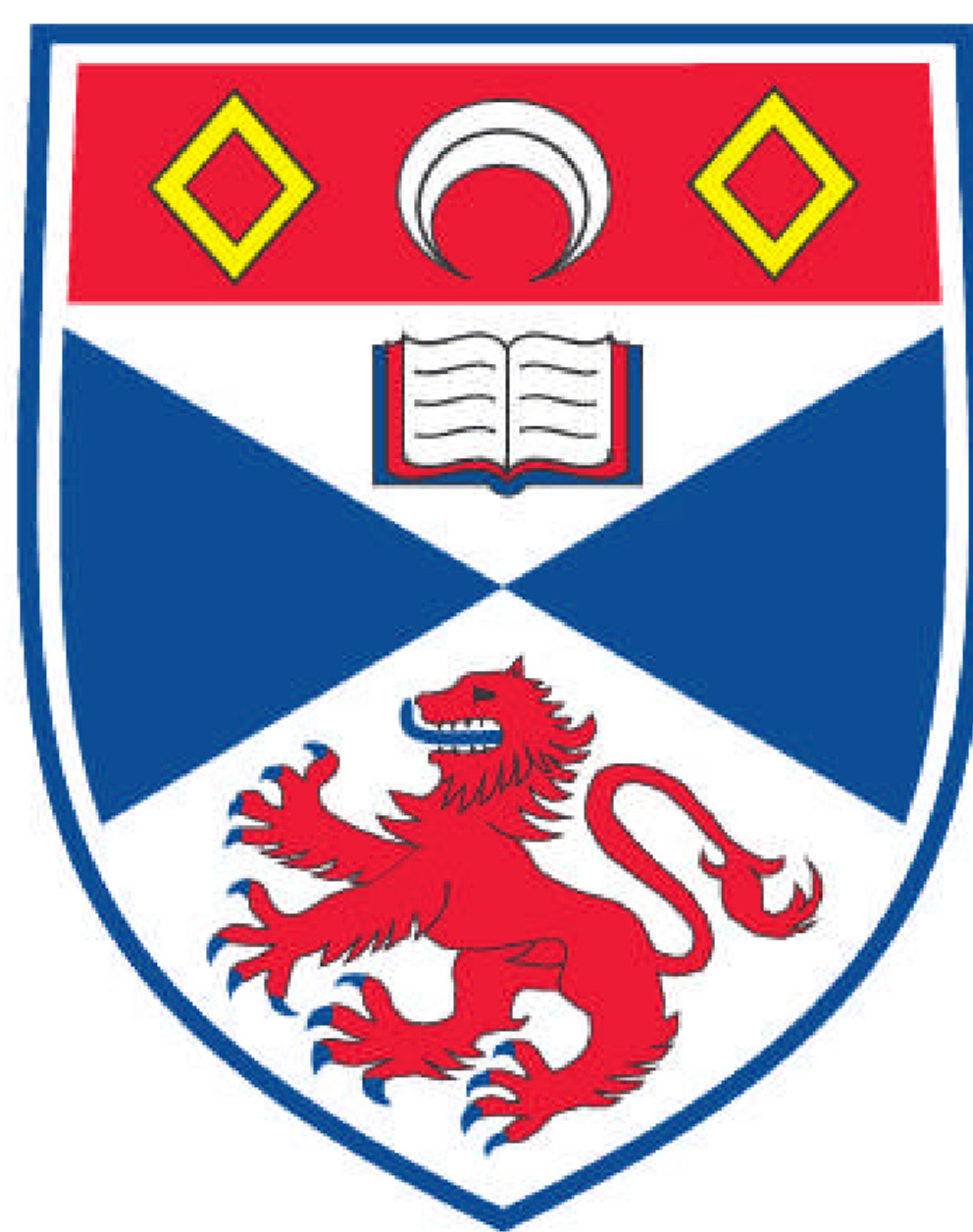


**FROM FOREST TO FAIRWAY: HULL ANALYSIS OF *LA BELLE* A  
LATE 17<sup>TH</sup> CENTURY FRENCH SHIP**

**Toni L. Carrell**

**A Thesis Submitted for the Degree of PhD  
at the  
University of St. Andrews**



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**From Forest to Fairway:  
Hull Analysis of *La Belle* a Late 17<sup>th</sup> Century French Ship**

By  
Toni L. Carrell

Prepared in partial fulfillment of Ph.D. requirements in Maritime Studies  
University of St. Andrews

2003



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## Abstract

This thesis is a comprehensive analysis of the hull remains of *La Belle*, a ship wrecked off the coast of Texas in 1684 during the failed attempt by Robert Cavalier Sieur de La Salle to establish a colony at the mouth of the Mississippi River.

The analysis of *La Belle*'s hull focused on five research goals. The first was to reconstruct the conception and design of the hull. Because *La Belle* was built on France's Atlantic coast, it was expected that the ship would fit into Atlantic traditions of shipbuilding. Instead, it exhibits an ancient Mediterranean method known only from Renaissance manuscripts. Until *La Belle*'s discovery no archaeological example associated with this method had been identified. Reconstruction of the lines also revealed the unexpected use of surmarks that reflect a transition from a largely empirical approach to the architecturally-based ship plan.

The second goal was the documentation of a previously unstudied ship type, the *barque longue*, through an analysis and description of the hull's assembly and its comparison to contemporary shipbuilding practices. The third goal was an analysis of newly discovered registries, letters, and documents specific to *La Belle* that raised fundamental questions regarding the ship's genesis and typological identification.

The fourth goal was species identification of the timbers to provide a more detailed picture of forest exploitation and to identify whether Old or New World timbers were used in the repairs noted in the hull. The fifth goal was to obtain information on the origin of the wood through dendrochronological analysis. That analysis raised unexpected questions regarding dating and the possibility of re-use of whole frame sets. Because there are no other investigated late 17<sup>th</sup>-century shipwreck sites from the Rochefort region with species and dendrochronology data, *La Belle* has provided a benchmark for these two analyses.

These five research foci provide a unique picture of late 17<sup>th</sup>-century shipbuilding in French Atlantic shipyards and contribute to the study of hull design, ship typology, construction and assembly, wood species use and origin, dendrochronological dating, and timber reuse.

## Acknowledgments

All major research projects involve many individuals and this project is no exception. To list all of their names and to describe all of their contributions would fill another thesis. Nonetheless, they all deserve recognition. The various departments of the Texas Historical Commission provided everything from personnel to purchasing to public relations. Their tireless efforts made the field work possible. During the excavation hundreds of volunteers came to the site to excavate, clean, sort, and process thousands of artifacts. Without them the project could not have been completed in so short a period. These were the foundations upon which the project depended.

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The specialized timber photographs were taken by George Vandervlugt, a photographer with the skill of an artist and the eye of an archaeologist. The hull drawings and other illustrations were variously made by Taras Pevny, Greg Cook, Marie-André Marchand, and Donald H. Keith. Carole Medlar digitized many of the hull drawings and Donald Keith transformed their art into electronic images. Juan Rodriguez did everything from finalizing AutoCad drawings to high resolution scanning. If a picture is worth a thousand words, they each contributed volumes.

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### Note on Weights and Measures

Two sets of measurement conventions are used in this thesis. All modern data are provided in metric format. However, because the ship was built using contemporary French standards, these are used in discussions specific to the ship's hull and when comparing it to 16<sup>th</sup> and 17<sup>th</sup> century treatises, drawings, and related documentary evidence, which used the contemporary standard. The Royal French foot of the period, the *pied de roi* was divided into 12 *pouces de roi*. Each *pouce* was further divided into 12 *lignes de roi* and each *ligne* was divided into 12 *points*. The *point*, however, did not appear in any of the documents. The metric equivalents are as follows: 1 *pied de roi* is equivalent to .32484 m; 1 *pouce de roi* is equivalent to .02707 m; 1 *ligne de roi* is equivalent to .00225583 m. The ton, or *tonneau*, was equivalent to 2000 *livres*, which is 1956 kilograms. (Source: David H. Roberts ed., *18<sup>th</sup> Century Shipbuilding*, 1992:4)

## Chapter I. Introduction and Historical Context

### Introduction

When Robert Cavelier Sieur de la Salle departed from La Rochelle in 1684 with *L'Aimable*, *St. François*, *Le Joly*, and *La Belle*, only *Le Joly* was fated to return. With its survivors came tales of privation, disease, death, shipwreck, escape and, ultimately, disappointment. The second ship, *St. François*, was taken by a well-armed and aggressive band of pirates. Another, *L'Aimable*, was destroyed through incompetence, negligence, or in a blatant effort to destroy the man and the mission on which it sailed. *La Belle*, the last and smallest, was wrecked during a fierce winter storm and with it was lost the only means of escape and survival for more than 100 sailors, soldiers, and colonists. The ship and its story quickly slipped from the memory of all but a few and was lost in the mists of time for over three centuries.

The 1995 rediscovery of *La Belle* revived interest in La Salle and his failed expedition to the Texas coast. While the boxes and casks containing trade goods and supplies told a compelling story of exploration, the analysis of *La Belle*'s hull provided a rare opportunity to investigate the craftsmanship of the 17<sup>th</sup>-century shipwright. Not only is the hull unusual for its degree of preservation, including the complete keel and master frame, but the ship, presumed to be a *barque longue*, is a previously unstudied type. This combination of good preservation and an archaeologically-undocumented ship type

furnished an excellent opportunity for a comprehensive hull study.

### **Research Goals**

The analysis of *La Belle*'s hull was undertaken with five aims in mind, several of which have broader implications for shipwreck studies. In general, the study and interpretation of ship hulls are undertaken to advance research concerning hull design and to advance knowledge of their evolutionary processes. Therefore, the first objective of this study is to reconstruct the conception and design of *La Belle*'s hull. Seventeenth-century treatises and drawings of Fournier (1667), the Album de Colbert (1670), Deane (1670), Witsen (1679), van Ijk (1690), and Dassié (1695), among others, described and depicted two contemporary schools of ship design and their application to ship construction. With roots in the 15<sup>th</sup> and the 16<sup>th</sup> century, these two approaches had their genesis in either the Atlantic or Mediterranean regions. As a result, shipwrights from these regions developed different approaches to the design of ships.

Because *La Belle* was built on France's Atlantic coast, it was expected that the ship would fit into the Atlantic construction scheme, reflecting shipbuilding customs associated with this region and would provide more information on its application. In addition, *La Belle* was built at a time of a dramatic change in ship construction. The burgeoning shipbuilding and design industry in the newly-created Royal shipyard at Rochefort was undergoing a transformation from the work of highly skilled craftsmen, working within vernacular traditions, to the nascent science of the naval architect. Therefore, the study of *La Belle* provides an opportunity to investigate aspects of the transition from a largely empirical approach to the development of the formal design



based on the concept of the ship plan.

The second aim is the documentation of a previously unstudied ship type through an analysis and description of the hull's assembly and comparisons with contemporary shipbuilding practices as revealed by written sources. *La Belle* was described in French marine rosters as a *barque longue*, a largely ignored ship type of which an archaeological example has never before been discovered. As such, this ship represents a unique archaeological resource that can contribute to research into the development of European warships at a critical point in their evolution.

Archival research unearthed a remarkably rich source of registries, letters, and documents related to *La Belle*. Examination of these documents raised fundamental questions regarding the ship's genesis and typological identification. Was *La Belle* the same 'good barque' that was referred to in a memorandum from the King? That ship was to be sent to the Gulf of Mexico, dismantled, on *Le Joly*. The documents reveal, however, that the disassembled ship would not fit as cargo and instead would have to be sailed to the New World. If *La Belle* was the one in the king's memorandum, the construction, disassembly, then reassembly should have left some physical evidence on the hull timbers. If it was not, what was this ship and where did it come from? Further, *La Belle* was variously referred to as a frigate, barque, and a barque longue in contemporary accounts and registries. This conflicting nomenclature is an important issue in the hull analysis. The third aim is an evaluation and analysis of the documentary sources in an attempt to resolve these issues.

The fourth aim is to obtain species identification of the timbers used in *La Belle*. Species analysis of a comprehensive sample of the timbers, combined with information

from dendrochronological investigation, was undertaken to provide a more detailed picture of forest exploitation locally and regionally. These studies can also help to identify the source of timbers used and, especially in the repairs noted in the hull remains, whether they came from the Old or New World.

The fifth aim of the research is to obtain information on the origins of the wood used in the ship's construction. Dendrochronology, widely used for dating purposes, focused instead on the origin of the timbers in in this study because the date of the site is not in question. This is an important research objective because the location of the forests from which wood was derived for shipbuilding at Rochefort is unknown. Less than 20 years prior to the construction of *La Belle* there was no Royal shipbuilding in this region. By 1680, just four years before *La Belle* was built, wood shortages in the district forced the planting of oak forests on Royal lands to the east and north of Rochefort and La Rochelle. Therefore, the source of the timbers has implications for the hull analysis. Because there are no other investigated late 17<sup>th</sup>-century shipwreck sites from the Rochefort region that can provide similar evidence of species and dendrochronology, *La Belle* has provided a benchmark for further historical research.

In addition, the dendrochronological analysis raised unexpected questions regarding the dating of the timbers and the possibility of the re-use of whole frame sets. Given the importance of dendrochronological dating of shipwreck remains, the resolution of these questions again places *La Belle* in a singular position to contribute to the study of 17<sup>th</sup> century shipbuilding.

When considered together, these five research foci provide unique opportunities for the study of late 17<sup>th</sup>-century shipbuilding in the Atlantic arsenals of France. The

analyses of this small ship thus contribute to the study of hull design and conception, ship typology, ship construction and assembly, wood species use and origin, dendrochronological dating of shipwreck remains, and timber reuse in shipbuilding.

### **Methodology and Data Sets**

A mix of methodologies and data sets were used to address the research goals. Attempts to reconstruct the conception and design of *La Belle* and to document a previously unstudied ship type, were approached using 17<sup>th</sup> and early 18<sup>th</sup> century treatises, drawings and sketches of contemporary ships from the Musée de La Marine, and the archaeological remains from which detailed three-dimensional drawings of each timber were produced. From these latter, lines plans and a variety of related drawings for analysis were developed.

The third research aim, which was to evaluate and analyze the archival documents in an effort to resolve issues of the ship's genesis and typological identification, was met using ship registries, notary documents, and related marine archival material from the Service Historique de La Marine (SHMR) in Rochefort and the Archives Départementales de la Charente-Maritime (ADCM) in La Rochelle. To these were added official correspondence and private papers from the Bibliothèque Nationale de France (BN) and the Archives Nationales de France (AN). Other sources include: a contemporary drawing of a ship described as a barque longue from the Dutch Archives; two well known contemporary journals, written by members of the La Salle expedition; and modern texts and reference materials.

Research into species identification and wood origin involved thorough sampling

and analysis of the ship's timbers. Contemporary timber contracts were also used as a source of comparative information.

### **Research Responsibilities**

The excavation of *La Belle* was under the direction of Dr. James E. Bruseth, Director of the Texas Historical Commission Department of Antiquities Protection. To insure continuity during Bruseth's frequent absences in his dual role as principal investigator and a department director, and because it was envisaged that the excavations would run seven days a week, I was hired as assistant project director. My specific responsibility was to oversee the excavation and disassembly of the hull.

During the excavation, it was quickly realized that a great deal of the hull was well preserved. Because of my extensive involvement with the project and familiarity with the hull remains, following the excavation I was contracted by the THC, under a separate agreement, and tasked with undertaking a full and detailed analysis of the hull.

As principal investigator for hull analysis, it required that I supervise and hire temporary staff to assist with timber drawings and data collection, a photographer for photo documentation of selected timbers, individuals or laboratories to undertake analysis based upon my sample collection and analysis strategy, archival researchers to undertake appropriate document research in France based upon criteria that I established, and artists and other individuals to create appropriate drawings and maps based upon information or sketches that I provided. The integration, analysis, and write up of the results of this multi-year international data-gathering effort has been my responsibility alone.

## **Historical Context**

### **French Presence and Policy in the New World**

By the time Louis XIV (1638-1715) assumed full control of the monarchy and the governance of France in 1661, the French were well established in the New World. In New France, the Company of One Hundred Associates had full powers to exploit resources and encourage settlement. In the Carribean, the French regularly took Spanish prizes and had settled the northern coast of Santo Domingo, and the islands of Guadeloupe, Martinique, and Tortuga. Shortly after the new king formally announced he would serve as his own first minister in 1661 and, therefore, chart the direction of the nation and its colonies, the status quo in New France and the French influence Caribbean and Gulf of Mexico began to change (Folmer 1953:131-132; Treasure 1966:200).

In 1663, New France had a population of only 2500 (Zoltvany 1971:2) and it was clear that the Company of One Hundred Associates was unable to fully develop the region. Constant attacks by the Iroquois kept the colony in a state of unrest and economic growth to a minimum. In that year, Louis XIV revoked the charter of the One Hundred Associates and brought the colony under direct state control, thereby paving the way for a dramatic increase military defense, political reform, and economic expansion. Control over the colony was highly centralized, vested in the monarchy, and delegated by the King to a hierarchy of ministers. The most influential was the Minister of the Marine Jean-Baptiste Colbert, whose wide-ranging powers included, among other things, creation of policies and directives that oversaw all aspects of the colony's growth (Zoltvany 1971:2-3).

In 1665, Jean Talon was named Intendant of New France and was charged with carrying out the King's directives. This position held enormous power because his authority included everything but war, diplomacy, and religion. In that capacity, Talon ostensibly also had control over trade and shipping. Just two months before Talon assumed his position, however, Colbert and the King created the French West Indies Company to which they granted a monopoly on trade and shipping for a period of forty years (Vachon 1982:7-9). Talon was adamantly opposed to this new company and worked to undermine its influence while pursuing his program of economic growth. He established policies to increase population and to develop agriculture and trade. He set up facilities for producing everything from wool to forest products and created a yard on the Saint-Charles River for shipbuilding. Talon envisaged a three-way trading empire between New France, the West Indies, and France. Products from the colony were to be shipped to the West Indies, products from the West Indies shipped to France, and products from France sent to the colony (Vachon 1982:7-9). Talon also encouraged and supported exploration of the west in order to form trading alliances with the native tribes. Under his administration, explorers were tasked with surveying the country, discovering new waterways, and taking possession of the territories that they discovered (Vachon 1982:10).

Jean Talon left New France in 1672 and that same year Buade de Frontenac was appointed governor. The new governor vigorously suppressed all opposition to his assertion of royal power and a short two years later the monopoly of the Company of the West Indies was abolished (Treasure 1966:318). By the end of de Frontenac's administration in 1682, approximately ten thousand Frenchmen were settled along the

Saint Lawrence valley and in missions and forts along the route of the Great Lakes.

Quebec was becoming an important trading and shipbuilding port and an active jump-off point from which exploration and trade with North America could be launched and riches gained (Treasure 1966:318).

During this same period, the West Indies were proving to be the most prosperous European settlements in the New World. Their easily marketable products of tobacco, sugar, rum, and molasses were coveted and widely traded. Monopolistic regulations were nearly impossible to enforce and ships of all nations carried on trade throughout the region. The Spanish held the best ports and the English held Jamaica, but that did not stop France from exerting both influence and interest in the region (Folmer 1953:132).

In contrast to the busy islands of the Caribbean, the North American Gulf was virtually empty. The Spanish claimed the lands from Florida to the Rio Grande, but it was impossible for them to control such a vast territory. They were more involved in the prevention of piracy, the defense of coastal towns in New Spain, and protection of the lucrative mines and the convoys of ships carrying riches back to Spain (Folmer 1953:133-134). This situation presented an opportunity for France. In 1672, Colbert claimed the right of French ships to enter of the Gulf of Mexico and demanded free navigation. The Spanish were warned that Louis XIV would send orders to seize all ships sailing near the French West Indies unless the Gulf was opened. Because the Spanish were forced to pass by these islands on their return to Spain and French corsairs to continued to harass Spanish shipping, this threat was taken seriously as it could hinder Spain's ambitions in the region. The result was an uneasy diplomatic standoff with both countries attempting to avoid open war (Folmer 1953:132-134).

The desire of the French to obtain a greater foothold in the Caribbean and to find a harbor for the King's ships in the Gulf of Mexico was one of the reasons Colbert supported exploration of the Mississippi River. Colbert wanted a base where the French could "... establish themselves to harass the Spaniards and Louis XIV was interested in seizing the gold and silver mines of New Spain" (Margry 1879:17 in Folmer 1953:134). It is not surprising, therefore, that the commission given to Robert Cavalier Sieur de la Salle before his first trek down the Mississippi did not focus on French colonization, but on the promise of finding a route to penetrate into Mexico. When the expedition failed to find this strategic invasion route, there was little support for a second attempt (Folmer 1953:135).

After Spanish ships captured a French frigate in the Gulf of Mexico in 1679, however, Louis XIV ordered his fleet in the West Indies commanded by Admiral d'Estrées to use any pretext to attack the Spanish and to sink or to bring their warships as prizes to France. Not only was Louis XIV interested in teaching the Spanish a lesson, but he wanted to obtain information that would help him to capture Spanish towns on the Gulf coast (Folmer 1953:135).

Three years later, in 1682, a second small fleet was ordered to the Gulf to "... reconnoiter carefully the harbors where said Marshall d'Estrees has not been" (Margry 1879:13 in Folmer 1953:136). This expedition was in part fueled by a proposal by the Count de Peñalosa to seize the mines of New Biscaye for France. Peñalosa proposed a settlement on the Rio Bravo [Rio Grande] from which it was possible to strike the mines and easily conquer them (Margry 1879:44-45 in Folmer 1953:143). Although this plan was never undertaken, the seeds were sown for the establishment of a settlement on the

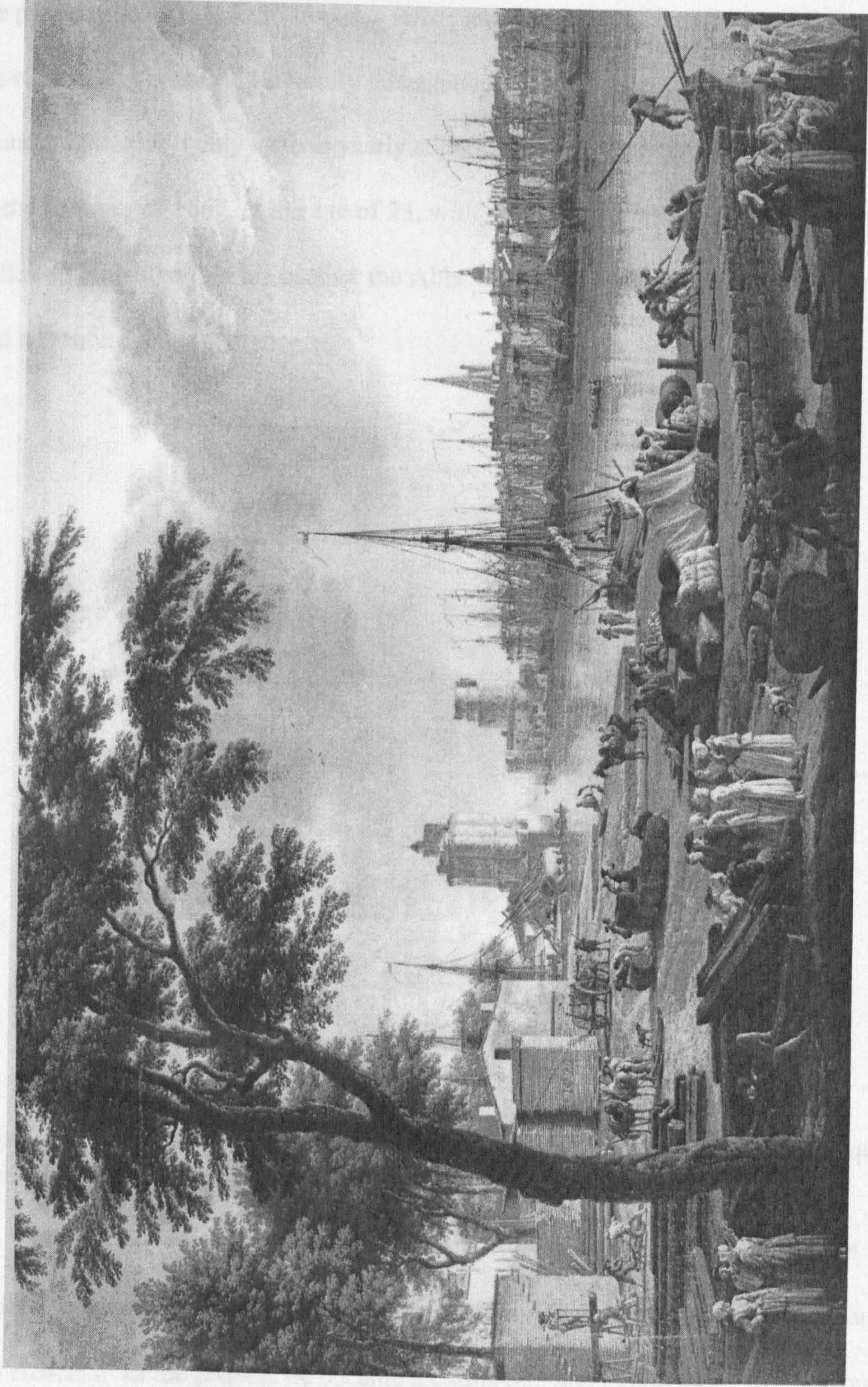


Gulf from which to attack and perhaps conquer the mines of New Spain. It was in this political milieu that La Salle approached the crown in October 1682 with a proposal to establish a colony at the mouth of the Mississippi River.

