking down those into how they affected the vessel in its systemic and archaeological contexts. Practices such as deliberate burning, or salvage, are c-transforms that have drastic impacts on ships such as *Fraternité* and processes like storms and fauna are some n-transforms that can change how an archaeological site forms.

Chapter 4 discussed how the historical documents, theory, and archaeological research come together in this study. This chapter focused mainly on how these resources were gathered and how they were used throughout the study. Primary and secondary sources such as the vessel plans, and ship building information of that time period were important in creating the historical model. All the data generated from the archaeological research done in 2008 was instrumental in creating and understanding the archaeological model.

The results and analysis chapters, Chapters 5 and 6, tied everything from the previous chapters together. Chapter 5 discuses in depth how the models were created, starting with the lines all the way to the breaking down of the historical model to make the subsequent models. Using *Rhino* 6, a historical model, several wrecking models, and an archaeological model were created to illustrate the major known events that shaped *Fraternité's* site formation. Chapter 6 provided analysis of all the previous information to answer the research questions and shows details of the models back up these assertions. These models were studied to gain insights into the most likely c- and n-transforms that affected the ship.

Fraternité went from an active ship to a messy dispersed site through the many c- and n-transforms which affected the vessel's site formation. C-transforms such as the decision to use particular building materials and design affected site formation during *Fraternité's* systemic context. The vessel wrecked through a combination of c- and n-transforms like crew unfamiliarity with Bermuda waters and the shallow reef system. *Fraternité* was quickly salvaged at the wreck site though wind and currents also damaging the ship. Once the vessel was refloated it was moved to shore and where c-transforms such as burning and further salvage took place. After everything of use and value was removed, n-transforms like ship worms and iron corrosion, that had been taking place throughout the site formation process, really started to take effect and storms could have scattered the site. Further salvage actions of other ships resulted in the large amount of metal dumped on top of the site.

In terms of how *Fraternité* is different from a wholly wooden or wholly steel vessel this was shown as *Fraternité* having common site formation processes of both types. Like a wooden ship, the site is drastically affected by ship worms. Like a steel vessel, components of *Fraternité* are covered in concretions. The truth is that *Fraternité* lies somewhere closer to a wholly wooden vessel and a composite vessel on that spectrum. Some of the steel components protect and hold parts of the site together, but not to the extent of a wholly steel vessel; however, it is better than other wholly wood vessels like *L'Herminie*.

Fraternité should be protected from most future c-transforms due to its restricted status and Bermuda's laws that protect their maritime cultural heritage. The site, however, will continue to deteriorate by the corroding of the iron components and the breakdown of the wood in Bermuda's warm water environment. Parts of the site have some protection thanks to the steel that has been dumped on top of the wreck. These are areas which could use further study.

Fraternité can teach us a lot about 20th century ship building, specifically the very end of the transition from wooden sailing ships to iron and steel steam ships. *Fraternité's* design and construction was not up to the standards of the period and ship builders in America were following much of the rest of the world's lead into steel ship construction. *Fraternité* shows an attempt made at having wooden ships compete in a world of steel vessels but was ultimately a failure. Like much of the rest of the ships that came out of the Emergency Fleet Project, the design and ships were quickly scrapped for stronger, faster, more efficient ships.

Although the objective of this study was achieved in answering the research questions which were laid out at the beginning of this paper, there are several areas where it could be expanded upon. There were limitations placed on this study in terms of access to certain information about *Fraternité* and the site. With more information, it would be possible to expand upon this research to create a much more detailed site formation study than this paper provides. As was discussed in Chapter 4, the historical model created for this study was only based off a few pages of the plans. With the rest of the plans much more detailed models could have been created, possibly giving new insights into the ship's site formation. Another possible avenue of information would be a more comprehensive archaeological survey of the site. Studies of wood condition and corrosions could provide more information about the transforms which have affected them. Studying the flora and fauna on the site could produce more information on their impact. This study could not provide a definitive path of future degradation and could only speak in hypothetical terms. Studying the site multiple times over the course of multiple years might help to develop a more predictive model of how the site will continue to degrade.

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