Two years later, on August 1, 1684, a four-ship flotilla headed by La Salle sailed from the busy port of La Rochelle (Figure 1-1). With him were nearly 300 soldiers, sailors, and colonists on a mission to establish an outpost on the Mississippi and open a profitable trade market in the heartland of the New World. What the colonists did not know was that the expedition had another unpublicized purpose and La Salle's efforts to accomplish this secret task proved to be his and the expedition's undoing.

### **La Salle and the Expedition**

Born in Rouen, France, in 1643 and baptized Robert Cavelier on November 22 (Bibliothèque Municipale Rouen, 92N Cavelier), the youngest son of the wealthy merchant Jean Cavelier and Catherine Geist was educated by Jesuit priests (Figure 1-2). With a gift for mathematics, and training in languages and the sciences, Cavelier excelled under their tutelage and at the age of 17 was accepted into the Society of Jesus. Sent to Paris and later to the college of Le Flèche to complete his studies, the restless and headstrong Cavelier dreamed of a foreign appointment. Instead, he was posted to a series of small provincial towns to teach. Frustrated, in 1666 he first requested an appointment to China and, when that was denied, then a posting to a position as a professor of mathematics in Portugal. Following a second denial for a more challenging position, he resigned from the order and returned to his family home in Rouen (Garraghan 1937:93-103).



**Figure 1-1:** La Rochelle harbor in 1762 with all of the activity typical in La Salle's day. This small port became the center of French preparations for voyages to the new world. Painting by Joseph Vernet courtesy Musée de la Marine, Service Etudes, Paris.

Although born to a wealthy family Cavelier de La Salle, who by now had received the property called La Salle from his father and was known by that name, had renounced his right to any share of the family inheritance when he became ordained. La Salle thus found himself with only a small yearly stipend from his family and a desire for adventure. In the summer of 1667, at the age of 23, with only the capital set aside for his annuity La Salle left Rouen to join his brother the Abbé Jean Cavelier to begin a life of exploration and adventure in New France.



**Figure 1-2:** This portrait of Robert Cavelier Sieur de La Salle appears on a plaque at the Bibliotheque Municipale in Rouen. Photograph by Toni L. Carrell.

After quickly obtaining a grant of land west of Montreal, La Salle began exploring to the west, trading with the native peoples and, as importantly, learning their languages and customs. In the process he became a competent and experienced frontiersman. Over

the next 14 years, he navigated the Ohio River, eagerly read the exploits of Jolliet and Marquette's explorations, and decided he would follow the Mississippi to the Orient. After receiving government permission in September 1681, La Salle left with a band of Indians and Frenchmen to begin the trek that would eventually follow the entire course of the Mississippi River to the Gulf of Mexico. La Salle traveled from Indian settlement to settlement and at each he made efforts to establish friendly relations and, when possible, a small fort. Finally, in the spring of the following year the expedition reached the Gulf and the open sea. On April 9, 1682 La Salle claimed all the Mississippi Basin from the Gulf to the Great Lakes for Louis XIV (Foster 1998:20-22; Muhlstein 1994:141-158).

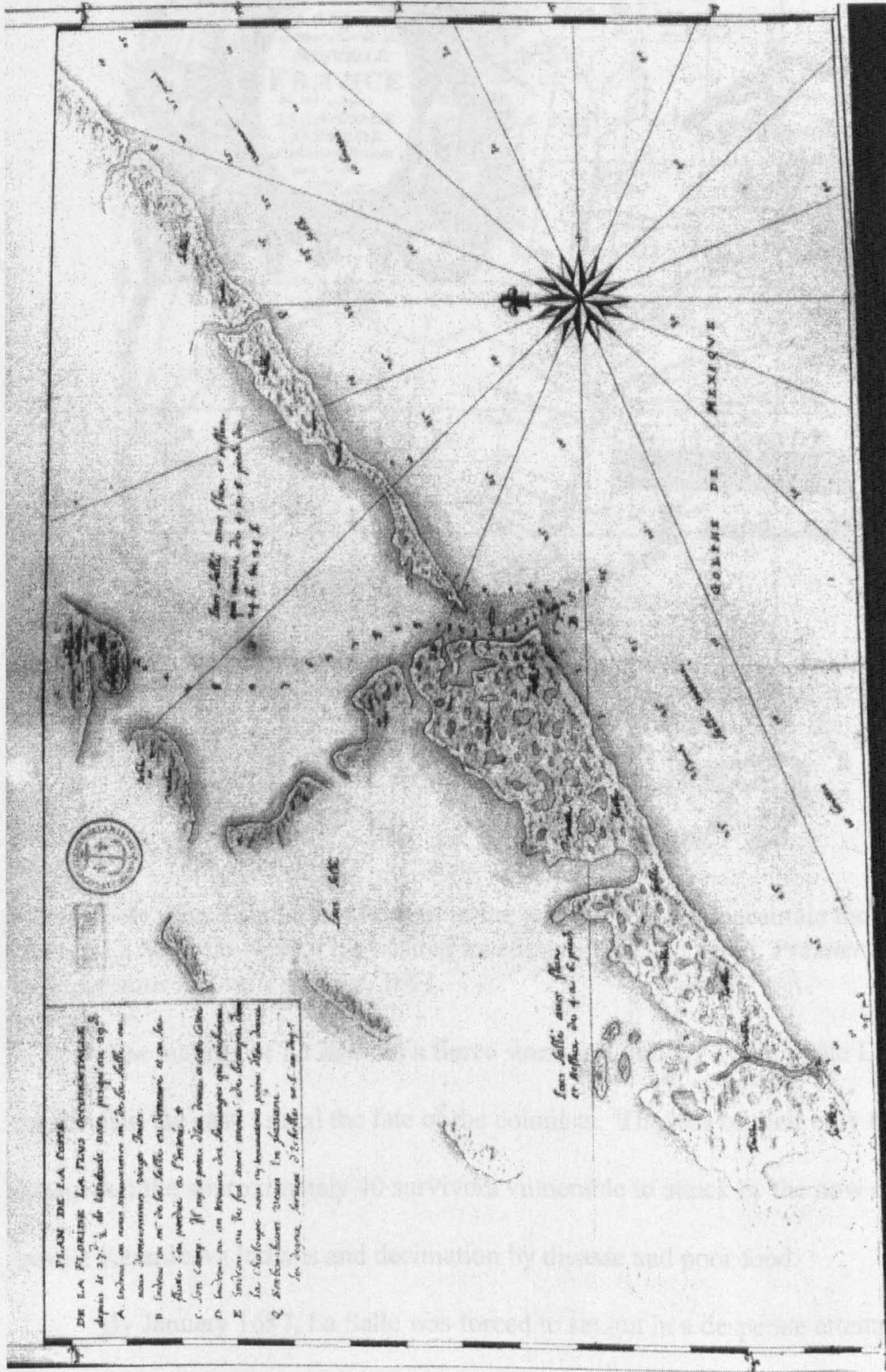
Despite this accomplishment, upon his return to New France La Salle was not immediately given support for his plan to establish a series of trading posts the length of the river culminating at the mouth of the Mississippi. Instead, the new governor of Quebec declared that La Salle's adventurism threatened to drive the Iroquois to hostilities and refused him. Recognizing the futility of any efforts in Quebec to pursue his plans, La Salle sailed to France where, after much effort and political maneuvering, he obtained an audience with Louis XIV. La Salle's original plan was only to establish trading posts, but in order to gain the support of influential members of the court, including the Marquis de Seignelay son of Jean-Baptiste Colbert, he agreed to the military aspects of the enterprise proposed by Seignelay. On April 14, 1684, almost two years to the day after his declaration creating Louisiana, La Salle was ordered by Louis XIV to:

... command all the Frenchmen and Indians he may need to execute the orders we have given him and we commission said nobleman to command, under our authority, in all the lands of North America that may hereafter be submitted to our rule, from Fort St. Louis on the Illinois river to New Biscay (Margry 1876-1886, II:377).

Those orders included a secret mission to explore the coast and discover an overland route that would enable a strike against the Spanish forts and lucrative silver mines of northern Mexico.

Instead of a bold and glorious venture, however, by January 1686 more than half the colonists were dead, the survival of the settlement was tenuous, the crew of the only surviving ship, *La Belle*, was demoralized and dying, and La Salle had not found the overland route to New Biscay. Elsewhere, Spain had launched an intensive manhunt for the intruder. Finally, La Salle had to admit he was lost and the small bay so carefully mapped by Minet was not the mouth of the Mississippi River (Figure 1-3).

Although La Salle possessed the latest maps, the cartographers he relied upon had perpetuated a huge geographical blunder. The 1656 map by Nicolas Sanson d'Abbeville, *Le Nouveau Mexique et La Floride* (Martin and Martin 1984:83), placed the mouth of the Mississippi River some 400 miles west of where it is actually located. This mistake persisted even after the expedition d'Iberville (1698-1699), and appeared on maps by Rouillard in 1692, *Carte Generale de la Nouvelle France* (Figure 1-4) and Nicolas de Fer in 1704, *Le Costes aux Environs de la Riviere de Misisipi* (Martin and Martin 1984:49). Trusting a similar map, La Salle believed that one of the many channels that flow into Magatorda Bay was the mouth of the Mississippi. A year earlier, when the expedition arrived on the coast, La Salle was confident that he had found a safe anchorage and suitable land on which to deliver his supplies and to establish Fort St. Louis 30 mile inland. From that outpost he planned to launch trading missions up the Mississippi to the tribes he had previously encountered. When La Salle realized that the maps were wrong and he was not at the mouth of the Mississippi, it was too late.



PLAN DE LA CÔTE  
 DE LA FLORIDE LA FLORIDE OCCIDENTALE  
 depuis de 27<sup>o</sup> 1/2 de latitude nord jusqu'à 29<sup>o</sup>  
 A. Entrée de la Rivière de la Louisiane  
 B. Entrée de la Rivière de la Floride  
 C. Entrée de la Rivière de la Floride  
 D. Entrée de la Rivière de la Floride  
 E. Entrée de la Rivière de la Floride  
 F. Entrée de la Rivière de la Floride  
 G. Entrée de la Rivière de la Floride  
 H. Entrée de la Rivière de la Floride  
 I. Entrée de la Rivière de la Floride  
 K. Entrée de la Rivière de la Floride  
 L. Entrée de la Rivière de la Floride  
 M. Entrée de la Rivière de la Floride  
 N. Entrée de la Rivière de la Floride  
 O. Entrée de la Rivière de la Floride  
 P. Entrée de la Rivière de la Floride  
 Q. Entrée de la Rivière de la Floride  
 R. Entrée de la Rivière de la Floride  
 S. Entrée de la Rivière de la Floride  
 T. Entrée de la Rivière de la Floride  
 U. Entrée de la Rivière de la Floride  
 V. Entrée de la Rivière de la Floride  
 W. Entrée de la Rivière de la Floride  
 X. Entrée de la Rivière de la Floride  
 Y. Entrée de la Rivière de la Floride  
 Z. Entrée de la Rivière de la Floride

**Figure 1-3:** Minet's 1684 map of the present-day Texas coastline, which La Salle hoped was the mouth of the Mississippi River. The entrance to the bay is shallow and dangerous and it was just outside the entrance that *L'Aimable* wrecked, indicated by the letter B on the map. Courtesy Archives Nationales, Service Hydrographique, Paris.



**Figure 1-4:** The Rouillard 1692 map of the gulf shows how inaccurate those maps were, forcing La Salle far west of his desired location. From Le Clercq, *Premier établissement de la foi dans Nouvelle France*, 1691.

The sinking of *La Belle* in a fierce storm in February 1686, while La Salle explored to the east, sealed the fate of the colonists. The loss of their only means of escape left the approximately 40 survivors vulnerable to attack by the now distrustful and hostile Karankawa Indians and decimation by disease and poor food.

By January 1687, La Salle was forced to set out in a desperate attempt to reach a French fort on the Illinois River, some thousand miles away, to organize a rescue party

for the survivors. Although able to lead men in remarkable achievements, La Salle was regarded as headstrong and difficult. On what would have been one of his most demanding treks two of his party, with quick tempers and dark grudges, lured him into an ambush and killed him somewhere between the Brazos and Trinity Rivers in eastern Texas (Foster 1998:191-199).

### **The Wreck Event**

The story of the disintegration of the expedition is revealed through the journal of one of its survivors, Henri Joutel (Foster 1998). A trusted member of the expedition, Joutel's account of the problems and conflicts is considered the most comprehensive and reliable record. It is filled with details of the plants, animals, and native peoples encountered. Joutel recounted the murder of La Salle and the survivors overland trek to the Mississippi River. Unfortunately, Joutel was not present when *La Belle* wrecked but he recorded Sieur Chefdeville's account of the ship's loss, which is set out in full below:

After [their party] had remained in that same place for some time and the water supply had begun to run low, they decided to send the shallop ashore with four or five casks to fill them with water. For this purpose, the best men were chosen to set off in the shallop. Planterose was among this number. It was he who was the godfather of the small native slave girl taken in the action that I earlier mentioned. The young girl had been baptized by Chefdeville. She alone had had the advantage of knowing Christianity by means of the sacrament of baptism, and she died a short time later.

The shallop left with these orders and headed for shore. That evening, the wind, having freshened a bit, caused the bay to rise. Shortly after sunset, one could see that the shallop seemed to be heading out to sea. They had a head wind and could not make much forward progress. Chefdeville, realizing that night was advancing, told the master of the frigate [Tessier] that it would be wise to put a torch atop one of the masts so that those aboard the shallop could see the ship from a distance more easily. But the master disregarded the advice that had been given him and was content to



only light a candle in the ship's common lantern. This did not stay illuminated long because the wind freshened and made the swells heavy, and no trace was had of the shallop the next day. So that day was spent in impatience. It was thought that they must have perished although it could not be known whether the shallop had sunk or gone aground on the shore.

The lack of water added to the loss of the five best men on board (the rest were not their equals) forebode a deadly end for the survivors.

Meanwhile, they stayed a few more days in the same place waiting to learn something. During this time, several people among them died from lack of water. They had eight pigs from the settlement that had been put aboard and they ate them, not having water to give them. They began to fade one after another as they saw that their hopes for news were in vain. Also they realized that the longer they waited, the weaker their condition became to save themselves.

They had cooked some flour with seawater; but that did not agree with them at all. They could not even eat it. They still had some wine and some brandy and even a case of Spanish wine that the Abbe Cavelier had put aboard. He had abstained from this in order to say the mass on his return because none was left at the settlement. The ship's master took possession of the wine and filled his gullet well indeed. According to Chefdeville's report, he hardly spent a day that he was not drunk.

Seeing that they were at risk of perishing where they were, they decided to weigh anchor and move near the settlement where I was. But they had only a few men, and the wind rushing from the north drove them off course to the other side of the bay. Seeing themselves approaching land, they cast the only anchor they had. But as the wind was too strong, they were driven upon the anchor. The master could have avoided this if he had the foresight to anchor a cannon with the anchor. Carried away thus, they soon ran aground, dragging all the while on the anchor. During the night, the wind moderated, and they remained calm enough. If they had only had their shoreboats to carry an anchor forward the next day, they would have been able to put the frigate afloat. Their circumstances thus [lacking a shallop and failing water], they considered how to send a few people ashore to see if they could find water. The master contrived a sort of raft with two casks and a few planks upon which two men set off to go ashore. But the planks were not well fastened, the waves disengaged them, and the casks got loose. The two men went in, one to one side and the second to the other side. One did not know how to swim and drowned. Indeed, the one who made land did not have any greater fortune. After having searched to the right and left to find water, he realized that no one was making ready to rescue him. In spite of the wind from the north that was blowing cold as it was February, he plunged into the water again to

return to ship. But his strength failed him and he drowned.

Thus, it seemed that all sorts of misfortune occurred to thwart the enterprise. However, all of this happened only because of great rashness and lack of direction, for all this disorder would not have occurred without the drunkenness of the master. But, in brief, the next day it became a matter of making another raft. This one, fortunately, was better constructed with sail yard and planks that were well fastened together, and this provided the means to go ashore. After they had found fresh water there, the task was to unload things from the ship by the raft. As it was not large, not many things could be unloaded at once. Besides, they had to indulge the caprice of the master who was usually drunk. He had put the case of brandy that he had seized on the poop deck, and he alone handled it. This meant that as long as it lasted, he was in no hurry to leave the ship. He used the pretext that he was staying until all the cargo was unloaded. In the end, a number of things were saved among them La Salle's clothes, specifically one scarlet dresscoat and another blue coat with large gold braid, as well as some of his papers, dampened though they were. Chefdeville took care to dry them. They were careful to bring some barrels of meal ashore and a few casks of wine which were the most necessary. After this they tried to save some linen clothing belonging to La Salle, his brother [the Abbe], and Chefdeville. They also saved a few beads and other similar things.

They went on board almost every day for this purpose, bringing what they could each time until a wind blew in from the sea that stirred up the waves and made the hull of the ship settle deep into the sand. The water covered her except for the poop deck. As they had provisions on shore, they did not seek a means to get away. One could say that they were very happy to have escaped and that no natives had come near this place which was, it happened, along their customary route. At least I saw natives come by there several times while I was on the shore [of that peninsula]. Our men would have had difficulty escaping their clutches had they attacked because they were few in number with little defense

Had our men set out for the settlement immediately after the shipwreck, the frigate could have been saved, or we could have gone with several canoes to unload it with dispatch. But I believe that if their provisions had not failed, they would not have considered coming back to the settlement. They still had some wine left; that is the reason the master was in no hurry. They often shot ducks and caught fish; they found oysters which were in abundance. It was when they realized their meal supplies had diminished that they behaved like the wolf that hunger forces from the forest. Then they had a piece of good luck in [finding] the canoe that had gone adrift when La Salle was camped on the bay shore before his departure. The

wind had driven his canoe to the other side of the bay where it had gone aground. They found it, and fortunately it was not smashed. Thus they put what was most valuable inside the canoe and set off to cross the bay to come and join us. If they had not found the canoe, they would have been forced to walk around the bay and they might have encountered obstacles blocking them.

They had remained in that same place nearly three months. Chefdeville told me that they had been near the tip of that long strip of land [peninsula] opposite the place where the natives had camped when we saw them for the first time. I learned that near this same place there was a large pond of fresh water, quite deep, around which there were tall reeds which would be most advantageous if one wanted to build a fort there. This post would guard the entrance of the bay and shelter the ships which would be anchored behind the strip of land where there was room to moor about 50 ships in five or six fathoms of water in good bottom (translated by Johanna S. Warren, in Foster 1998:135-138).

This second-hand report of the wreck event and a brief mention in the interrogation of Captain Gregorio de Salinas Varona and Pierre Meunier in Mexico City in 1690 (Archivo General de Indias [AGI], Seville, Mexico, 61, 6, 21 in Foster 1998:283-289), are the only two accounts that appear to exist.

The next known mention of the wreck of *La Belle* appeared in the diary of Juan Enríquez Barroto who, together with Antonio Romero, was sent by the Spanish Admiral Gaspar de Palacios to search for the La Salle and his party. News of the Frenchman's intention to establish a colony at the mouth of the Mississippi reached Spain when deserters from La Salle's party were captured and interrogated. Thus, in November 1685, Barroto and Romero with two ships began their first voyage to seek out the French colony and in the process to map the coast from San Marcos de Apalache (St. Mark's, Florida) to the bay of the Mississippi (AGI Mexico 616 in Weddle 1987:129). The unsuccessful first expedition was followed in December 1686, by a second, again with Barroto and Romero in charge. By late March 1687, the two ships were near the entrance to Pass Cavallo.

There they were presented with circumstantial evidence of the loss of *L'Aimable* in the form of pieces of equipment and a French hatchet in the possession of a native woman with whom they hoped to trade (Barroto Diary, March 30, 1687 in Weddle 1987:168-169).

A few days later, having entered Matagorda Bay, they discovered the remains of *La Belle*. Barroto described the discovery and the condition of the ship:

Friday the 4<sup>th</sup> [of April 1687]. Before sunrise the canoes went out with the native guides and the two assistant pilots. They returned after 5 in the afternoon, saying that 3 leagues from here, east-northeast, inside the bay on the windward shore, they had found a lost ship that has 3 *fleurs-de-lis* on her poop; six pieces of artillery, mounted, woolded, and hove down; two iron swivel guns without chambers, which they brought in our canoe. The masts have fallen into the water (because the shipworms had eaten them in two at the holes) with all the rigging. Even though they were ruined, the yards resting among the rocks, holding up the topsail sheets, we recognized by these things that she was a warship. On the beach they found some barrels of powder, full but ruined by the weather; other broken ones; and other things that the captains wished to go see tomorrow. They found the channel, from here to the shipwreck close to shore, of four fathoms, sometimes more and others less, and, half a league north of Punta de Culebras, a sandbank with two and three spans of water in places. It is large and the channel goes between it and the shore.

Saturday the 5<sup>th</sup>. At 7 in the morning we got underway and went along the inner shore, northeast by east and east-northeast, to the ship, which we recognized as being French and of war by the things mentioned. She has all the starboard side, the deck, and the prow under water. All her tackle (from what I saw in what was being appraised) was very fine, new, and mostly of four strands. She had eight portholes and as many other flues. As for swivel guns [sic], five pieces that fire a ball of up to four *libras* [pounds] were still upon their carriages, lashed to the ship's sides. The others perhaps had fallen into the water. The double tackle was rotten because, from appearances, she has been here more than a year. We gathered up some cordage that still might be serviceable for us and embarked the 5 pieces for ballast, two of them in our galley. We also took an anchor of up to 6 *quintales* and some 30 fathoms of 8-inch cable, half of which was divided into strands for yarn. The other *piragua* [the ship type used by the Spanish searchers] took half. On the beach were found the other gun carriage and the main yard, which was measured to be 16

cubits. Therefore I am saying that the ship's keel is 24 cubits. We brought this yard and that of the fore topsail for making oars, and from that of the foresail a boom was made for ours. Captain Pedro de Yriarte took that of the mizzen also. There were found some large smith's bellows and some other very small ones of hand type, a large cooper's plane, some leaves torn from an arithmetic and artillery book in the French language with a piece of map, from which I conclude that she was a French ship. ...The launch of this one was not found; perhaps the people saved themselves in it, having left this ship with all their equipment except the manual arms. There have been diverse opinions; and, because they are so various, I write none of them so as to refrain from extraneous matters. I named this place Navío Quebrado [literally broken ship] (Barroto Diary, April 7 and 8, 1687, translated in Weddle 1987:171-172).

Barroto's description of *La Belle* accurately reflects the position of the hull as found on the sea floor in 1995, down at the bow and lying over on its starboard side. The length of the keel at 24 cubits, estimated by Barroto and translated by Weddle as 36 feet, falls far short of the actual 45 *pieds du roi*<sup>1</sup> (approximately 47 feet 10 3/4 inches) of the keel. Barroto also mentioned a foremast topsail yard, a foresail yard, and a mizzen yard. No archeological evidence of a mizzen mast was found, but that does not mean that the ship was without such a mast; the mizzen is often stepped into a deck and not into the keelson. Because the extent of preservation does not include the deck, the presence or absence of the mizzen cannot be determined by archaeological evidence.

Barroto also mentioned eight portholes [gun ports] and on April 7, the presence of six, then on April 8, five pieces of artillery still in their carriages. This seeming contradiction in their numbers is likely the result of poor writing and not an inability to count. Because Barroto remarked finding "the other gun carriage" on the beach, this suggests that only five of the six cannons on the ship were still in their carriages. One additional discrepancy on the nature of the ship's artillery deserves clarification.

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<sup>1</sup> Royal French feet, hereafter referred to as *pieds*. One *pied* equals .32484 m.

Translated by Weddle as swivel guns (1987:171), the artillery pieces could not have been swivel guns because they do not require a carriage, but small bore iron cannons. These, together with the two true swivel guns retrieved on April 7 by the canoe party, were removed from the ship by the Spaniards. Although none of the ship's iron cannons were found during the excavation, suggesting that while equipped with eight gun ports it carried only six guns, a carriage suitable for a 4-pounder cannon and a swivel gun were discovered.

### **Rediscovery**

The account by Barroto, some 14 months after it grounded and then sank, was the last recorded sighting of the wrecked and partially submerged *La Belle*. The next time *La Belle* was seen was in the summer of 1995, 309 years after wrecking. Even then, the ship was not easily viewed by divers because the visibility in the shallow bay is often limited to one to two feet and the fine silt on the muddy bottom is easily stirred.

The rediscovery of *La Belle* occurred during a Texas Historical Commission remote sensing survey of Matagorda Bay between June 4 and July 31, 1995. The survey was undertaken as part of an overall management program whereby the agency sought to locate, identify, and record the position of the state's many underwater cultural heritage sites, which include ships, wharves, lighthouses, and other maritime-related submerged resources (Arnold 1982, 1989, 1992). In 1995, this effort focused on a previously unsurveyed portion of the bay during the course of which 39 anomalies were recorded (Arnold 1996a:243).

Following evaluation of several well-defined anomalies, a handful were selected

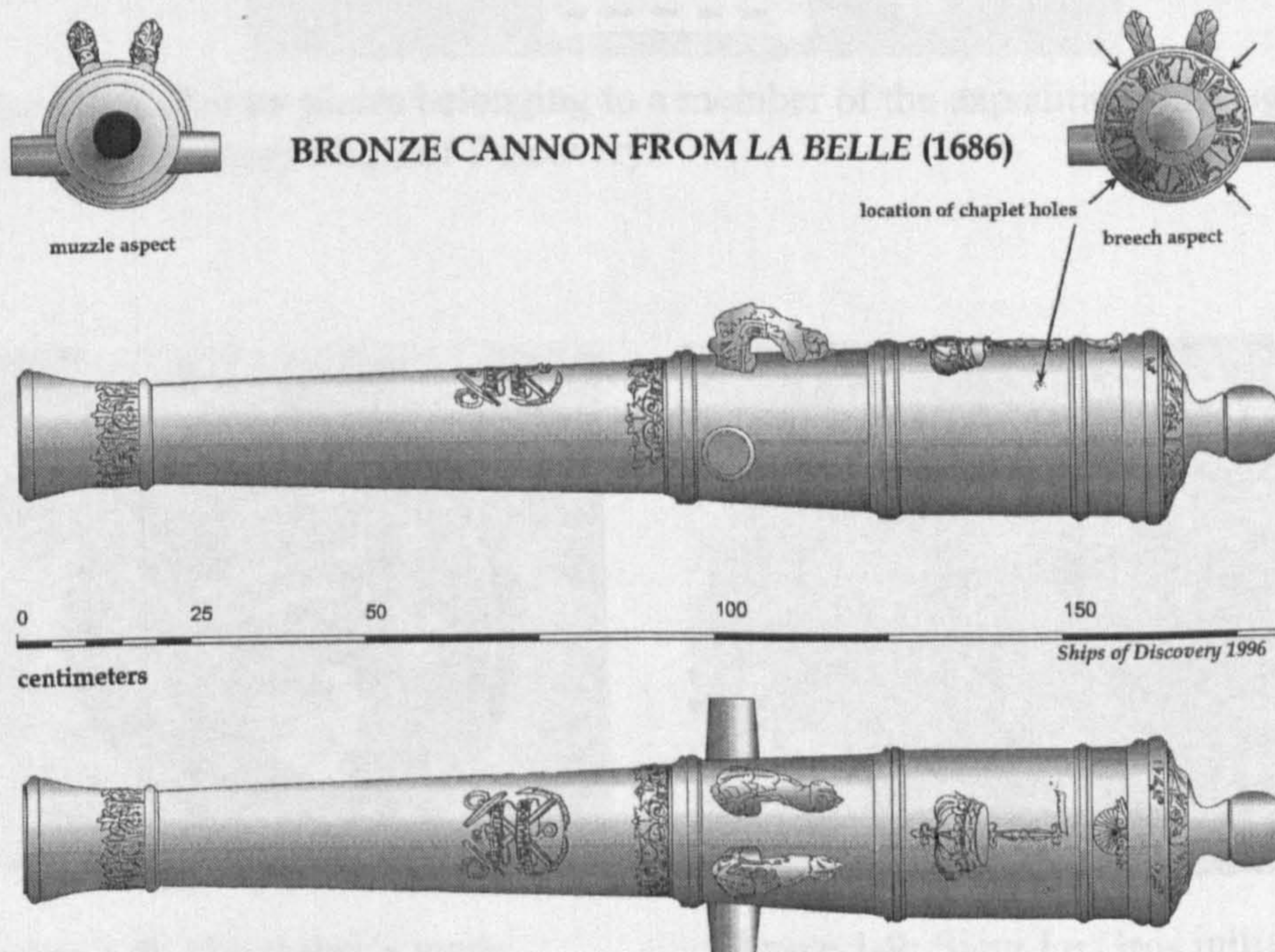
for further testing, one of which appeared to be the especially promising. Localization of that anomaly using a diver-towed magnetometer isolated the point of greatest change in signal strength, which was buoyed and targeted for ground-truthing. Because initial visual inspection of the bottom did not reveal any remains, Arnold employed the use of a prop-wash deflector as a means to initially test the site. Divers quickly found loose boards and cast lead shot, followed shortly by the discovery of a bronze buckle. Continued testing revealed the first of three bronze cannons that were eventually found on the ship (Arnold 1996b:72).

The discovery of the well-decorated bronze cannon was highly suggestive of an early French ship. However, it was not until that cannon was taken to the Ships of Discovery conservation laboratory at the Corpus Christi Museum of Science and History and a portion of the encrustation removed that the armorial device was revealed. This established the ship's probable nationality and date (Arnold 1996b; Keith, Carlin and de Bry 1997). The device is composed of a pair of crossed anchors entwined by a banner bearing the inscription 'Le Comte de Vermandois' (Figure 1-5). Together with the letter L surmounted by a crown (Figure 1-6), this information was sufficient to accurately date the gun to the period between 1669 and 1683. The Count of Vermandois was the Grand Admiral of France during those years and all cannon cast in the royal foundries during that interval bear his name (Boudriot 1992:26; Keith et. al 1997:144-145).

While the cannon strongly suggested an association with La Salle, it is known that two ships were lost during the expedition, *La Belle* and *L'Aimable*, and the bronze cannon could have been loaded on either ship. A group of pewter plates confirmed the



**Figure 1-5:** The armorial device on the bronze cannon together with the crowned 'L' on the breech dates the piece to 1669-1683. Photograph by Juan Rodriguez courtesy Ships of Discovery.



**Figure 1-6:** The highly decorated bronze cannons helped to confirm the identity of the ship as *La Belle*. Drawing by Donald H. Keith courtesy Ships of Discovery.



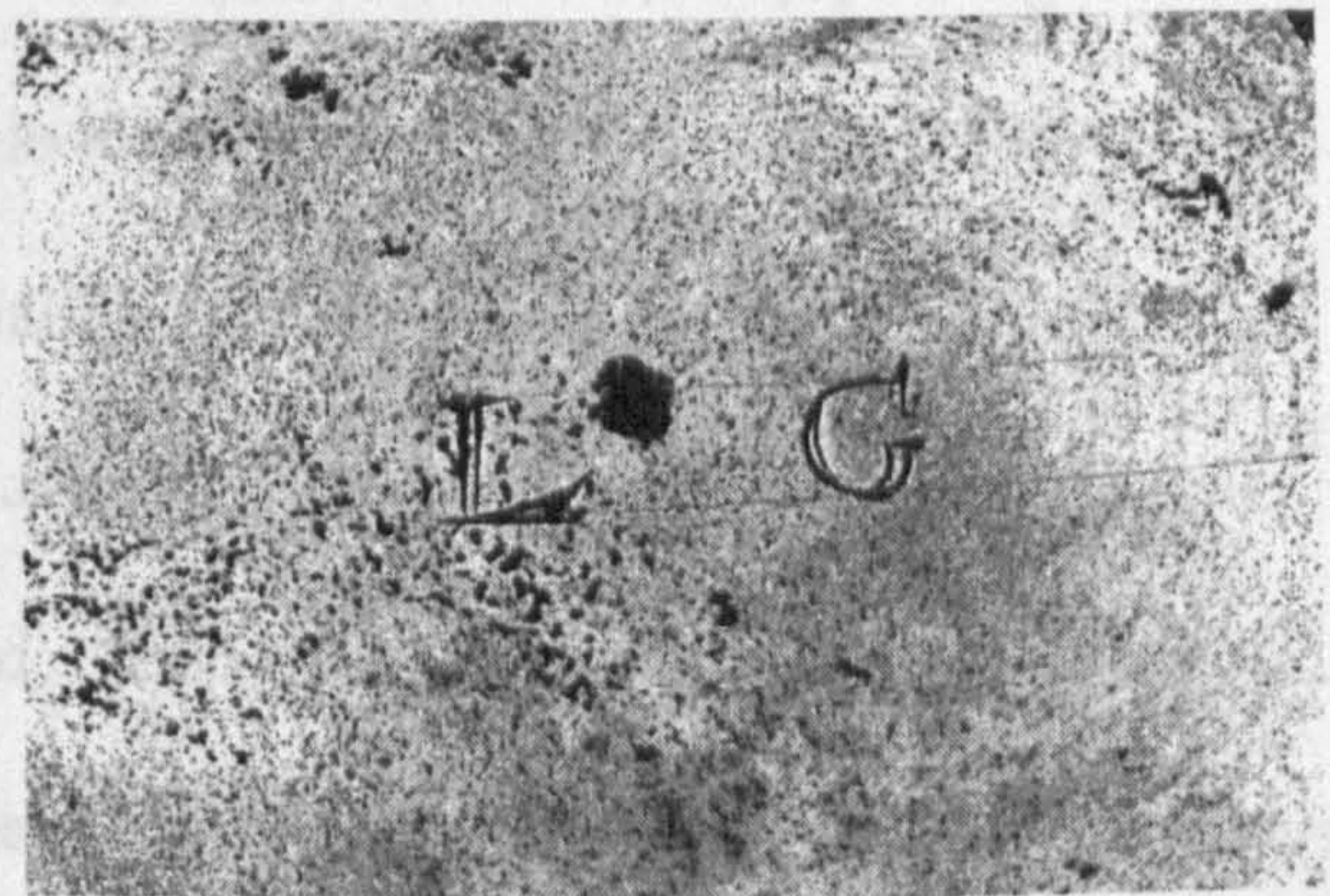
identity of the ship as *La Belle* (Figure 1-7). During cleaning in Corpus Christi both the faint remains of a maker's mark (Figure 1-8) and initials on the plates were revealed. The maker's mark is clearly French and the initials, L.G. (Figure 1-9), were carefully inscribed on all 22 plates in the stack, suggesting that these were the initials of their owner (Carlin and Keith 1997:66-67).



**Figure 1-7:** Pewter plates belonging to a member of the expedition. Photograph by Jerry Livingston courtesy Ships of Discovery.



**Figure 1-8:** The maker's mark confirmed a French origin. Photograph by Jerry Livingston courtesy Ships of Discovery.



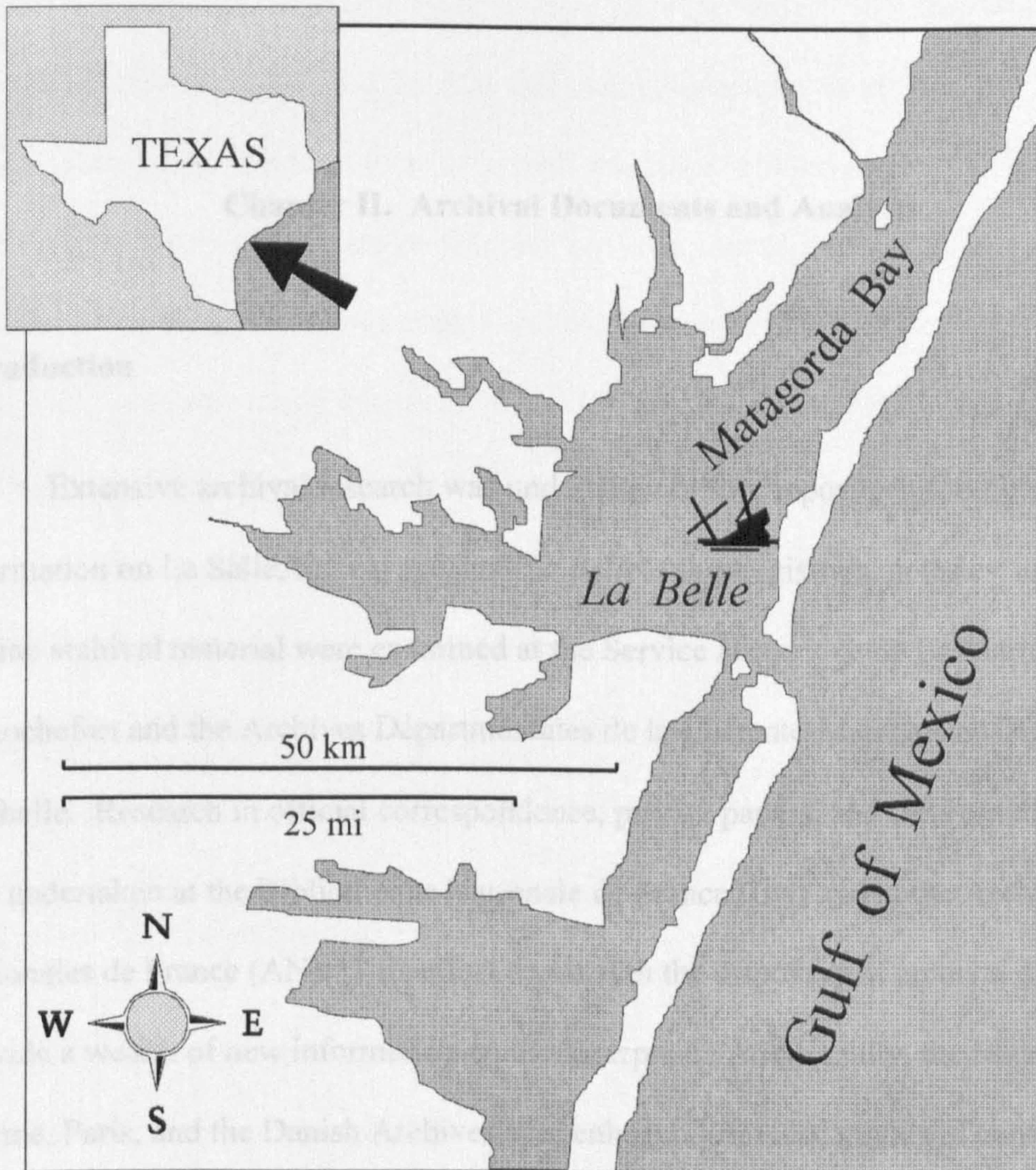
**Figure 1-9:** Sieur Le Gros initials inscribed on each plate. Photograph by Mary Caruso courtesy Ships of Discovery.

One of La Salle's expedition was Sieur Le Gros, an important member of the company whose belongings were reportedly placed on board *La Belle* following the wrecking of *L'Aimable* (John de Bry, pers. comm. 1995). The cannon and plates, together with hundreds of hawk-bells, lead shot, ceramics, a brass rapier hilt, a buckle, and a pair of copper alloy dividers, not only confirmed a virtual association with La Salle, but with the ship *La Belle*.

Once the identity of the ship was certain, the Texas Historical Commission (THC) began planning for a full scale excavation, which began in September 1996 and continued through April 1997

### **Site Location**

Matagorda Bay is located on the gulf coast of Texas between Houston and Corpus Christi (Figure 1-10). The bay trends roughly NE to SW with the former barrier island that once closed the bay broken by Pass Cavallo. The entrance of the pass, located at 28° 23'N and 96° 24'W, effectively breaks the barrier into a long peninsula and an island. The area behind the peninsula and island is divided into three smaller bays, Matagorda to the north, Lavaca to the west, and San Antonio to the south. As described by both Barroto and Joutel, the entrance to the bay was shallow and dangerous and once inside shifting sand bars and shallows presented many hazards. It was on one such sand bar that the small ship identified as *La Belle* grounded, began taking on water, and eventually sank. The hull was found buried in approximately 4 meters of water just a few hundred meters from the north shore of Matagorda Peninsula.



**Figure 1-10:** *La Belle* wrecked in four meters of water on the north side of Matagorda peninsula. Drawing by Donald H. Keith courtesy Ships of Discovery.

## Chapter II. Archival Documents and Analysis

### Introduction

Extensive archival research was undertaken in four repositories to obtain information on La Salle, the voyage, and *La Belle*. Ship registries, notaries, and related marine archival material were examined at the Service Historique de La Marine (SHMR) in Rochefort and the Archives Départementales de la Charente-Maritime (ADCM) in La Rochelle. Research in official correspondence, private papers, and the French marine was undertaken at the Bibliothèque Nationale de France (BN) and at the Archives Nationales de France (AN). This effort resulted in the discovery of archival data that provide a wealth of new information on the enterprise. Additionally, the Musée de la Marine, Paris, and the Danish Archives, Copenhagen, provided copies of contemporary ship drawings.

This information can be broadly divided into background on the voyage and its mission, the relationship between La Salle and his captains and creditors, recruitment and voyage preparations, the voyage and subsequent events, and the ships with an emphasis on *La Belle*. In this last, and smallest category the materials fall into two groups: first, those that can be indisputably associated with *La Belle* because the ship is mentioned by name and, second, those that may have a bearing on *La Belle*.

Examination of the documents related to *La Belle* raised fundamental questions regarding the ship's genesis and typological identification. Was *La Belle* the same 'good

barque' that was referred to in a memorandum from the King? That ship was to be sent to the Gulf dismantled on *Le Joly*. The documents reveal, however, that the disassembled ship would not fit as cargo and instead would have to be sailed to the New World. If *La Belle* was the one on the king's list, the construction, the disassembly then reassembly should have left some physical evidence on the hull timbers. If it was not the same ship, what was it and where did it come from? Further, *La Belle* was variously referred to as a frigate, barque, and a barque longue in contemporary accounts and registries. This conflicting nomenclature is an important issue in the hull analysis. Because the question of typology has implications in all areas of the hull analysis, a discussion of the barque longue and its construction in the late 17<sup>th</sup> and early 18<sup>th</sup> centuries provided as background on this ship type.

### **Document Identification and Provenance**

Twelve documents were identified that have a bearing on this study. These consist of four ship registries, a registry description, five pieces of official correspondence, a memorandum from the King, and a declaration by the Intendant of Rochefort.

### **Documents Associated with *La Belle***

The documents that can be unquestionably associated with *La Belle* include four ship registries and a registry description. These five documents, together with four pieces of official correspondence in the collected papers of Pierre Arnoul, Intendant of

the Marine at Rochefort (BN, NAF<sup>1</sup>), are the only new materials discovered that refer to *La Belle* by name that have a bearing on the study of the hull and its identity.

The first and the most important document for this research is a notarized description that provides 18 measurements (Figure 2-1). Entitled *Proportions d'une barque nommée La Belle qui a esté construite au port de Rochefort durant les mois de may et juin 1684 au por de 40 à 45 tonneaux*<sup>2</sup> (SHMR, Series IL<sup>3</sup> 19, f. 88v-89r), this record provides rarely-discovered information including the names of key individuals involved in the ship's design and construction. It also includes the names of the members of the *Conseil de Construction de Rochefort*. This council certified the dimensions and architectural characteristics of every ship ordered to be built by the King (Boudriot 1998:128). The proportion document was signed on December 15, 1684, nearly six months after the ship was completed. A full discussion and analysis of the measurements in this description are provided elsewhere.

The second item is a registry of armaments placed on ships in the royal marine, *Armemens des Vaisseaux du Roi en 1684* (Musée de la Marine, Paris, J2583). This registry was first organized by arsenal, then by ship type (Figure 2-2). *La Belle* appeared on folio page 102 under the group of "*Barque Longues*" with the notation of 50 tons, built in Rochefort, 6 cannons, and a shorthand notation of 84, indicating 1684, the year it was built. Although the registry did not specify the month in which it was written, several documents in this folio were prepared in either July or December. Because *La*

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<sup>1</sup> Bibliothèque Nationale de France (BN), Paris, Section des manuscrits Nouvelles acquisitions Françaises (NAF), Volumes 21306 to 23144 , Papiers de Nicolas et Pierre Arnoul, Intendants de la Marine.

<sup>2</sup> Proportions of a barque named *La Belle* that was constructed at the port of Rochefort during the months of May and June 1684 of 40 to 45 tons.

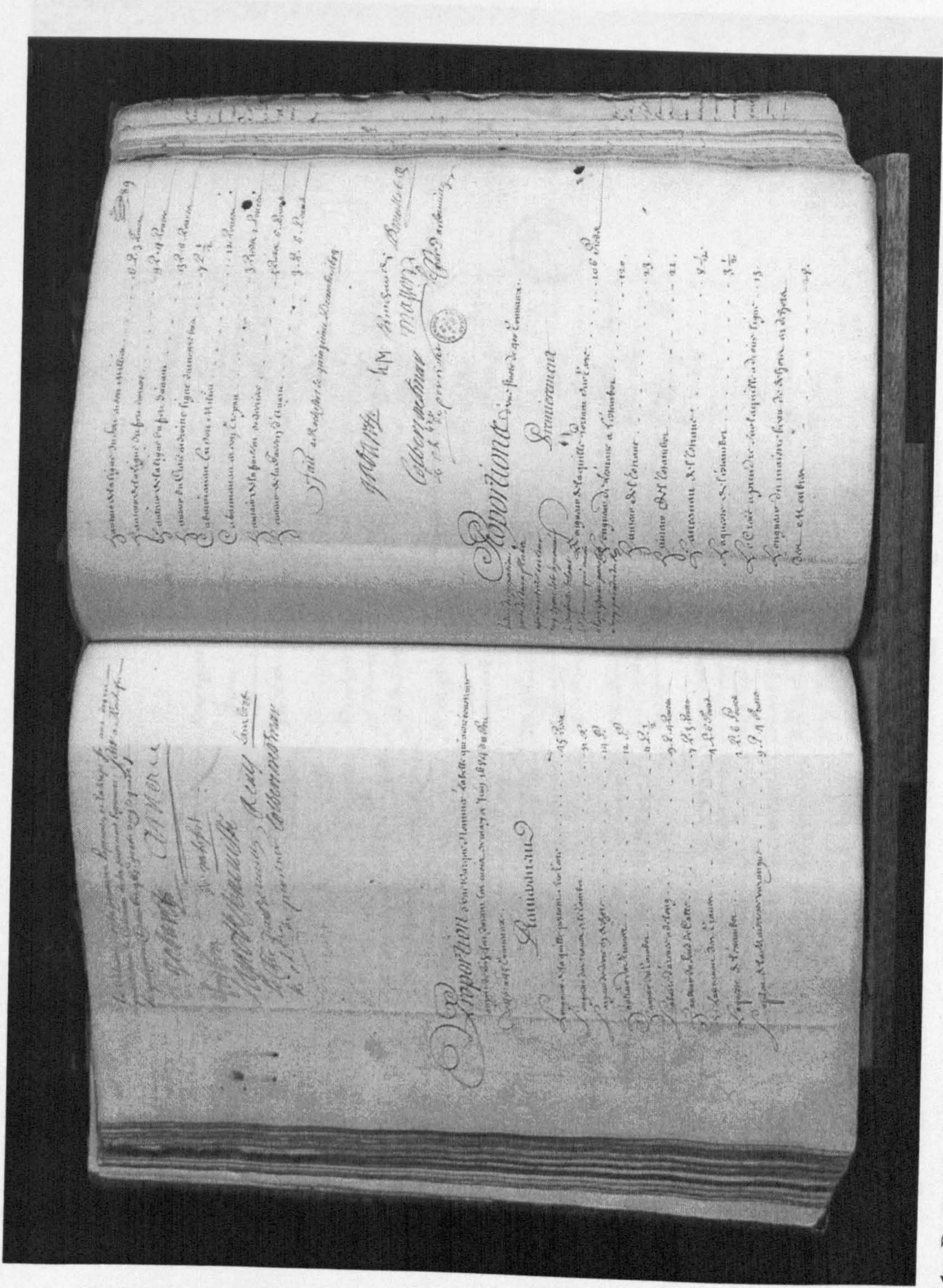


Figure 2-1: Proportion document for *La Belle*. Service Historique de La Marine, Rochefort. Photograph by John de Bry courtesy Center for Historical Archaeology.





*Belle*'s proportions document was completed in December 1684, it is likely that this list was also prepared that month.

The third item is a ship registry, *Liste des du Roy [sic] du Département de Rochefort, Juillet 1687* (SHMR, 1L<sup>3</sup> 20, f. 1v-9r). This registry includes information on the type of ship, the ship's name, tonnage, numbers of cannons, place of construction, depth of hold, number of crew, months of supplies, and qualities. Under the category of *barque longues*, *La Belle* is listed with the notations of 50 tons and 6 pieces of cannon (SHMR, 1L<sup>3</sup> 20, f. 9r).

A similar list appeared elsewhere in the same registry, *Liste des Vaisseaux, Frégattes, Brulots et autes batiments du Port de Rochefort, 1688*<sup>3</sup> (SHMR, 1L<sup>3</sup> 20, f. 24v). This document includes the same information as the July 1687 list: ship categories, ship names, tonnage, numbers of cannons, but it also includes marginal notes (Figure 2-3). The first ship listed under the category *barque longue* is *La Belle*, 50 tons, 6 cannons. The marginal notation reads: "*est au Mexique commandée par Mr. De La Salle*"<sup>4</sup>. A second important notation follows *La Folle* on this list, which reads "*autres Vx qui ne sont pas sur la liste Envoyée a la cour.*"<sup>5</sup> This registry also included a notation that it was copied and sent to the court on January 20, 1689, suggesting it was prepared in December of the previous year.

The fifth item, found in the same register as both of the previous two lists, is *Vaisseaux du Roy [sic] du Département de Rochefort* dated 1688 (SHMR, 1L<sup>3</sup> 20, f. 32v-

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<sup>3</sup> List of Vessels, Frigates, Brulots and other ships of the Port of Rochefort 1688.

<sup>4</sup> "in Mexico under the command of Mr. De La Salle"

<sup>5</sup> "other vessels that are not on the list Sent to the Court."

Ship Name	Value	Quantity
Stunite	140-	20-
Le Souvrou	400-	20
Le Profond	400...	30
La Beronne	300-	26
La Mula	250-	10
Barquette Conguée		
La Belle	50-	6
La Sibille	40	8
La Tolle	25	8
Auxca V. qui ne Dom par Luo Ca		
Lish-Emoyée il la coue		
La Gaillaode	250-	26
Le Dragon Volant	90-	12

Figure 2-3: A registry of royal ships from the port of Rochefort in 1688. The marginal note states that *La Belle* is in Mexico under the command of La Salle. Photograph John de Bry courtesy Center for Historical Archaeology.

33r). This registry includes similar pieces of information: type of ships, names of ships, tonnage, cannons, port and master carpenter, draft, qualities, months of food [supplies], officers, marines, and sailors (Figure 2-4). Under the heading "*Barque Longue*," the third ship listed is *La Belle*, 50 tons, 6 cannons, Rochefort, H. Mallet, and 7 feet draft. The notation under qualities reads: "*Mr De La Salle le emmené au Mexique d'ou elle n'est encore pas revenue.*"<sup>6</sup> The notation under months of food is 2 ½. In the far left a marginal notation reads: "*On ne met point d'équipage à ce vaisseau parceque le pilote qui en est arrive dit qu'elle ne subsiste plus.*"<sup>7</sup>

Four additional references to *La Belle* appear in official correspondence between Pierre Arnoul and the Marquis de Seignelay. The first appeared on July 8, 1685, in which Arnoul related the comments of de Beaujeu, the captain of *Le Joly* upon his return to Rochefort (BN, NAF 21331, Vol. 26, f. 307). In referring to *La Belle*, Arnoul only mentioned that the ship remained with La Salle. This letter adds nothing other than to confirm the participation of the ship in the expedition. The second letter in the Arnoul papers is dated July 17, 1685, in which various expenses were discussed followed by a request for support for the families of the *La Belle*'s crew:

*... J'eus l'honneur de vous envoyer dernièrement l'estat de ce qui estoit deub au Joly, vous trouverez cy joint celui de ce qui seroit deub à l'esquipage de la barque la Belle qui est restée avec M. De la Salle, leurs familles auroient grand besoin de secours* (BN, NAF 21331, Vol. 26, f. 333).

Six months later Arnoul sent another request for support for the families:

*... Il y a aussy des pauvres femmes de matelots qui sont sur La Belle avec M. De la Salle qui meurent de faim, si vous auriez la bonté de leur faire*

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<sup>6</sup> "Mr De La Salle has taken her to Mexico from which she has not yet returned."

<sup>7</sup> "The number of crew members is not given for this vessel because the pilot who has just returned says that she no longer exists."



*donner quelque chose ce seroit d'une grande charité* (BN, NAF 21332, Vol. 27, f. 455, 31 December 1685).

The last reference appears on March 5, 1686, in a letter from Arnoul to Seignelay noting a payment of 900 livres to the wives of the sailors serving on *La Belle*, “. . . *Un autre [paiement] de 900 livres pour les femmes des matelots servants sur la belle*” (BN, NAF 21333, Vol. 28, f. 131). Because these latter letters were sent to Seignelay, and it was he who pressed for a military component of the expedition with an eye toward the Spanish mines of Mexico, they confirm the dual nature of the venture.

These nine primary references comprise the total known to date that specifically mention *La Belle* and, with the exception of the Beaujeu commentary and requests for money for the wives of sailors, provides direct information on the ship's construction, identity, and classification. It should be noted, however, that other primary documents do mention *La Belle*. These include Henri Joutel's journal (Foster 1998), Minet's journal (Bell 1987:83-126), and Meunier's interrogation (Foster 1998:283-289). These comments generally concern the ship during the voyage and provide no primary documentation on the ship's construction or authoritative information on its classification.

Another source of information on La Salle and the voyage is the multi volume work compiled by Margry (1876-1886). In it he reproduced portions of many official letters and other materials housed in the Archives Nationales de France, Series de Marine and the Series des Colonies. This latter series has not received the extensive examination that other groups of archival materials have undergone and remains a source that should be more thoroughly investigated and transcribed. With the exception of a brief mention by La Salle and a memorandum, discussed in more detail elsewhere, Margry's research

provided no new or additional definitive information on the construction or classification of *La Belle*.

### **Documents That May Have Bearing on *La Belle***

In the second group, those that may have a bearing on *La Belle*'s construction or identity but do not mention the ship by name, are three documents. The first is a memorandum dated March 23, 1684, quoted in Margry, *Mémoire de ce qui aura esté accordé au Sieur de La Salle*<sup>8</sup> (1879, II:378). This memorandum includes a numbered list of items for the expedition, which includes a reference to a barque:

. . . 22<sup>e</sup>. *Une barque de 40 à 50 tonneaux, grée ou en bottes avec ses agrès, 1.200 liv.*

[translation] 22<sup>nd</sup>. A barque of 40 to 50 tons, rigged or in frame with its rigging, 1,200 livres [pounds].

Margry cited the Archives du Ministère de la Marine et des Colonies as the location of this document, but he provided no specific book or folio. As of this writing, the original memorandum remains unlocated, but may reside in either the *Ordres du roy concernant la marine* or in the *Ordres et lettres du Ministre de la Marine*.

No matter its location, the memorandum is an important source of information, particularly when considered with two other documents that involve Charles Du Mont de Blaignac, Commissaire Général de la Marine<sup>9</sup> of Rochefort. The first is a declaration from the officers of the port and pilots included in a letter to Seignelay:

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<sup>8</sup> Memorandum of what has been accorded to Sieur de La Salle.

<sup>9</sup> Chief Superintendent of the Navy. This position is one of three that reports directly to the Intendant and as such is of great authority and importance at the arsenal (Acerra 1993:108). In his role as Chief Superintendent, Du Mont would also have the authority to communicate directly with Seignelay.

*Nous officiers du port Mes et pilottes entretenus par sa Ma.té soubz.ez convenons tous unanimement qu'une barque de quarente à cinquante thonneaux, mise en bon estat, peu facillem.nt faire le trajet des costes de France et celluy de Canada, avec sa charge réglée et bien plus aisement dans les saisons ou nous entrons presentement, fait a Rochefort le 9e Avril 1684, HEURTIN (SHMR, 1L<sup>3</sup> 19, f. 67r).*

[translation] We, the undersigned officers of the port and Royal Pilots, unanimously agree that a bark of 40 to 50 tons, put in good condition, can easily make the crossing from the coast of France to that of Canada, with its load well distributed, especially in the season we are entering now, made in Rochefort on 9<sup>th</sup> April 1684, HEURTIN [notary].

Receipt and acknowledgment of this testament and accompanying letter appeared only as a note in correspondence from Seignelay dated April 17, 1684 (AN<sup>10</sup>, Series Marine B<sup>2</sup>, Vol. 51, f. 210v), in which he also acknowledged receiving letters dated April 6 and 10, 1684 from Du Mont<sup>11</sup>

The second item is correspondence from the King to Du Mont acknowledging the receipt of his letters dated March 30, April 2 and 3, 1684<sup>12</sup> (AN<sup>13</sup>, Series Marine B<sup>2</sup> 50, f. 177v-179r). Dated April 14, 1684, the King commented on the merchandise and munitions for *Le Joly*, on a ship under repair (rebuilt), and then confirmed the use of *Le Joly* instead of the previously suggested *Dromadaire* for the expedition. This letter also included a reference to problems with the space on *Le Joly* and a dismantled ship that

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<sup>10</sup> Archives Nationales de France, Paris, Fonds Marine série B (service général), Marine B<sup>2</sup>, Volume 51, Dépêches de Seignelay, minstre de la Marine.

<sup>11</sup> Copies of the letters dated April 6 and 10, 1684, were not found in the archives searched for this study, nor do they appear in Margry.

<sup>12</sup> Copies of the letters dated March 30, April 2 and 3, 1684, as well as any response were not found in the archives searched for this study, nor do they appear in Margry.

<sup>13</sup> Archives Nationales de France, Paris, Fonds Marine série B (Service Général), Marine B<sup>2</sup>, Volume 50, Ordres du Roi concernant la Marine.

was to be loaded and reassembled at their destination. Lastly, the letter confirmed the appointment of de Beaujeu as captain of *Le Joly*.

*a-r des lettres de Du Mont des 30 mars, 2 et 3 avril 1684*

*a-r le mémoire des marchandises et munitions qui seront envoyées sur le vaisseau Le Joly.*

*. . . celui de la depense à faire pour radouber tous les vaisseaux du port.*

*. . . Elle a veu tout ce qu'il escrit sur le sujet du vaisseau Le Joly. Elle ne veut point changer sa destination, et son intention est qu'il fasse embarquer tout ce qu'il pourra contenir. Ainsi il ne doit point penser à se servir de la fluste Le Drommadaire. Elle luy permet de charger sur ce vaisseau des farines au lieu des rations nécessaires pour la subsistance des hommes qui y seront embarquez et d'entrer dans les expédiens que le sieur de La Salle luy proposera lorsqu'il sera à Rochefort, mais elle ne veut pas qu'il se serve d'un autre vaisseau.*

*. . . A l'esgard de la barque en fagot, puisqu'elle ne peut pas estre embarquée sur ledit vaisseau, Sa Ma.té trouve bon qu'il arme un traversier ou une bonne barque et qu'il la charge de tout ce qui ne pourra estre embarqué sur ce vaisseau.*

*Il doit prendre soin d'acheter les fusils et pistolets qu'il a eu ordre de tenir prest, a l'égard des espées et sabres, puisqu'il y a suffisamment de sabres dans les magasins, il peut s'en servir au lieu d'espées estant une même chose.*

*. . . et pour le surplus des autres marchandises et munitions qui ne sont pas dans lesd. magasins, il trouvera cy joint copie de l'ordre qui a esté donné au trésorier de la marine de remettre à Rochefort 2332 # pour acheter a quoy il doit s'appliquer incessamment.*

*Sa Ma.té ayant fait choix du s.r de Beaujeu pour commander led. vaisseau le Joly au lieu du s.r Pingault, il se rendra dans peu aud. port.*

[translation] Acknowledgment of the letters of Du Mont of March 30, April 2 and 3, 1684

Acknowledgment of the memo of the goods and munitions that will be sent on the ship *Le Joly*.

... the one of the expense to make to repair all vessels of the harbor.

He [his Majesty] has viewed everything that he [Du Mont] wrote on the



topic of the vessel Le Joly. He [his Majesty] does not want to change its destination, and his intention is that it has everything that it will be able to contain is loaded. So he must not think about using the flute Le Drommadaire. He [his Majesty] permits a change to this vessel [Le Joly] to get instead the necessary rations for the subsistence of the men that will be there to embark and to enter the expedition that the sieur de La Salle will propose when he will be in Rochefort, but He [his Majesty] doesn't want that he uses another vessel [Le Drommadaire].

With regard to the boat in pieces [literally, boat in bundles], because she is not able to be embarked [loaded] on the aforesaid vessel, His Majesty finds it good that he arms a *traversier* or a good *barque* and that he charges it of everything that will not be able to be embarked on this vessel [Le Joly].

He must take care to buy the rifles and guns that he had ordered to hold quickly, as to the consideration of the swords and sabers, since there are sabers sufficiently in the stores, he can use some instead of swords, being the same thing.

And for the other goods supplies and munitions that are not in the magazines, he will find joined to this copies of the order that has been given to the treasurer of the Marine to put back in Rochefort 2332 # [pounds, e.g., livres] for the purchase that he must administer immediately.

His Majesty made the choice of the Sieur de Beaujeu to command the vessel Le Joly instead of the Sieur Pingault, to which he will surrender soon in the aforesaid harbor.

When considered together, these documents raise as many questions as they provide answers. Only through careful analysis is it possible to unravel their inconsistencies and resolve their uncertainties.

### **Document Analysis and Implications**

Unlike many shipwreck investigations, the identity of the ship is indisputable, its date, location of manufacture and, with a high degree of certainty, its designer and builders are known. Of less certainty is the ship's genesis; is the barque described both as "rigged or in frame" and "in pieces" in the official memoranda and correspondence *La*

*Belle*? Or was it another ship that was already under construction in the yard and substituted? This ambiguity arises from the three references that do not mention *La Belle* by name: the memorandum of what was granted to La Salle (Margry 1879, II:378); the attestation by the officers of the port and pilots that Du Mont sent to Seignelay on April 9, 1684 (SHMR, 1L<sup>3</sup> 19, f. 67r); and a letter from the King to Du Mont on April 14, 1684 (AN, Marine B<sup>2</sup> 50, f. 177v-179r) annotated by Arnoul (BN, NAF 21330, Vol. 25, f. 78).

A second question central to the hull study is what type of ship was *La Belle*? It is variously described as a “*meschant vaisseaux, fregatte, barque, and barque longue*” in registries, journals, and correspondence. The resolution of these questions has a direct bearing on the study of the hull.

### **A Ship in Pieces**

The King’s memorandum of March 23, 1684, formally communicated a long list of items for the expedition. Among them was item 22, “... a barque of 40 to 50 tons, rigged or in frame with its rigging ...”(Margry 1879, II:378). Because no specific ship was designated in the memorandum, the King gave Arnoul, and through him Du Mont, wide latitude in making a final selection. Important is whether the selection resulted in using a ship in pieces or another ship under construction in the yard. Because construction at the arsenal was then at a fever pitch, Arnoul’s decision had to take into consideration several factors: the limitation imposed by a deadline to ready the expedition for departure as quickly as possible, personnel and supply shortages, the sheer bulk and quantity other items from the arsenal, and the available space on *Le Joly*.

Two pieces of correspondence and marginal notes by Arnoul provide some useful, although cryptic, information on how these factors may have influenced his

decision and the outcome. Two paragraphs from the letter sent on April 14, 1684, from the King to Du Mont, require special attention; the first is paragraph four:

He [his Majesty] has viewed everything that he [Du Mont] wrote on the topic of the vessel *Le Joly*. He [his Majesty] does not want to change its destination, and his intention is that it has everything that it will be able to contain be loaded. So he [Du Mont] must not think about using the flute *Le Drommaire*. He [his Majesty] permits a change to this vessel [*Le Joly*] to get instead the necessary rations for the subsistence of the men that will be there to embark and to enter in the expedition that the Sieur de La Salle will propose when he will be in Rochefort, but He [his Majesty] does not want that he uses another vessel [*Drommaire*] (AN, Marine B<sup>2</sup> 50, f. 177v-179r).

The full text of this correspondence appears in two archival locations, in the *Ordres du Roi concernant la Marine*, as noted above; it also appears in the Arnoul papers (BN, NAF 21330, Vol. 25, f. 78r-80v). This second reference includes marginal notes not found elsewhere. Because no response to the King's letter from either Arnoul or Du Mont is known, the two marginal notes, presumably written by Arnoul, assume greater importance.

The first marginal note appeared opposite the fourth paragraph, above, and reads: "*Le changement est pour diminuer l'encombrement dud. v.au*"<sup>14</sup> (BN, NAF 21330, Vol. 25, f. 78r-80v). In January 1684 correspondence to Du Mont, the King ordered that *Le Joly* carry the ". . . 400 people and everything that must pass to the Isles [of America]. . ." for the expedition (AN, Marine B<sup>2</sup> 50, f. 43v). Correspondence regarding the quantity of munitions and number of sailors to be loaded, along with the size and limited space on *Le Joly*, clearly prompted Du Mont to write to the King expressing his concern and suggesting the use of a larger ship. To reduce overcrowding on *Le Joly*, the King responded in this letter by permitting Dumot to remove some items and instead load food

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<sup>14</sup> "The change is to decrease overcrowding (clutter) on the aforesaid vessel."

and supplies.

This reference to overcrowding has a direct bearing on the content of the next paragraph in the King's letter:

With regard to the boat in pieces<sup>15</sup>, because she is not able to be embarked [loaded] on the aforesaid vessel [Le Joly], His Majesty finds it good that he [Du Mont] arms a *traversier*<sup>16</sup> or a good barque and that he charges it of everything that will not be able to be embarked on this vessel (AN, Marine B<sup>2</sup> 50, f.179r, 14 April 1684).

Arnoul's second marginal note appears opposite this paragraph and reads:

*On ne laisse pas que de continuer à faire lad. barque qui est desja fort avancée, soit pour cet usage ou pour celui du port qui en a besoin*<sup>17</sup> (BN, NAF 21330, Vol. 25, f. 78r-80v).

No date is associated with this marginal note, but it was written after April 14, 1684, following receipt of the King's letter. This note strongly suggests that the "ship in pieces" referred to by the King was under consideration by Arnoul for La Salle's use because it was already "well advanced" in its construction in mid-April.

It should be remembered, however, that the letter from the King was written in response to letters sent by Du Mont on March 30 and April 2 and 3, 1684, in which the overcrowding problem on *Le Joly* was presented. Between the dates of these three letters

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<sup>15</sup> In the original French it reads ". . . la barque en fagot", literally a boat in bundles or in pieces. This archaic term was used to describe a boat that was dismantled into five or six pieces in a methodical fashion so it could be reassembled later in a different location (*Encyclopédie Méthodique Marine* 1786 II:297).

<sup>16</sup> A *traversier* was a fishing boat also referred to as a Bermuda boat, rather wide to carry a substantial cargo, yet fairly fast for such a vessel. *Traversiers* were common and numerous in the Aunis region, i.e. between Rochefort and La Rochelle (*Encyclopédie Méthodique Marine* 1787 III:789).

<sup>17</sup> "We do not slow [literally, stop] in our construction of the aforesaid barque which is already well advanced, whether for this use or the use of another port that has need of it"

and the receipt of the April 14, 1684, letter Du Mont prepared a declaration that a small ship could make the ocean crossing:

. . . the undersigned officers of the port and Royal Pilots, unanimously agree that a bark of 40 to 50 tons, put in good condition, can easily make the crossing from the coast of France to that of Canada . . . (SHMR, 1L<sup>3</sup>19, f. 67r).

This deposition clearly alluded to the King's memorandum of March 23, 1684, in which La Salle was to be provided “. . . a barque of 40 to 50 tons, rigged or in frame with its rigging . . .” (Margry 1879, II:378). With this attestation Du Mont was trying to comply with the King's orders by selecting the first option, a completely constructed and fully rigged barque. While the affidavit did not mention La Salle or the *Isles de l'Amérique*, the intention was to assure both Seignelay and the King that a small ship could make the crossing with La Salle and thus permit the use of an assembled ship.

This affidavit was sent to Seignelay, who presented the information to the King for his consideration in the overcrowding situation on *Le Joly*. With the April 14 response letter from the King with instructions to provide La Salle a *traversier* or good barque for the expedition, the King essentially repeated his previous order to furnish “. . . a barque of 40 to 50 tons, rigged . . .” and therefore ready to sail.

In neither the testament of April 9 nor the letter of April 14, however, was there any suggestion that the boat in pieces, the *barque en fagot*, would or should be used to fulfill the order of the King. Nor is it clear that the *barque en bottes* from the memorandum and the *barque en fagot* from the letter were considered the same, either in nature or size. Furthermore, the fifth paragraph in the King's letter, while alluding to the overcrowding problem, appears to suggest that because the boat in pieces “. . . is not able to be embarked” instead they could substitute and use another “. . . traversier or good

barque . . . ” for the expedition. If this is an accurate assessment of the King’s intent, this severs any connection between the boat in pieces and the *traversier* or a good barque, perhaps except in the mind of Arnoul, as alluded to in his marginal note. This would also suggest the possibility that another ship under construction was eventually selected and became *La Belle*.

Without letters from Du Mont specifying the nature of the overcrowding problems, sufficient ambiguity exists in the King’s letter and marginal comments of Arnoul that a closer examination of three broad issues is warranted. The first is that the term *barque en fagot* was simply a turn of phrase and that it could be interpreted as the *barque en bottes*. More specifically, is there a difference between a *barque en fagot* and a 40-50 ton *barque en bottes* and how do these compare with a *traversier*? The second is that a ship the size of a typical *barque longue* was rarely, if ever, broken into pieces and shipped and, therefore, could not be the ship in pieces under any circumstance. More specifically, is there any evidence that *barque longues* were shipped in pieces? The third is that a ship the size of *La Belle* was simply too large to fit into *Le Joly*, despite any overcrowding problem. More specifically, could *La Belle* fit into *Le Joly*? The fourth is that the ship in pieces and *La Belle* are not one <sup>and</sup> the same and *La Belle* was substituted. More specifically, was *La Belle* the ship in pieces?

To answer these questions, several additional pieces of information are needed. This information can be characterized by the following: What and how big was a typical *barque en fagot*? What and how big was a typical *traversier*? How big was a typical *barque longue* and were they ever shipped in pieces? How big was *Le Joly* and what size ship could it carry? Was the ship in pieces *La Belle*?

### **What and how big was a typical *barque en fagot*?**

According to Ollivier, in the late 17<sup>th</sup> early 18<sup>th</sup> century a *barque en fagot* was intended to give the navy additional small ships that they could assemble when there was a situation “. . . where the number or the size of the . . . ships of the naval army [were not] sufficient” (1736:89). The *Encyclopédie Méthodique Marine* defined a ship *en fagot* as one that:

. . . has been divided in well preserved five or six pieces and gathered in a heap, and numbered, to be of the least clutter, until one is at a place to serve themselves of it and to bring it up; it is said *en fagot*: shallop *en fagot*, *barque en fagot*, canoe *en fagot* (1787, II:297).

Lescallier also defined a *barque en fagot* as:

A boat in frame; an assemblage of all the pieces of a boat, ready formed and put on ship-board in order to build her at the place where she may be required (1791:np).

Thus it appears that a boat *en fagot* was any craft broken down for later reassembly and may be in either five or six pieces or broken down to its frames.

Regarding the size of a *barque en fagot*, Ollivier (1736:89) stated that they were “. . . constructed in the same way as the shallop of a vaisseau [a ship of the line], but commonly bigger” than a ship’s boat or tender. In the 17<sup>th</sup> century it was common practice for a ship of the line to carry a small boat or tender on the deck once they left the shore and were in open water. The largest ships, first ranks, often carried more than one boat nested one inside the other. Ollivier provided (1736:87) some insight into the size of these assembled ships:

[A] shallop of 34 to 35 feet long [is carried] in the vessels of the first rank, of 33 to 34 feet long in vessels of the second rank, of 32 to 33 feet long in vessels of the third rank, about 30 feet in vessels of the fourth rank, 24 to 29 feet in the frigates, and 24 feet in the bomb galiotes, brulots, and big flutes.

Therefore, based upon this information a *barque en fagot* could be as large as or larger than the largest shallop carried by a first rank ship of the line, which was approximately 35 feet and 23 tons when assembled and outfitted (Boudriot 1986 II:190). Unfortunately, no information has appeared during this study that details exactly how much larger a typical *barque en fagot* was compared with the largest shallop or whether they could reach *La Belle's* 51 feet and 45 tons in size.

### **How big was a *traversier*?**

The King's letter to Du Mont on April 14, 1684, stated that he wanted a *traversier* (or a good *barque*) provided to La Salle. This ship type, as defined by Ollivier was:

. . . a small ship of burden that serves for fishing or to make short crossings. It is about 50 feet in length from the stem to the stern post, 13 ½ feet to 14 feet in width, and 6 ½ feet depth of hold. It has a mainmast with two square sails and a bowsprit mast . . . (1736:337).

If this description and Du Mont's attestation can be used as guides, a *traversier* was also a ship of between 40 and 50 tons, which was much larger than the largest ship's boat or tender. Given the length and tonnage of a typical *traversier*, *Le Joly* could not have carried it in an assembled condition. Furthermore, Ollivier's description of a *traversier* could as easily apply to *La Belle*, the two being nearly identical in size and tonnage (SHMR, 1L<sup>3</sup> 19, f. 88v-89r).

In answer to the first issue, which is (1) what is the relationship between the terms *barque en fagot* and *barque en bottes* and, (2) how do these compare with a *traversier*? First, it appears that the terms *en fagot* and *en botte* were roughly equivalent, being more a difference of degree of disassembly. Second, the largest shallop was much smaller than a typical *traversier*, it also appears that a *barque en fagot* was more a description of a condition and not necessarily a delimiter of size. Because no information



is known that clearly suggests the maximum size of a ship in pieces, it is conceivable that a *barque en fagot* might range from that of the largest shallop to that of a *traversier*, which for all practical purposes can be equated with *La Belle*.

### **How big was a typical *barque longue* and were they ever shipped in pieces?**

The *barque longue* of the late 17<sup>th</sup> and early 18<sup>th</sup> centuries ranged in size from 25 to 90 tons. The vast majority of those whose tonnage was recorded fall into the 30 to 50 ton ranges (Le Conte 1935:38-41). At the lower end, they were similar in size to the largest shallops carried by first rate ships of the line and at the upper end similar in size to the smallest light frigates (Le Conte 1935:22-26). Accordingly, their cannons ranged from two to ten in number and from two to six pounds in size. Consequently, their bulk when broken into five or six pieces, or into their component frames, varied widely as did the space necessary to store their associated ordnance, rigging, ammunition, provisions, and accoutrements.

Given the previously described letters and memoranda referring to transporting a ship in pieces, the practice was likely a common one. Unfortunately no information has appeared that indicates the size of the largest ship to which they applied this practice.

The *Encyclopédie Méthodique Marine* (1786 II:297) stated that they applied the procedure to shallops, *barques*, and canoes, which ranged widely in size. That they also applied it specifically to the *barque longue* is suggested in a memorandum in which they were sent to Canada in bundles:

*. . . mais une autre fois Il suffira de faire porter en fagot les membres des barques longues qui devront demeurer aux dites Iles, afin de les faire border de poirier de l'Amérique, quand elles y seront arrivées (AN, Marine B<sup>2</sup> 42, Ordres du Roi concernant la Marine, au sieur Demuin [sic], 5 April 1680).*

[translation] . . . but another time we will only have to carry in bundles the members [frames] of the barque longues, those staying in the aforesaid Islands to be planked [r assembled] with American pear tree wood, after their arrival.

This brief mention of assembling and planking barque longues transported in a disassembled condition to America suggests that the procedure was commonplace.

Based on this citation it also appears that the ships in question might be broken down to their frames for transport, “. . . *porter en fagot les membres . . .*” not just into the five or six pieces suggested by other sources.

To answer the second issue, is there any evidence that they shipped barque longues in pieces? Clearly, it appears that they transported barque longues in bundles and they could be broken down to individual frames for shipping. However, no information is available on the size of the ships to be transported in this manner or the size of the ships that carried such cargos. Transporting a barque longue of only 25 tons in bundles or in frame with all of its equipment, is much different from transporting a ship double that in size, i.e., the size of a typical *traversier*. Because of the great deal of difference in dimensions and tonnage between a 35-foot open shallop and the 51-foot decked *La Belle*, the required dimensions of the transporting ship were equally different.

### **How big was *Le Joly* and what size ship could it carry?**

*Le Joly* was a comparatively small ship in the French marine of the late 17<sup>th</sup> century. In provisioning orders for Le Havre, it is described as a 5<sup>th</sup> rank carrying 36 cannons (AN, Marine B<sup>3</sup> 47, f. 301v, December 1683). *Le Joly* also appeared on a “List of Vessels of the King of the Department of Rochefort” from July 1687, in which it was described as a 5<sup>th</sup> rank, 412 tons, with 34 cannons (SHMR 1L<sup>3</sup> 20, f. 9r). Ollivier (1736:288) stated that a ship of this size was considered a frigate: “In the fifth rank this

consists of vessels of 40 to 46 canon and even those of 30 to 40 cannons.” Lescallier corroborated this classification:

All the inferior ships, which are not comprehended in the [three] rates and [two] orders, are called frégates and corvetts. . . . frégates [which are] from 46 to 32 guns have sometimes two tiers of cannons (1777:212).

Within the category of frigate, a ship of 36 canons was considered in the second order and was between 115 and 118 feet<sup>18</sup> from stem to stern post (Ollivier 1736:178).

Boudriot and Berti (1992:48) also noted that frigates in the 17<sup>th</sup> century, depending on the number of decks (one or two), ranged from 70 to 100 feet on the keel; those at the upper size were roughly 500 tons. Lacking any other specific information on the size of *Le Joly* and using Ollivier and the 1687 registry as a guide, it is reasonable to suggest that the ship was approximately 116 feet long from stem to sternpost.

As a fifth rank, *Le Joly* could carry an assembled shallop of 26 or 27 feet and would likely have done so on an ocean crossing. A shallop of this size was approximately six or seven tons. However, a ship’s boat served a different function than a *barque en fagot* and was, as already demonstrated, a different scale. Given that stipulation, one must first consider whether a *barque en fagot* of the same size as the largest shallop, i.e., 35 feet, could fit into *Le Joly*?

Keeping in mind that *Le Joly* was approximately 116 feet long with as many as two decks, a quarterdeck, and a forecastle, it probably had a depth in the hold amidships of approximately 14 feet, as measured from the top of the keel to the horizontal line of the deck at the top of the beams (SHMR 1L<sup>3</sup> 20, f. 9v; Ollivier 1737:135). Further, a ship of this size was approximately 29 feet wide on the gun deck, as measured to the inside of

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<sup>18</sup> All measurements are given in French feet (*pieds du roi*) and inches (*pouces du roi*). One *pie*d equals .32484 m, one *pouce* equals .02707 m.

the planking (Ollivier 1737:134). Because a *barque en fagot* was not needed until the ship arrived at its destination, the pieces were likely stowed rather than placed on the open deck. Although dismantled, a *barque en fagot* might not be disassembled down to individual pieces, but “. . . divided in five or six pieces . . .” to speed reassembly (*Encyclopédie Méthodique Marine* 1786 II:297).

The size of the largest single-piece elements, such as the keel, and the relative proportions of the assembled ship necessarily dictated the limits of disassembly. A ship's boat of 36 feet<sup>19</sup> in 1780 was not decked, measured 9 feet in breadth, and had a depth of 3 feet 8 inches (Boudriot 1986 II:186). A reasonable assumption is that a ship this size was built with a two-piece keel, the longest portion of which, using the relative proportions of *La Belle*'s keel as a rough guide, was 22 feet including scarf overlap. Given its other dimensions, 9 feet in breadth and less than 4 feet in depth, it is conceivable that the largest shallop dismantled into five or six pieces was both narrow enough and shallow enough to fit between the decks of a ship the size of *Le Joly*. If the intended *barque en fagot* was only slightly larger than the largest shallop, it is conceivable that it also could fit into *Le Joly* if partially disassembled, other stowage and personnel considerations aside.

What is the probability, however, that the 51-foot *La Belle* after disassembly into five or six pieces could fit into *Le Joly*? When evaluating *La Belle* in a disassembled state, it should be kept in mind that the ship had a registered keel length of 45 feet, was 51 feet overall, had a registered maximum beam of 14 feet, a depth of hold of 7 feet 3 inches, and was 40 to 45 tons (SHMR, 1L<sup>3</sup> 19, f. 88v). Because a *barque en fagot* might

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<sup>19</sup> According to Ollivier (1737:132), French ships were measured on the gun deck between stem and stern rabbets. Measurements given here are based upon that method.

be only partially disassembled, the limitations for stowage imposed by these dimensions are great.

Due to the disparity between a 25-ton 35-foot open-decked ship's boat and *La Belle*, other details regarding *Le Joly*'s construction must be considered. Beyond its overall dimensional limitations, the ship had stanchion posts along the centerline to support the decks. As a result, the full 29-foot width of the gun (or main) deck was not available for stowage. The presence of additional stanchion posts further reduced this space between the centerline and deck beam knees. The depth of the frames, which are estimated to be a minimum of 1 foot for this analysis, also reduced this space. If the half-breadth to the inside the planking of 14 feet 6 inches is reduced by a minimum of 1 foot for frames and 1 foot for two rows of stanchion posts, then the maximum available half breadth at a stanchion post was 12 feet 6 inches. This is a generous estimate of the space available and it was probably closer to only 10 or 11 feet. This maximum breadth, furthermore, was only possible in the middle area of the ship due to narrowing forward and aft. Structures that also reduced the available deck space in the middle area of the ship were the main mast and pump wells. Various other enclosed storage and living spaces and the presence of the ship's 36 cannons also reduced this space. Below the main deck, the maximum breadth of the ship quickly narrows to the keel and it was often subdivided into smaller storage compartments.

The depth of the hold amidships in *Le Joly* was approximately 14 feet, measured from the top of the keel to the underside of the upper deck planks. Because the ship had two decks, the space was reduced accordingly. It is unlikely that it was evenly divided, but it is possible. The height of the deck beams and the thickness of the deck planks further reduced head room between the decks as did deck beam knees and the

tumblehome at the sides. If the deck beams were minimally 1 foot and the deck planking 3 inches, the maximum height available on the main deck was 5 feet 9 inches. This is only an estimate of the room available on the main deck and may have been greater if the depth of the hold was not divided equally. In any event, the space below the main deck was quickly reduced both forward and aft as the ship both narrowed and raised to accommodate the bow and stern configurations.

The last consideration is access via hatchways for stowage. Hatchways were limited in size in their forward and aft dimension by frame spacing, incorporating as few frames as feasible for reasons of safety and constructional integrity. For similar reasons hatches did not span the entire breadth of the ship. Placed along the centerline, they were kept as small as possible. Using deck plans of a 1758 French frigate very similar in size to *Le Joly* as a guide, the largest hatchway on *Le Joly* may be assessed as approximately 6 feet 5 inches wide by 6 feet 1 inch long, i.e., forward to aft (Boudriot and Berti 1992:237). For obvious reasons, this is one of the most crucial limitations to stowage.

The dimension of the hatchway quickly precludes loading *La Belle* into the hold of *Le Joly* unless the ship was broken down into many more than five or six pieces. Therefore, the only way *La Belle* could conceivably be packed into the hold of *Le Joly* was if it were broken down to its frames and other component pieces.

The longest elements in any ship are generally the keel, keelson, masting elements, and planking. In *La Belle* the longest section of keel is approximately 34 ½ feet, while the longest section of keelson is 40 feet. Masting elements were similar in length, while longest planks were 23 to 26 feet. With the limitations of deck height, it is not likely that the longest these could be maneuvered into the hold. The widest elements

are the assembled frames in the mid-section of the ship, which is a maximum breadth of 15 feet<sup>20</sup>. The assembled frames were also approximately 12 feet from the base to the top of the third futtock. Because frames are essentially large open-ended U-shaped objects, it is conceivable these could be maneuvered into the hatches and stored on the gun deck. It is also possible that the frames could be maneuvered into the lowest hold of the ship and stored there. In both instances, however, it is more likely that the frames would require further dismantling before attempting stowage. Because these were assembled using iron fasteners, dismantling would have been severely limited. A discussion of frame assembly and disassembly practices in the French marine is provided elsewhere.

Another large piece is the stern assembly and transom. Together this piece was 7 feet 6 inches at maximum breadth (SHMR, 1L<sup>3</sup> 19, f. 88v) and approximately 8 feet from the fashion frame to the top of the sterncastle. Unless this piece was further disassembled, it could not fit through the hatchways on *Le Joly*. Other large preassembled pieces would face similar problems of stowage.

Thus, regarding the third issue, i.e., that a boat the size of *La Belle* was simply too large to fit into *Le Joly* despite any overcrowding problem, the evidence is mixed. Clearly, some pieces of *La Belle* could conceivably be maneuvered into the hold of *Le Joly*, but with some difficulty. While many others simply could not, either because they are large one-piece elements or would require complete disassembly to do so. These latter would be relegated to storage on the deck of the ship for the duration of the voyage. These large elements would have represented a substantial portion of the partially disassembled ship.

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<sup>20</sup> The measurement used here is based upon the archaeological evidence rather than on the registry and so it is measured to the outside of the frame.

Deck clutter, while common on ships, was necessarily kept to a minimum to facilitate sailing. The marginal notation by Arnoul that the *barque en fagot* was removed from *Le Joly* to reduce clutter seems to address this inherent problem (BN, NAF 21330, Vol. 25, f. 78r-80v). However, that note does not resolve the more basic question that a ship the size of *La Belle* was simply too large to be loaded onto *Le Joly* despite other considerations. Based upon the known and presumed physical characteristics of *Le Joly* and *La Belle* and the information in the preceding discussion, it is highly doubtful that *La Belle* could have been loaded onto *Le Joly*.

### **Was the Ship in Pieces *La Belle*?**

Regarding the connection between the ship in pieces in the documents and *La Belle*, the ambiguity of the written record and an inability to determine solely from the evidence the maximum size of a *barque en fagot* makes it extremely difficult to either confirm or deny a direct connection between the two. Given this finding what, if any, other circumstantial evidence exists that might provide further insight into this question?

There is no question that it was the King's intent to provide La Salle a ship of 40 to 50 tons for the expedition (Memorandum of 23 March 1684 in Margry 1879 II:378). How this order was fulfilled, however, was left to the discretion of Arnoul and Du Mont. With this understanding, Du Mont had two options: 1) build something new, or 2) use something already in the yard, whether existing or currently under construction.

Arnoul's marginal note referring to a barque that was "... already well advanced ..." in its construction (BN, NAF 21330, Vol. 25, f. 78r-80v) suggests that the first option was preferred. This marginal note was written sometime after April 14, 1684. Exactly how long after that date is unknown. However, the response time suggested by the dates on



and the content in the correspondence between March 23 and April 14, suggested delay of 7 to 10 days, allowing for the time it took to travel from Paris to Rochefort. If so, this marginal note may have been written as early as April 21 or as late as April 23, other considerations being equal.

Certainly by the fourth week of April, Du Mont had to decide. If the ship in pieces to which Arnoul referred in his marginal note would not fit into *Le Joly*, Du Mont had to consider other means to meet the requirements of the King's order. Furthermore, he had to do so quickly.

Correspondence from the King and Seignelay to Arnoul beginning in January 1684 continually stressed the need to organize the ships quickly and for the expedition to be on its way. Seignelay commented on January 16, 1684, that there “. . . was not a moment to lose to finish raising [the soldiers] . . .” for the expedition (AN, Marine B<sup>2</sup> 51, f. 34). This desire to move forward rapidly was echoed by additional letters from the King to Du Mont on February 6, 1684 (AN, Marine B<sup>2</sup> 50, f. 77), April 14, 1684 (AN, Marine B<sup>2</sup> 50, f. 177), and a letter from Seignelay to Du Mont in which he admonished:

. . . you must apply yourselves to work there without loss of time and make it so that the [raising of officers] can be finished at the end of this month (AN, Marine B<sup>2</sup> 51, f. 200, 11 April 1684).

In another demand to move the expedition forward, in mid-May Seignelay wrote to Arnoul:

Unless there is something yet to be done to the vessel *Le Joly*, finish it immediately and send Sieur La Salle expeditiously [on his way] according to the orders that Sieur Du Mont received (AN, Marine B<sup>2</sup> 51, f. 236, 14 May 1684).

Thus, there was clear pressure to on both Arnoul and Du Mont to decide on a ship that could be used in place of the *barque en fagot*, which they removed from *Le Joly*.

Clearly, the attestation from Du Mont on April 9 (SHMR, 1L<sup>3</sup> 19, f. 67r), and the response from the King on April 14, 1684 (AN, Marine B<sup>2</sup> 50, f. 177v-179r), opened the door to the use of a different ship. Although Arnoul stated that the barque in pieces was already well advanced, there is no indication that it was far enough along to be completed soon.

Because all this correspondence took place in a period of less than two months, from March 23 to April 14, and was followed by the letter of Seignelay on May 14 urging immediate action, this suggests that Du Mont may have been forced to choose a ship nearing completion in the yard. The proportions document for *La Belle* (SHMR 1L<sup>3</sup> 19, f. 88v-89r) stated it was completed during the months of May and June 1684. It should be kept in mind that a busy shipyard like Rochefort had many ships under construction simultaneously. Small ships like *La Belle*, which was wide enough to carry a good deal of cargo, could be armed, and was fast, were widely used along the coast. Because the arsenal was in a period of extensive construction and a high state of activity, a ship like this was equally useful in support of both the port and its Intendant.

In fact, *La Belle* may have originally been intended for use by Intendant Arnoul. This hypothesis is supported by two pieces of evidence. The first is a letter from La Salle to Beaujeu while off the coast of Texas:

*J'ay receu l'hausiere que vous avez pris la peine de m'envoyer, dont je vous suis fort obligé. Je vous en envoyé mon billet comme vous me le tesmoignez souhaiter. Il ne seroit pas juste que vous nous fissiez un sensible plaisir à vos despens. Si j'eusse sceu ce qui a este fourny pour la barque de M. l'Intendant [emphasis added], il l'auroit payé comme les cordages qu'il a eus de moy (AN, Series Colonies C<sup>13</sup>, f. c3, 18 December 1684)<sup>21</sup>.*

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<sup>21</sup> I received the hawser that you took the pain to send me, for which I am very  
(continued...)

The second piece of evidence is an entry from the journal prepared by the engineer Minet describing the fleet's voyage to the gulf in 1684-1685 while on *Le Joly*.

We left from the *chef de bois* before La Rochelle the 24th of July 1684, with four ships of our company: *Le Joly*, the frigate *La Belle*, which the King gave him *instead of the little bark that was requested* [emphasis added] . . . (translated by Bell 1987:84).

In both the letter to Beaujeu and in Minet's comment the boat being referred to was clearly *La Belle*. The journal notation and letter together are the least ambiguous of the references to *La Belle*'s genesis providing a clear indication that there was in fact a substitution.

Therefore, regarding the fourth and last question, was *La Belle* the ship in pieces? Given the pressure to quickly comply with the wish of the King that the expedition was on its way, and the short time span involved, it seems likely that the ship that they eventually called *La Belle* was nearly complete and was not, in fact, the boat in pieces that was referred to elsewhere. Furthermore, sufficient additional circumstantial evidence exists, beyond the physical inability of the ship to fit onto *Le Joly*, to support this conclusion. Thus, they substituted *La Belle*, a ship nearing completion in the yard and originally projected for the Intendant, for the still to be completed little *barque en fagot* that was first requested.

### **Frigate, Barque, or Barque Longue**

*La Belle* is variously referred to in contemporary documents as a merchant ship, a

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<sup>21</sup>(...continued)  
obligated. I send you this note for it, as you wished and expressed to me. It would not be accurate [to say] that you gave us a noticeable pleasure at your expense. If I had secured what had been well stocked *for the barque of Monsieur Intendant* [emphasis added], he would have paid for it with the cordage that he obtained for me

barque, a frigate, and a barque longue. The difference between these ship types is more than mere semantics and is, for this study of the hull, an important issue to resolve. The archival documents that described the ship provide what can be considered its maritime classification. These fall into two general categories: unofficial commentary and authoritative texts. In the former are letters, memos, journals, and testimonies and in the latter are the several official lists and registers previously described. Not surprisingly, it is in the former that there is the widest divergence.

For example, in Henri Joutel's journal the ship was mentioned several times and generally called a frigate:

On the 2<sup>nd</sup> day of October the store ship L'Aimable and the frigate *La Belle* arrived (Foster 1998:54).

*La Belle* dragged her anchor and proceeded to strike the bowsprit of our ship splitting the yard of the bowsprit and the topgallant sail . . . . The frigate had a broken mizzen mast and lost a good 100 fathoms of hawser and the anchor (Foster 1998:64).

He was of the notion that the frigate had left and was going to the islands from where he would have news of her (Foster 1998:134)

The first question was where the ship, *La Belle* was. They answered that she had perished, or rather gone aground on the other side of the bay and that only six [seven] had escaped. They were all in the canoe, namely . . . Tessier, who was one of the masters of the frigate . . . (Foster 1998:135).

In the Minet journal it was also called a frigate: "We left from the *chef de bois* before La Rochelle the 24th of July 1684, with four ships of our company: *Le Joly*, the frigate *La Belle* . . ."

In Meunier's interrogation it was called both by the generic term vessel and frigate: "It was decided that the vessel, *La Belle* should be brought in . . ." (Foster 1998: 286); and "La Salle spent all of the winter sounding and inspecting the whole of the surrounding bay, trying to bring the eight-piece frigate closer inside . . . . The frigate

was broken into pieces on the north shore by a wind that threw her onto the coast ”  
(Foster 1998:288).

La Salle called the ship a barque in a letter to Beaujeu: “If I had secured what had been well stocked for the barque of Monsieur Intendant . . .” (AN, Colonies C<sup>13</sup>, f. c3, 18 December 1684), and Beaujeu called it a *meschant vaisseaux* in a letter to La Salle during the expedition:

We will use, if you please, the signals that I gave here before, and in case that we are attacked, I would judge and propose that you make way with *La Belle* while I will amuse the enemies, because you are not well sent to fight, and with only a merchant vessel that you would have difficulty defending yourself (AN, Colonies C13<sup>c3</sup>, 23 November 1684).

Arnoul also referred it as a barque in a letter to Seignelay, to whom the comments of Beaujeu were forwarded after his return from the gulf: “. . . it is not impossible that [La Salle] is going to look for [the river] on the land or in the barque *La Belle* that he retained” (BN, NAF 21331, Vol. 26, f. 307, 8 July 1685).

It is not surprising that La Salle, Minet, and Joutel called the ship both frigate and barque. Their general unfamiliarity with nautical terminology and ship classification and experience likely account for this. However, even the letters written by Beaujeu and Arnoul, men who were ostensibly familiar with ships and their classification, differed depending upon time, circumstance, and possibly the person to whom they were writing. The obvious question is why the difference in usage by knowledgeable men?

Lescallier (1777:165) defined the term barque as a “ship particular to the Mediterranean . . . short and full . . . [with rigging that is] a mizzen mast with topmast, a mainmast with three square sails, and a foremast with calcet . . . and one Latin sail, without a bowsprit.” In Ollivier’s extensive treatise on construction published in 1736, which is a long dictionary of maritime terms, barque does not even appear. While in the

multi volume *Encyclopédie Méthodique Marine* (1783-1787) barque was defined as:

The general name of a multi-decked ship of 100 to 150 tons that can be rigged in different manners from which it takes its particular name ... they are as fit for war as for commerce; these ships are quite short and bluff, with their fullness forward and almost no narrowing, with not much change until the middle; they have a lot of rake and projection [of the stem] beyond the end of the keel (1783, I:116).

English-speaking sailors commonly used bark or barky in an informal sense, much like a nickname, when referring to their own ship or another ship in the fleet rather than to denote a particular type of ship or even a particular type of rig. Thus, the term barque, was also a generic or informal term similar to the use of bateau to suggest a rowed or small boat in Canada. Because of their informal nature, letters, journals and similar documents are not generally good indicators upon which to base a determination of ship classification.

Of more use were the four authoritative lists and the proportions document<sup>22</sup>, previously described, that mention *La Belle*. On each of the four official naval lists, which were forwarded to Versailles, *La Belle* is included under the classification barque longue. It is only on the ship's proportion document, which is a declaration by the arsenal's Council of Construction that a specific ship of a specific size was built, was the ship referred to as a barque. This declaration, unlike the official lists, remained at the arsenal and was used to account for expenditures and ship constructions. This type of document was also likely used in partial fulfillment of the order of 16 September 1683,

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<sup>22</sup> *Armemens des Vaisseaux du Roi en 1684*, Musée de la Marine, Paris, J2583, f. 102; *Liste des Vaisseaux du Roy [sic] du Département de Rochefort, Juillet 1687*, SHMR, 1L<sup>3</sup> 20, f. 1v-9r; *Liste des Vaisseaux, Frégattes, Brulots et autes batiments du Port de Rochefort, 1688*, SHMR, 1L<sup>3</sup> 20, f. 24v; *Vaisseaux du Roy [sic] du Département de Rochefort 1688*, SHMR, 1L<sup>3</sup> 20, f. 32v-33r; and Proportions of a barque named *La Belle*, 15 December 1684, SHMR 1L<sup>3</sup> 19, folio 88v-89r.

which required a plan to be drawn up of each ship built, and an earlier order requiring the council to approve and certify the construction of both ships and buildings at the arsenal (AN, Marine B<sup>2</sup>, in Rieth 1998:111). The proportion declaration, therefore, was not a document that necessarily reflected a ship's naval classification.

Based upon the four naval documents, *La Belle* was classified as a barque longue in the manner of the French marine of the late 17<sup>th</sup> century. This official classification must carry the most weight in any consideration of ship type. In the absence of other definitive documentation or evidence, it is to that ship type the remains should be compared and evaluated.

### **Barque Longue of the 17<sup>th</sup> Century**

Scholars have a variety of sources and methodologies at their disposal for the investigation of construction and identification: contemporary written sources, contemporary images and plans, archaeological remains, and ethnographic survivals. The least ambiguous are the archaeological remains and formal plans, often the most confusing are written sources, the most fraught with misinterpretation are ethnographic survivals, and often the most romanticized and idealized are the images. Of these four, written descriptions and contemporary images are the archaeologists' best clues to piece together a picture of the ship as it was when sailing.

Archival materials that include contemporary ship registries, proportion documents, notarized contracts, dictionaries, and treatises, provide a good source of data although they are subject to errors in copying and accuracy. Despite these potential shortcomings, these sources are among the first to be sought and examined when attempting to define, describe, and characterize a ship or ship type and its salient

statistics.

For this study of the barque longue as a ship type, several treatises and dictionaries were examined. No mention was made of the barque longue in the earliest known French treatise on ship construction by Georges Fournier, *Hydrographie cotenant La Theorie et la Pratique de toutes le Parties de la Navigation* (1643). Dassié's treatise on naval architecture included definitions of a few ship types, but the barque longue was not among them (1695:8-10). He only generally mentioned the barque longue in a list of ships characterized as good for the open sea including it with the galleon, patache, flûte, frigate, brulot, gabarre, and caravel. Among those he described as less seaworthy in that respect were the chaloupe and barque. Elsewhere in *L'Architecture Navale* Dassié (1695:68-70) provided the salient dimensions for various ships roughly organized by size. At the smaller end of the scale he included the dimensions of the corvette and double chaloupe, with which the barque longue is closely associated, and the barque longue (Figure 2-5). The barque was not included in his list.

**Figure 2-5: Dimensions of Corvette, Barque Longue, and Chaloupe**  
(after Dassié 1695:68-70)

	Corvette	Barque longue	Chaloupe
length of keel	50 feet	40 feet from stem post to stern post	30 feet from stem post to stern post
breadth	16 feet	9 feet	7 feet
depth of hold	8 feet	absent	3 feet
height of sternpost	10 feet	6 feet	absent
height of stem post	12 feet	7 feet	absent

Ollivier made no mention of the barque longue in his 1736 treatise. He did, however, describe the double chaloupe:

These are bigger chaloupes [shallops] than those that one embarks in the



ships of the line, that have a deck or only a half deck, they act as a coast guard and to the trade. Their length from stem to the stern post is from 40 to 50 feet, their width is of about 5 inches 3 lines by foot of their length and their depth of hold is of 4 inches 6 lines by foot of their width. Their hulls are similar to those of the shallops of the ship of the line, and they have their deck or half deck above, dead work of about 18 inches height to the middle and forward and of 2 feet to 2-1/2 feet behind.

When double shallops are destined for war, one establishes several swivel gun mounts on every side. Their mast is the same as that of the shallops of the ship of the line when they carry lateen sails but otherwise they have a mainmast that carries a big square sail and a big topsail, a foresail mast that carries only one square sail, and a bowsprit mast where one tacks the jib. Most double shallops, particularly those that have square sails, have a cutwater similar to the one of the ship of the line (1736:88).

He also described the corvette:

It is a small frigate that goes to sails and oars and that carries from 4 up to 16 or 18 cannons. One uses the corvettes for piracy, to escort small fleets, and following a naval army to discover and to carry news. The corvettes are 50 to 80 feet of length from the stem to the stern post, their width is of about 3 inches 3 lines by foot of their length, their depth of hold to the middle is of 5 inches or 5 inches 2 lines by foot of their width . . . . The hulls of the corvettes are similar to those of the frigates. Their deck is cut aft of stern post to 15 or 16 feet in the big corvettes and only to 8 or 9 feet in the smallest; in this space a floor is situated below . . . the level of the deck and on which one establishes the captain's room. Above this, the forecastle is elevated 5 feet or 5 feet 3 inches. Most also have a castle forward, of about 10 feet of length, elevated 4 feet or 4 feet 1 inch above the deck. The corvettes are pierced for 2, 3, 4, 5, 6, 7 or 8 ports, on both sides for cannons of 4 or 6 pounds. They are also pierced of several ports for the oar ... Most corvettes have masts similar to that of the ship of the line, that means a mainmast and a foresail mast that each carry a topmast and a topgallant sail, a mizzenmast that carries a topgallant sail, and a bowsprit mast .... The small corvettes don't carry topgallant sails, nor a mizzenmast; some don't have a small topmast. There are also some that are masted for a boom and gaff (1736:115-116).

Du Monceau did not mention the *barque longue* in his important treatise *Elémens de l'architecture navale, ou traité pratique de la construction des vaisseaux* (1758),

which focused on larger ships of the line. He did, however, mention the corvette:

The custom is to distinguish the different size vessels by classes that one calls ranks; the largest are of the first rank, and the smallest are of the

third: past this term, these are the frigates, that one distinguishes by the number of the cannons that they carry; the smallest are called corvettes . . .

[Ships with less than] 20 cannons . . . are no longer considered frigates; one names them corvettes, and distinguishes them, as with the frigates, by the number of their cannons. A corvette of 16 cannons only has one deck, a forecastle of three beams forward of the big capstan, and a castle forward. A corvette of 12 cannons has a deck, a forecastle, two beams forward of the big capstan, and a castle of 15 feet of length. One finds it more convenient to make these small ships [with] a cut in the front deck and to the rear, so that the lodgings are there more practicable; so that the cannon only occupies the middle. The corvettes have 12 or 8 cannons of 4 [pounds caliber] (1758:56, 58, 62).

While not directly describing a *barque longue*, in his *Dictionnaire historique, théorique et pratique de marine* Alexandre Savérin (1758:np) defined the corvette as, “a *barque longue* species” describing that as a small ship without a deck also called a *double-chaloupe*. Lescallier (1791:np) defined the *barque longue* as: “a double *chaloupe*, a sort of *pinace* [sic], or large long-boat”. He did not include a definition of double *chaloupe*, but described a *pinnace* as a “square-sterned vessel” and the corvette as “a sloop of war” (1791:np).

The *Encyclopédie Méthodique Marine* (1783-1787) did not include a definition of a *barque longue*. However, it did define the *chaloupe* and *double chaloupe* as:

[A] *Chaloupe* is the biggest boat that a vessel can embark; the *shallop* serves to unload and to load the ship . . . . *Chaloupe canonnière* [gunboat] is a longer *shallop* than all other *shallops*; it goes very well to the sail and to the oar. A *chaloupe canonnière* cannot have less than fifty feet of length and some have sixty-six; it carries a cannon, some have two, as bow chasers, of 18, 24 or 36 [caliber]; it is excellent to defend a coast . . . . *Chaloupe double* or *double chaloupe*, is what one calls a *shallop* whose [hull] side is raised more [i.e., higher] than the plain *shallops*, and it is decked from end to end . . . The English have double *shallops* of 8, 10 & 12 cannons (1783 I:302).

The encyclopedia also defined a corvette as:

All ships that make superior way at sea, and that carry less than twenty cannons in battery, is a corvette; its use is to carry orders and packages; ...

the corvette is the most difficult ship of its kind to execute well (1783, I:629).

With the exception of Dassié, who mentioned the *barque longue* in passing and gave some general dimensions, and Lescallier, who defined the *barque longue* as a double *chaloupe*, there is little written in contemporary documents that provide much description of the type.

In lists of the marine sent annually to Versailles, similar to those previously discussed, the ships are grouped according to their ranks followed by frigates, and *bâtiments interrompus*, that is, ships that do not fall in the official ordering by ranks and are not frigates. According to Boudriot (1990:6), one such list dated to 1675 included nine unnamed *barque longues* in the latter category. By 1676 *barque longues* were recognized in the French marine as a separate category and appeared on the annual lists after the light frigates and before the *bâtiments interrompus* (Boudriot 1990:6). The earliest known *barque longues*, however, appear to date to 1671 and were built in Brest and Dunkerque (Appendix A).

The category of *barque longue* persisted unchanged until 1696, when it was modified to read *corvette* or *barque longues* (Boudriot 1990:6). This combined category probably reflects the evolutionary changes that the type was undergoing at the end of the 17<sup>th</sup> century. The combined category persisted for another 50 years, until 1746, when the classification *barque longue* was dropped and the category *corvette* stood alone. The change in the classification scheme is clearly reflected in the contemporary treatises and dictionaries; the Fournier treatise written before the type appeared, the Dassié treatise written at the cusp of the change from *barque longues* as a single category to one combined with *corvette*, and the du Monceau treatise, Lescallier dictionary, and

*Encyclopedie Methodique Marine* written as much as 50 years after the classification disappeared. Because it was written when the barque longue and corvette were classified together, it is surprising that the Ollivier dictionary, so thorough in all other respects, did not include a description or definition of a barque longue. His omission of the barque longue appears to reflect the growing importance of the corvette for which he did provide a detailed description (Ollivier 1736:115). Through these documents it is possible to trace the development of the barque longue as a ship type.

Written documents, however, are only one source of information. Contemporary depictions through paintings, woodcuts, ship drawings, and images on coins, medallions, and similar objects, along with models are also useful sources. Unfortunately, only two contemporary images attributed as barque longues have appeared during this research. However, there are several contemporary images of the double chaloupe, barque, and corvette available for comparison.

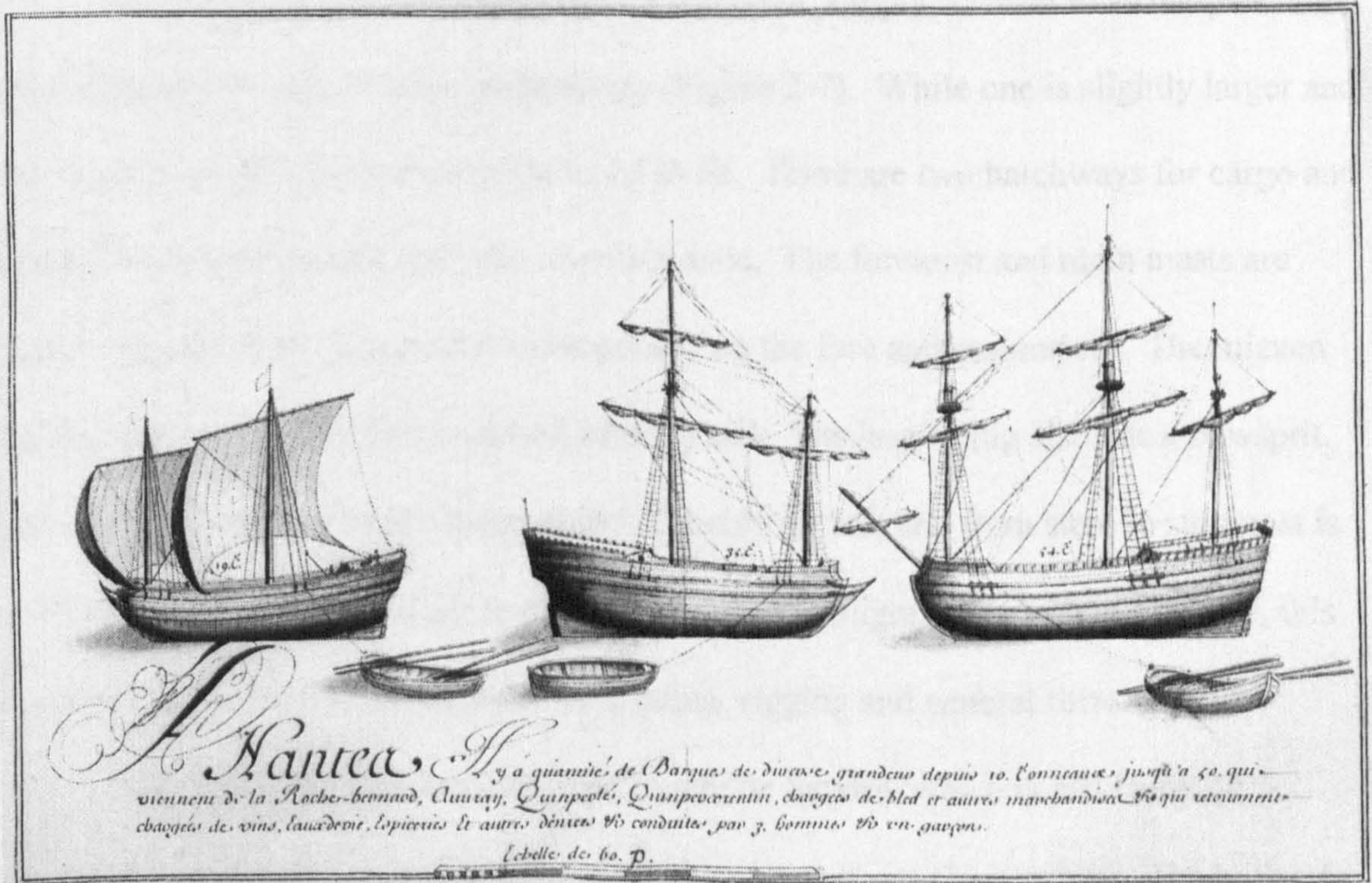
The artist/illustrator Jean Jouve undertook to document the ships of France at the beginning of the last quarter of the 17<sup>th</sup> century. Published in 1679, Jouve's two albums depicted both merchant and fishing ships plying the waters of the Atlantic west coast of France and the Mediterranean. Jouve drew nearly 40 ship types from the largest ocean going merchantmen to the smallest near-shore skiffs. Vergé-Francheschi and Rieth (1992:9-10) described the quality of those drawings:

Jouve, his disciples or collaborators, accomplished a work of superior quality concerning the accuracy and quantity of information. The plates are less numerous [than those of the Mediterranean], but the data contained in them constitute a real iconographic and historic resource . . . . For the ships of the Ponantais [west coast], every plate is accompanied by several lines of explanation giving with precision the type of ship, its maximal and minimal tonnage, its possible number of cannons, the number of men, the harbors in which one finds these ships, the composition of their cargos and their destination.

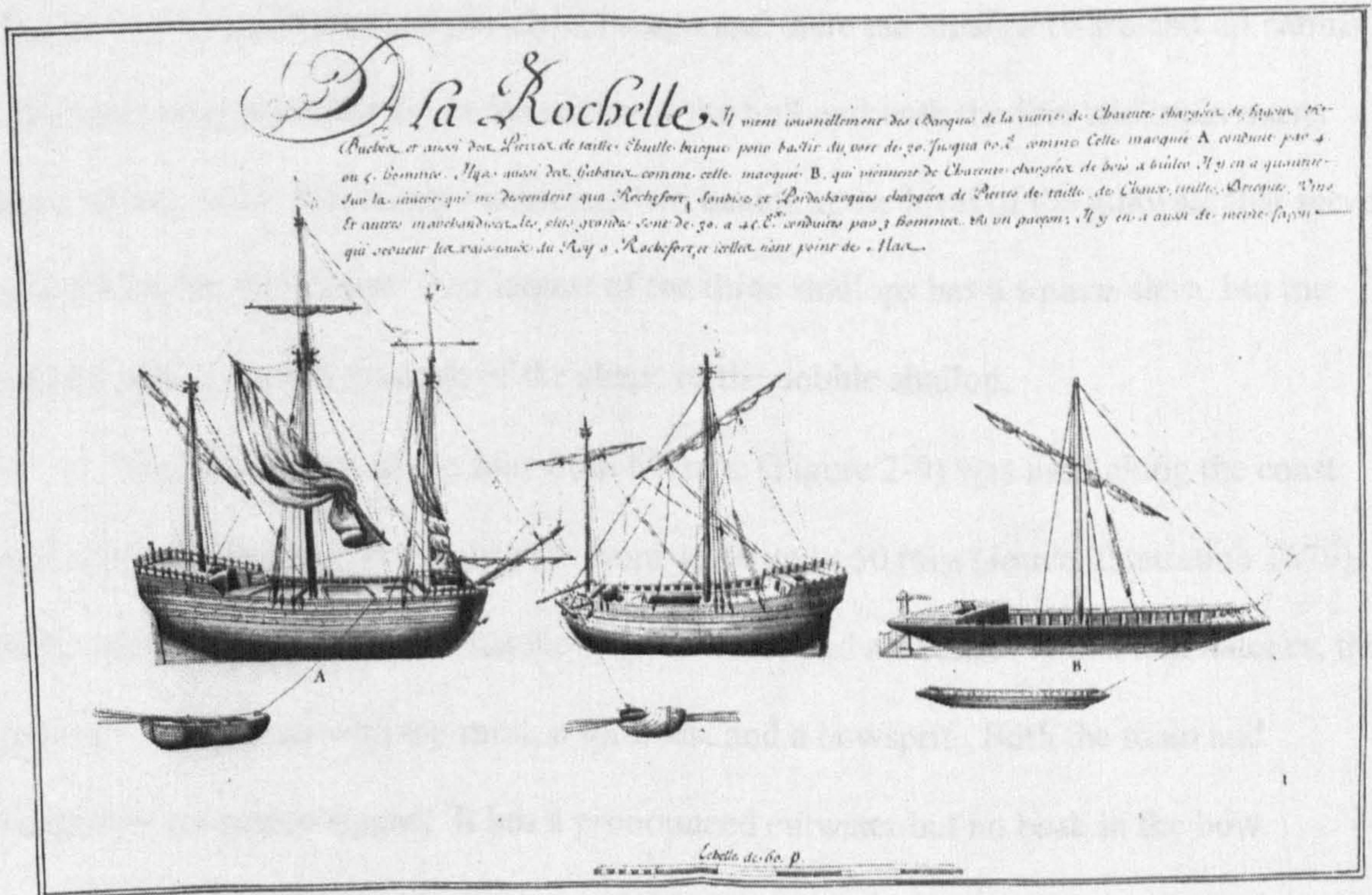
Of particular interest to this study are Jouve's illustrations of the ships found on the west coast from Nantes to Bayonne, which include ships identified as lighters, flutes, frigates, pinasses, shallops and double shallops, barges, and flibots, among others. He also took care to include ships of a variety of sizes in each of these classifications. Unfortunately, the albums did not include ships of the north coast, which would have included Brest, Le Havre, and Dunkerque.

Although the individual plates are not dated, they were drawn over several years from 1675 to 1679, when they were published for the first time. This period coincides with the earliest years of barque longue construction, which was concentrated in the northern arsenals of Brest, Dunkerque, and Le Havre. It is not surprising, therefore, Jouve did not include the barque longue. The plates also did not include an example of the corvette, which did not come into widespread use until more than 20 years after the album was completed.

Because of the excellent detail in the illustrations and accompanying notes, some useful information can still be gleaned from their examination. Of the three boats from Nantes, all of which were referred to as barques, the boat in the center and on the right are the most similar in tonnage and dimensions to that of *La Belle* (Figure 2-6). The smaller ship, which is 35 tons, is approximately 40 feet on the keel and 45 feet from stem to stern. It has only two masts with a topmast and square sails. Noticeably absent are a mizzen mast and a bowsprit. The larger ship is approximately 45 feet on the keel and 55 feet from stem to stern. This ship has three square-rigged masts with top masts on the foremast and main, it also has a bowsprit. If the illustrations of Jouve can be trusted, this masting configuration appears typical of ships of these general sizes. Both have low fore and aft castles and the smaller ship has an obvious beak in the bow.



**Figure 2-6:** Ships of the Nante region. Illustration by Jean Jouve 1679 courtesy Musée de la Marine, Paris.



**Figure 2-7:** Ships of La Rochelle. Illustration by Jean Jouve 1679 courtesy Musée de la Marine, Paris.

The two fully-decked ships from La Rochelle, simply referred to as barques, are approximately 60 and 30 tons, respectively (Figure 2-7). While one is slightly larger and one slightly smaller, both are similar to *La Belle*. There are two hatchways for cargo and hatches in the stern castle and very low forecastle. The foremast and main masts are square rigged and the larger ship has topmasts on the fore and mainmasts. The mizzen on the larger ship looks like it carried a lateen sail. The larger ship also has a bowsprit. The length of the keel on the larger ship is roughly 45 feet and from stem to sternpost is approximately 55 feet. Similar to the Nantes ship and slightly larger than *La Belle*, this illustration nonetheless is useful for its masting, rigging and general form.

The four ships illustrated for the Riviere de Seudre, which is just south of Rochefort, included a large pinnace and three small shallops (Figure 2-8). The hulls of the shallops are fine, with thick wales on the outside and a clamp visible on the inside. The undecked middle area is clearly for cargo and there are small forward and aft cabins. The main mast is essentially in the center of the hull and both the fore and main masts have square sails. Just barely visible are two beams at the level of the gunwale that serve to stabilize the main mast. The largest of the three shallops has a square-stern, but the middle ship is a good example of the shape of the double shallop.

The largest ship of the four from Mornac (Figure 2-9) was used along the coast and was described as commonly built from 15 to up to 50 tons (Jouve illustration 1679). Fully decked with two central hatches and low fore and aft castles with small hatches, the ship has a mainmast with top mast, a foremast and a bowsprit. Both the main and foremasts are square rigged. It has a pronounced cutwater but no beak in the bow. Approximately 48 feet on the keel, the ship is close to 60 feet overall. The two smaller

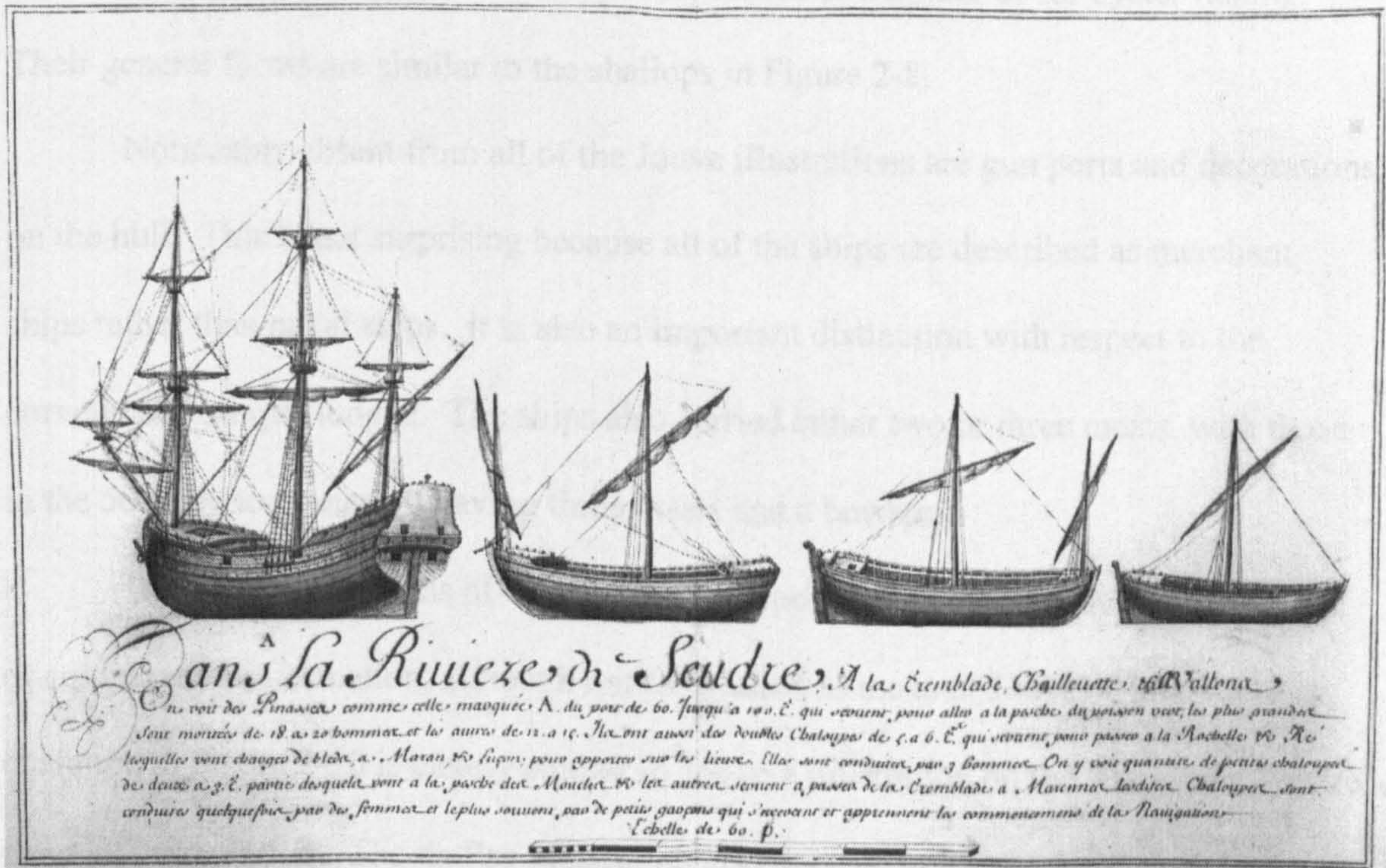


Figure 2-8: Ships of the River Seudre drawn by Jean Jouve 1679. Courtesy Musée de la Marine, Paris.

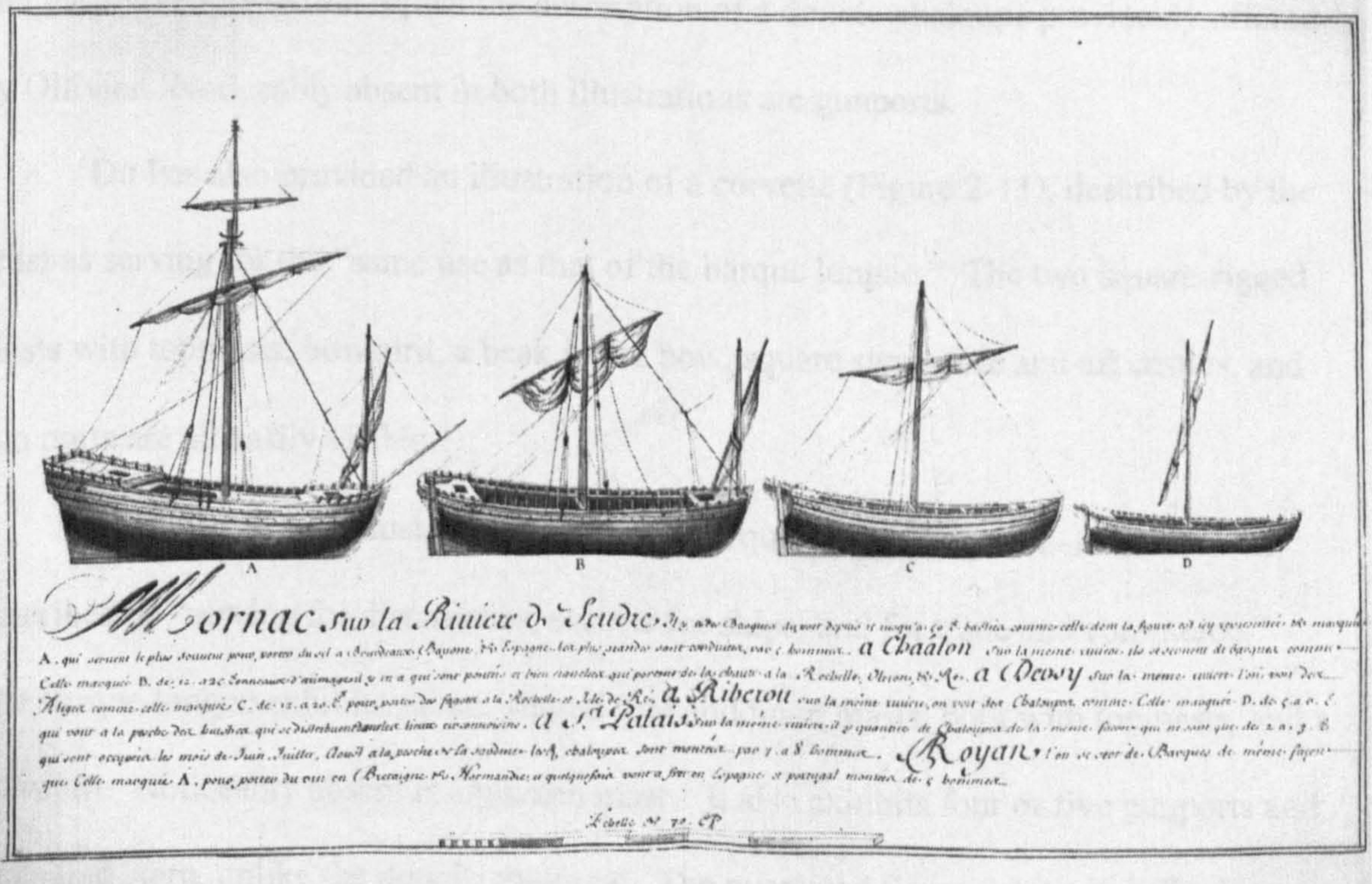


Figure 2-9: Ships of Mornac drawn by Jean Jouve 1679. Courtesy Musée de la Marine, Paris.



boats, C and D, are identified as shallops and served as a lighter or for oyster fishing.

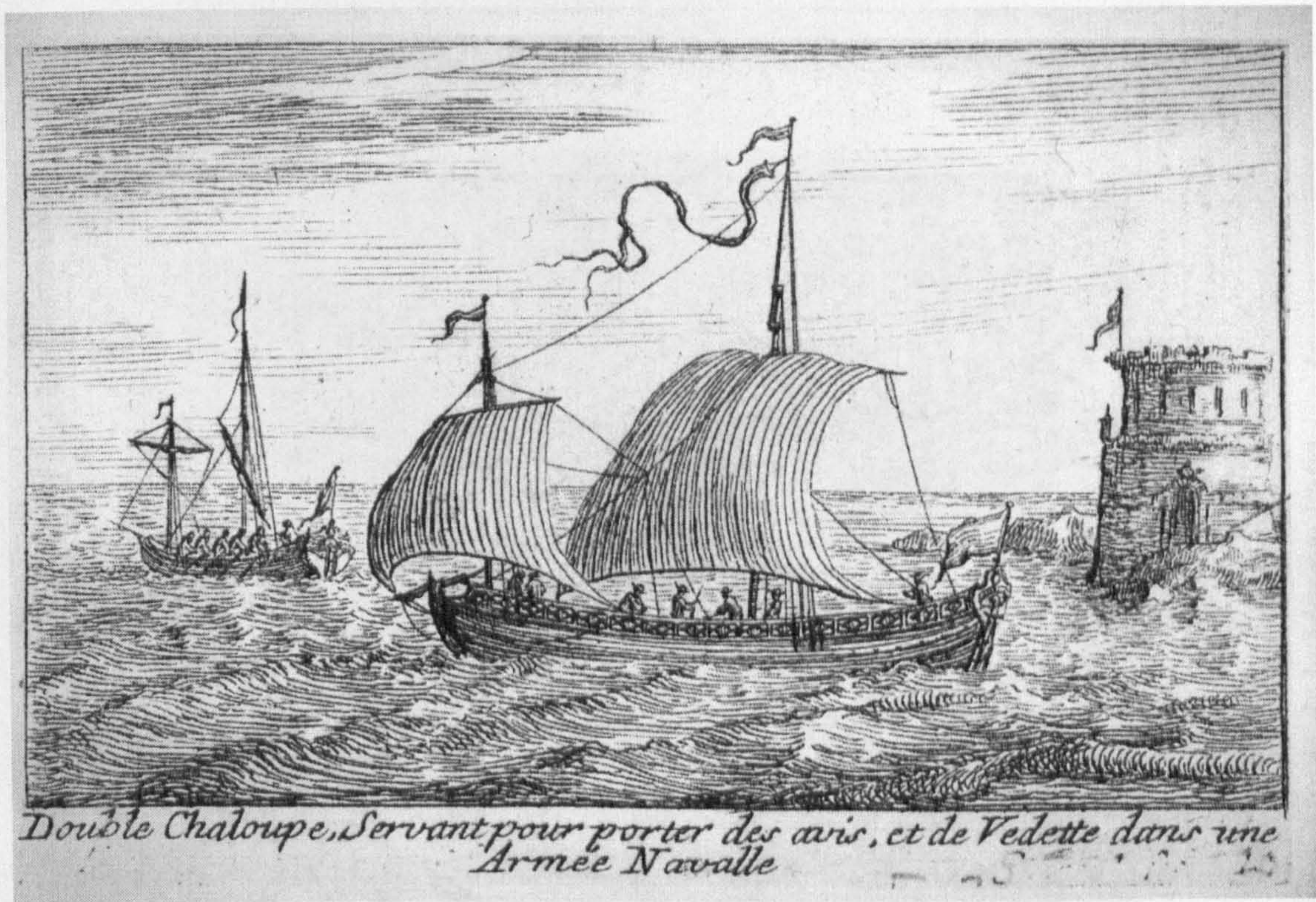
Their general forms are similar to the shallops in Figure 2-8.

Noticeably absent from all of the Jouve illustrations are gun ports and decorations on the hull. This is not surprising because all of the ships are described as merchant ships rather than naval ships. It is also an important distinction with respect to the corvette and barque longue. The ships also carried either two or three masts, with those in the 50 to 60 ton range all having three masts and a bowsprit.

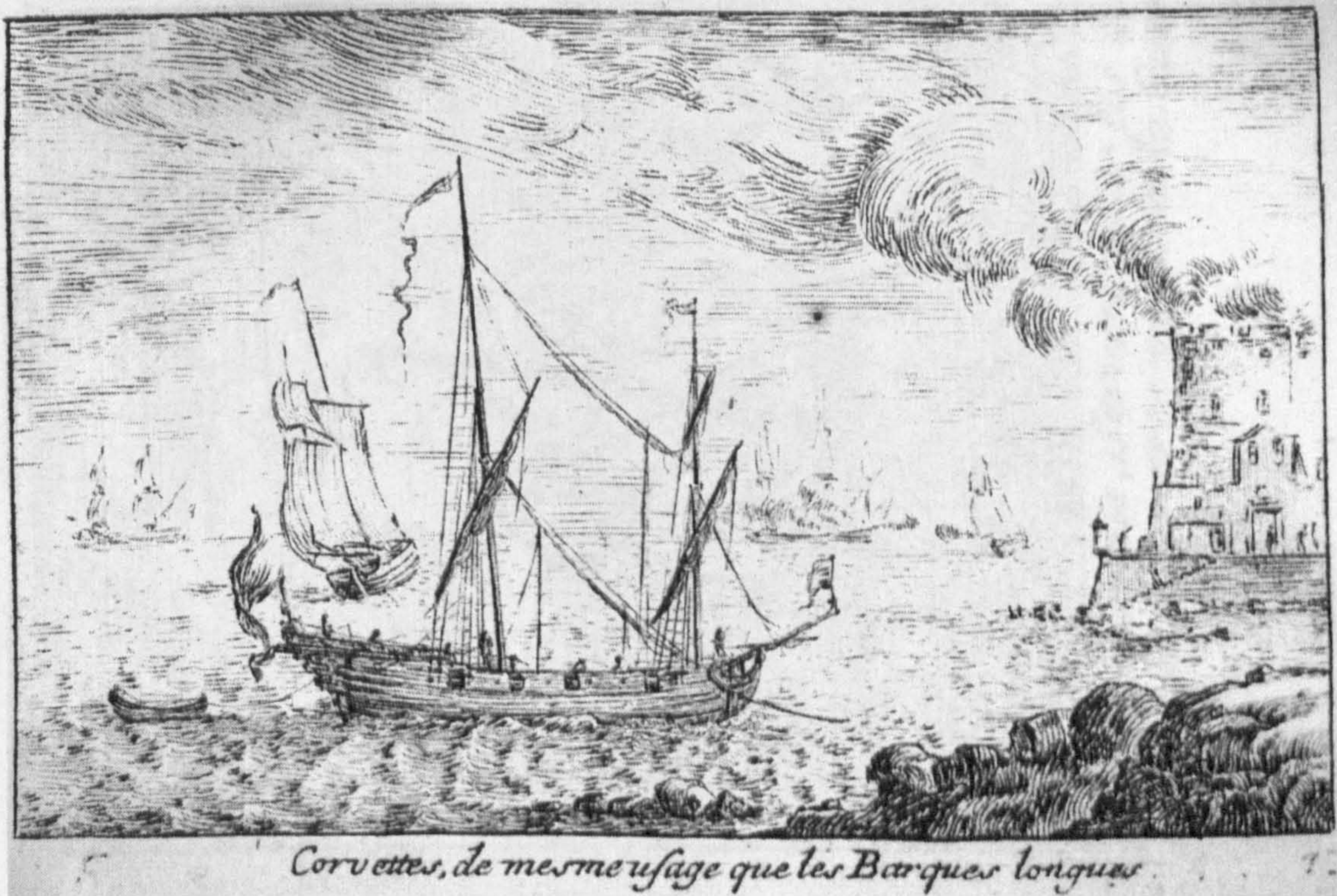
The three illustrations of Guérolt du Pas, published in 1710, provide a good deal of comparative information, although not as detailed as those of Jouve. The double chaloupe in Figure 2-10 is clearly similar to Jouve's illustration on the Riviere de Seudre from 30 years earlier. The du Pas illustration also appears to have a small beak in the bow and the hint of a bowsprit. With two square sails and a sleek hull design, both this and the Jouve illustration reflect the description of a double chaloupe previously offered by Ollivier. Noticeably absent in both illustrations are gunports.

Du Pas also provided an illustration of a corvette (Figure 2-11), described by the artist as serving for the "same use as that of the barque longue." The two square-rigged masts with topmasts, bowsprit, a beak in the bow, square stern, fore and aft castles, and gun ports are all easily visible.

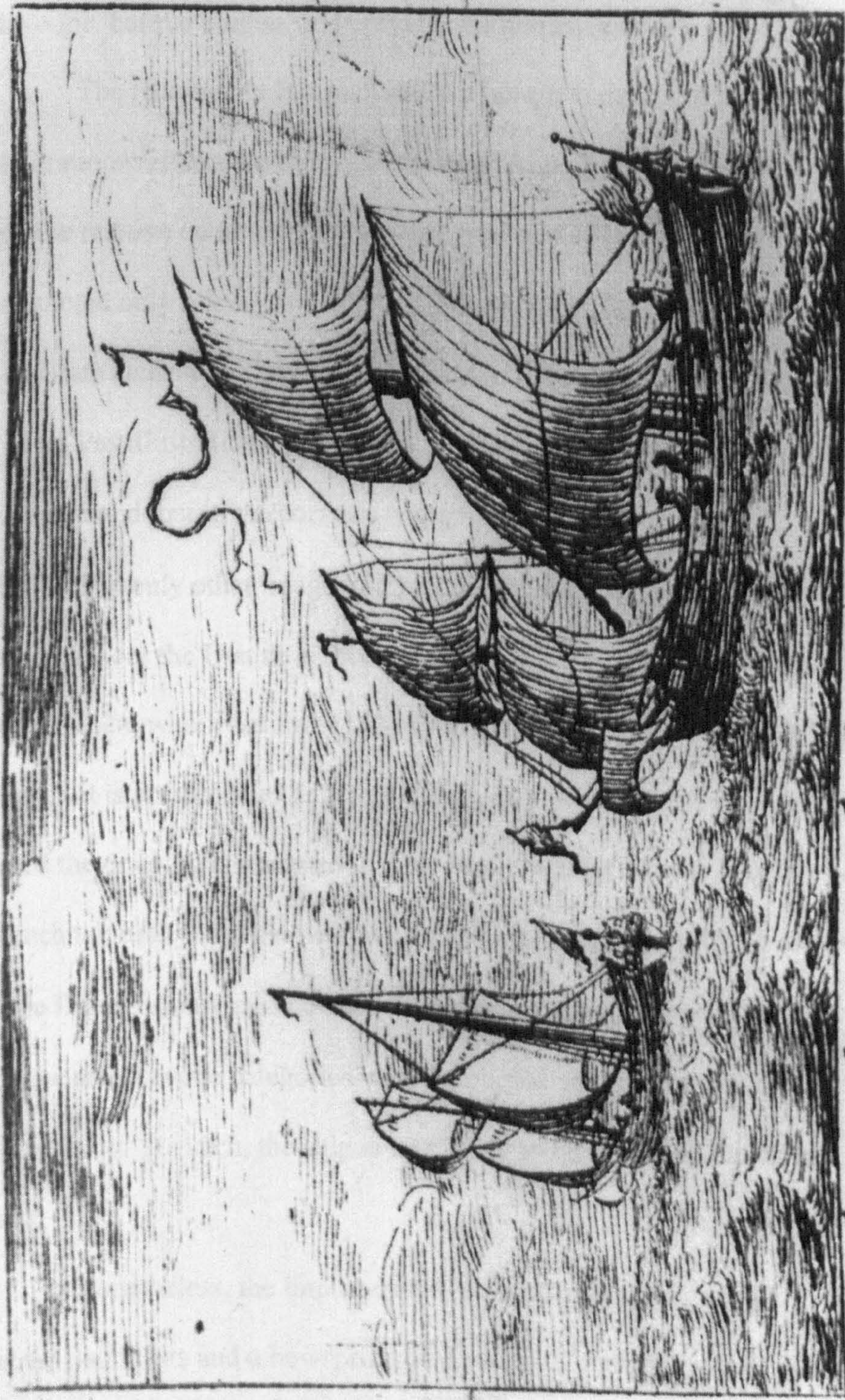
The third du Pas illustration is that of a barque longue (Figure 2-12), which he described as "serving for discoveries, escorts for ships, and for trade and commerce." The barque longue exhibits square-rigged fore and main masts, both with topmasts, and a bowsprit. Noticeably absent is a mizzen mast. It also exhibits four or five gunports and a squared stern, unlike the double chaloupe. The oversized figures make it difficult to judge size, however, it appears there is a low stern castle. The image is too imprecise to



**Figure 2-10:** Double chaloupe illustrated by Guérolt du Pas 1710. Courtesy Musée de la Marine, Paris.



**Figure 2-11:** Corvette illustrated by du Pas 1710. Courtesy Musée de la Marine, Paris.



*Barque longue, servant pour les découvertes, à escorter les bat. March. et faire le Commerce pendant la Guerre. F. II*

Figure 2-12: Illustration of a barque longue by Guérolt du Pas 1710. Courtesy Musée de la Marine, Paris.

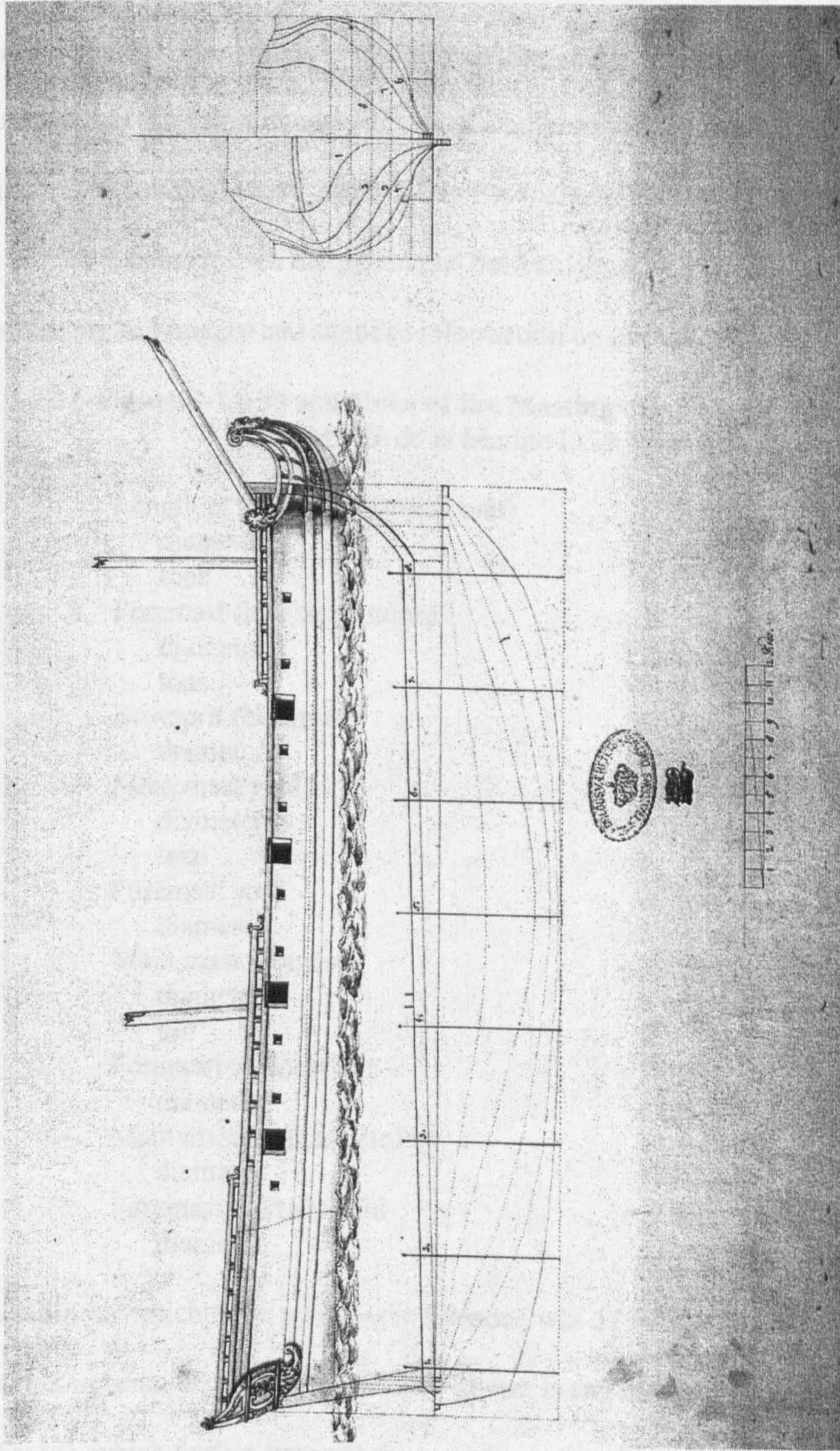
detect the presence of a forecastle, although it does appear to have a beak in the bow.

While the lack of scale hampers analysis, the similarities between the shape of the double chaloupe, barque longue, and corvette are unmistakable.

The fact that du Pas included the barque longue and corvette in his suite of illustrations reflects the thirty-plus year difference between the Jouve and du Pas efforts and the relative commonality of both types of ships. The Jouve illustrations were completed only a few years after the barque longue was listed in the French marine under a separate category. They were also drawn at ports where the barque longue was a rarity. The du Pas illustrations, in contrast, were completed while the barque longue was common and just as the corvette was gaining in popularity.

The only other image of a barque longue, and perhaps the most revealing, is a drawing from the Danish archive (Figure 2-13). It is from the collection of Admiral Peter Raben, who lived from 1661 to 1727. According to archivist Henrik Stissing Jensen, it is presumed to date to the last years of the admiral's life, ca. 1725. Jensen noted the drawing is assumed to have been made by Danish Naval officers visiting the French admiralty in what was an effort at espionage (Henrick Jensen pers. comm. 2000). If the Danish archivist is correct, then this drawing dates well into period after the barque longue and corvette categories were combined and when the corvette was in its ascendancy. As such, the ship is less likely to be typical of the barque longue during its peak.

Nonetheless, the importance of this drawing is the wealth of detail. It clearly shows two masts and a bowsprit, square stern, a beak in the bow, low fore and aft castles, and four gunports. Careful measurement of the image revealed that it is 50 feet 3 inches from stem to stern post, 13 feet 3 inches at its maximum beam, and 46 feet on the keel.



**Figure 2-13:** Illustration of a French barque longue circa 1720 from the Admiral Peter Raban Collection. Courtesy Danish National Archives, G3126.

Its hull is clearly sleek and low with a length-to-breadth ratio of 3.78 to 1. Noticeably absent is a mizzen mast. The absence of this mast may be an important feature of the barque longue. This ship is also highly decorated at both the bow and stern. When compared to the Jouve images, it is most similar to the Nante barque of 35 tons (refer to Figure 2-6) and the barque longue of du Pas (refer to Figure 2-12).

A document for a barque longue built at Dunkerque in 1693 compliments the definitions and images and supplies information on masting (Figure 2-14).

**Figure 2-14: Proportions of the Masting of a Barque Longue, 1693**  
(After Musée de la Marine J355, 8 January 1693).

Length of main mast (grand mât)	57 feet
diameter	11 inches 1 line
tons	6
Foremast (mât de misaine)	40 feet
diameter	9 inches
tons	4
Bowsprit (beaupré)	20 feet
diameter	12 inches
Main mast yard	31 feet 6 inches
diameter	7 inches
tons	1
Foremast yard	26 feet
diameter	5 inches 6 lines
Main mast topmast	23 feet
diameter	6 inches
ton	1
Foremast topmast	16 feet
diameter	4 inches
Main mast topmast yard	24 feet
diameter	5 inches
Foremast topmast yard	17 feet 6 inches
diameter	3 inches 6 lines

The ship for which these masts were intended was 57 feet on the keel and had a maximum beam of 16 feet. Noticeably absent is any mention of a mizzen mast (mât de artimon), which further supports the hypothesis that the absence of this mast is an important feature of the classic northern barque longue.

From these definitions, images, and the masting document it is possible to define the essential features of the classic barque longue, that is, the barque longue of the northern arsenals. Growing out of the basic chaloupe design with a low sleek hull and two square-rigged masts, the ship grew in tonnage with the addition of decks, gun ports, low fore and aft castles, rigged top masts and bowsprit. A decorated square stern and a beak in the bow are indisputable. Used for commerce, military escort, messages and packages, and for exploration where shallow draft and maneuverability were prized and where arming was necessary, it was clearly adaptable. Because of its small size, it required only a limited crew. As the usefulness of this basic design was recognized, it was transformed to the sleeker, faster, larger corvette style losing its barque longue classification completely by the middle of the 18<sup>th</sup> century.

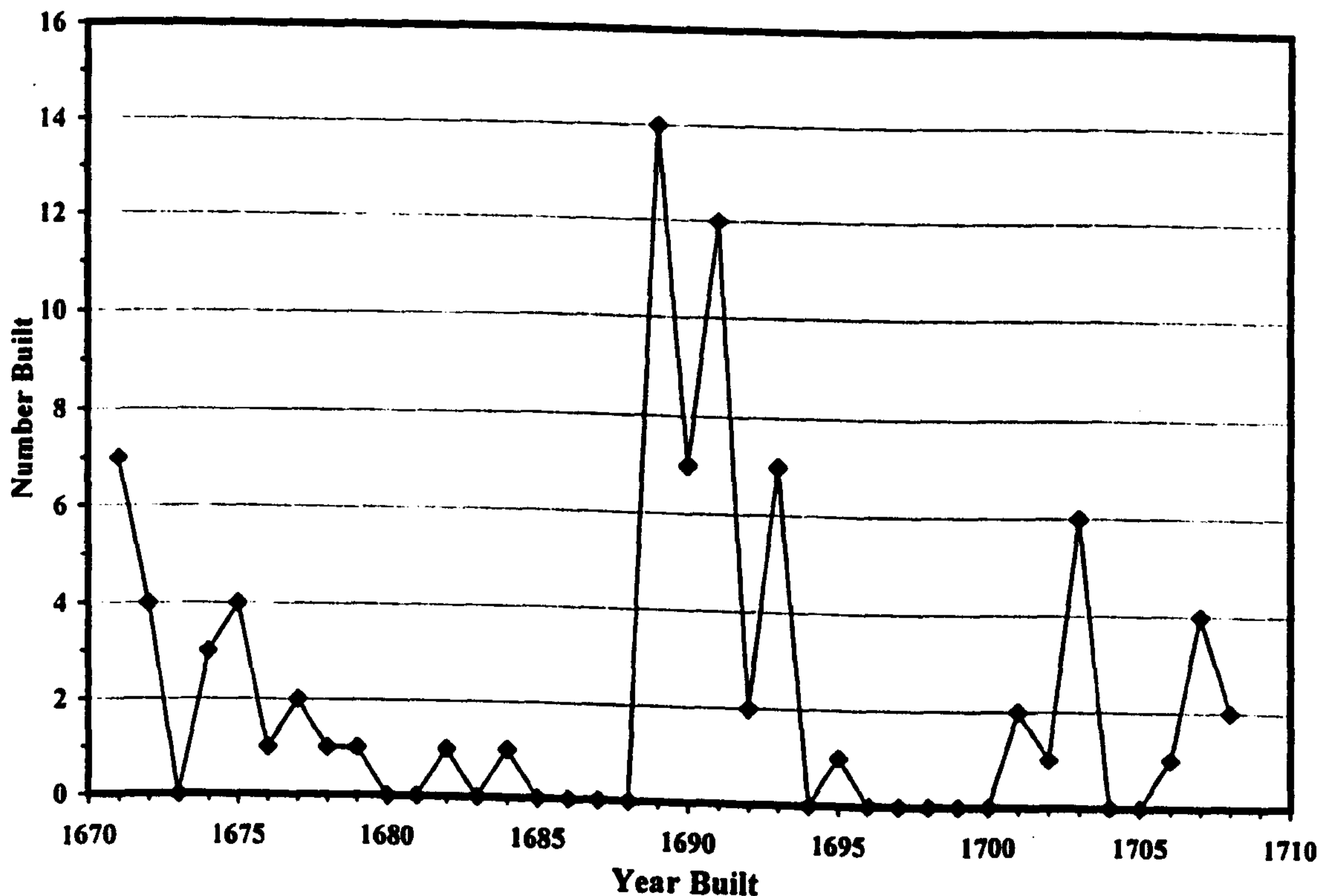
### **Barque Longue Construction**

The relative popularity of the barque longue in the late 17<sup>th</sup> and early 18<sup>th</sup> centuries can be inferred by the number of ships built between 1671 and 1708. Le Conte (1935:38-41) compiled a list of barque longues that included names, numbers of guns, where built, dates built, length, beam, tons, and notes on loss or name changes. In *Corvette la Créole* Boudriot (1990:12-13) provided a similar and slightly expanded list. The combined list is provided as Appendix A. Cross referencing these two lists revealed 84 ships built variously at Bayonne, Brest, Calais, Dieppe, Dunkerque, Le Havre, Rochefort, and Toulon over the 38-year period covered. Of these, 46 were built at the northern port of Dunkerque. Brest and Le Havre followed with 13 and 11, respectively. Dieppe and Rochefort built four and five, and Calais, Bayonne, Toulon each built only one.

Not only was Dunkerque the predominant location where barque longues were built, but the man who built more than any other was H. Hendrick, who completed 20 out of the 22 built during his tenure at that yard. These ships ranged in size from 25 to 90 tons, with the vast majority falling into the 30 to 50 ton ranges (Le Conte 1935:38-41). Their length and breadth varied similarly, from 47 to 70 feet long and from 9 to 20 feet in breadth. Within this broad range, the vast majority fell between 55 and 64 feet long and between 13.3 and 17.6 feet breadth.

The list in Appendix A, although providing basic information on construction, also reveals some shortcomings (Figure 2-15). There are two multi-year gaps for which no constructions were reported by either Broudriot (1990:12-13) or Le Conte (1935:38-41): a four-year period from 1685 through 1688 and a five-year period from 1696 to 1700. These may be a result of discrepancies in the archival record, lost or destroyed

**Figure 2-15: Barque Longue Construction By Year**





records, or a different emphasis placed on this type of reporting. Further reporting stops in 1708, well before the classification ceases on the annual lists to Versailles.

The first year for which there were numbers is 1671, which recorded the building of seven ships. For the next couple of years three to four ships a year were built then, in 1676, this number declined to only one or two a year. A five-year gap followed and then in 1689 a total of 14 ships were built, followed by 7 ships in 1690, 12 in 1691, then the number dramatically declined to only 2 ships in 1692, and then peaked briefly at 7 in 1693. After that the numbers dropped to zero in 1694, to one in 1695, then to zero for five years. In 1701 two ships were built, the following year only one was built, then another brief peak in 1703 of six ships. This was followed by two years in which no ships were built, then in 1706 a single ship was built, followed by four in 1707, and then two in 1708, the last year for which there was reporting. The peak years for construction were 1689 and 1691 with 14 and 12 ships built, respectively. Except for two years, the numbers were generally less than half the peaks with the average only one or two per year.

The lack of ships recorded from 1708 to 1746, when the *barque longue* classification was dropped completely in favor of the *corvette* classification, may reveal the rapid adoption of the *corvette* as a preferred ship type and the obsolescence and aging of the *barque longue* fleet. As *barque longues* were damaged or wrecked, they were simply not replaced. These data suggest that the *barque longue* only persisted for a 40-year period. Their heyday was from 1689-1693 when more than half of all *barque longues* for which there are records were built. Given this, the study of *La Belle* takes on greater importance if its hull form was a *barque longue* in more than just a name.

## Analysis

Clearly, *La Belle* was not a classic barque longue of the Dunkirk tradition. It's construction in Rochefort by Mallet necessarily eliminates that possibility. The important question for this study is whether and how well *La Belle* fits into the overall barque longue type. Because the Danish drawing is the only known technical image of a barque longue, it is also important to determine how well that ship fits into the category. These questions might be resolved by looking at the salient characteristics of all barque longues.

One key comparative statistic is the length-to-breadth ratio of all barque longues for which it is possible to determine this dimension<sup>23</sup> (Figure 2-16). As the data reveal, the length-to-breadth ratios of these ships varied widely from 3.08:1 to 5.4:1, the average is 4.08:1, and the range is 3.56:1 to 4.60:1<sup>24</sup>. *La Belle*, with a length-to-breadth ratio of 3.63:1, falls well within this range. The Danish ship's length-to-breadth ratio was 3.78:1, so it too falls within the range for all barque longues.

The next considerations are length and breadth. *La Belle*'s length was 51 feet, the average for all barque longues is 59.29 and their median is 60 feet. The standard deviation is 6.232, making their range from 53.05 to 65.52 feet. From that standpoint, *La Belle* falls two feet shy of the average range of all barque longues on length. The Danish ship's length was even less, falling 3.02 feet outside the range. *La Belle*'s document breadth is 14 feet. The average for all barque longues is 14.94 feet, the median is 15, and with a standard deviation of 2.52 feet the range is from 12.52 to 17.46. Here, *La Belle*'s

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<sup>23</sup> Only 39 of the 84 barque longues reported included this information.

<sup>24</sup> The range results from adding or subtracting the standard deviation from the average.

**Figure 2-16: Length Breadth Ratios of Barque Longues Constructed at All Arsenals Sorted by Ratio**  
(after Le Conte 1935 and Boudriot 1990)

Name	Date of		Place of	Builder	Length*	Breadth	Depth of		Length
	Construction	Construction					Hold	Breadth Ratio	
La Subtile	1689	Dunkerque			61.60	20.00	8.30		3.08
L' Hautaine	1693	Dunkerque	Hendrick		61.00	18.00	6.00		3.38
L' Agile	1707	Dunkerque	Le Vasseur		64.00	17.60	7.00		3.63
La Cigale	1707	Dunkerque	Le Vasseur		64.00	17.60	7.00		3.63
La Levrette	1707	Dunkerque	Le Vasseur		64.00	17.60	7.00		3.63
La Vipère	1707	Dunkerque	Le Vasseur		64.00	17.60	7.00		3.63
La Belle	1684	Rochefort	Mallet		51.00	14.00			3.64
La Fine II	1689	Brest	Brun		56.00	15.00			3.73
La Fine	1702	Dieppe	Blondel		56.00	15.00	5.40		3.73
La Commode	1691	Dunkerque	Houvens		62.00	16.60	5.30		3.73
La Diligente	1703	Dieppe	P. Cochois		56.20	15.00	6.60		3.74
La Trompette	1706	Brest	Blaise		56.00	14.60	5.60		3.83
La Rusée	1695	Calais			47.00	12.00			3.92
L' Agathe	1675	Dunkerque	Hendrick		54.00	13.60	5.60		3.97
La Dorade	1691	Dunkerque	Houvens		66.00	16.60	5.60		3.97
La Nymphe	1692	Dunkerque	Guillou		60.00	16.60	5.60		3.97
La Prompte	1692	Dunkerque	Guillou		60.00	16.60	5.60		3.97
La Vedette	1691	Dunkerque	Houvens		60.00	15.00	7.00		4.00
La Fine III	1693	Dunkerque	J. Houvens		60.00	15.00	7.00		4.00
La Curieuse	1701	Le Havre	P. Cochois		52.00	13.00	6.20		4.00
L' Utile III	1691	Bayonne	Masson		69.60	17.00	6.60		4.09
La Flatteuse	1690	Dieppe	Blondel		48.00	12.00	5.00		4.10
La Biche	1691	Dunkerque	Houvens		60.00	14.60	5.60		4.10

Name	Date of		Construction	Place of	Builder	Length*	Breadth	Depth of		Length
	Construction	Construction						Hold	Breadth Ratio	
La Choquante	1690	Dunkerque	Dunkerque	Hendrick	70.00	17.00	7.60	7.60	4.11	
L' Émeraude	1691	Dunkerque	Dunkerque	Cochois	70.00	17.00	7.60	7.60	4.11	
L' Agathe	1708	Rocheport	Rocheport	Masson	66.00	16.00	8.00	8.00	4.13	
L' Étoile	1708	Rocheport	Rocheport	Masson	66.00	16.00	8.00	8.00	4.13	
L' Utile	1689	Dunkerque	Dunkerque	Hendrick	55.00	13.00	5.60	5.60	4.23	
La Boussole	1691	Dunkerque	Dunkerque	Cochois	60.00	14.00	7.00	7.00	4.28	
La Flèche	1691	Dunkerque	Dunkerque	Cochois	60.00	14.00	7.00	7.00	4.28	
La Trompette	1691	Dunkerque	Dunkerque	Cochois	60.00	14.00	7.00	7.00	4.28	
La Blonde	1689	Le Havre	Le Havre	B. Chaille	65.00	14.00	5.00	5.00	4.64	
L' Active	1703	Brest	Brest	Blaise	50.00	9.10	4.60	4.60	5.49	
L' Insensée	1703	Brest	Brest	Blaise	50.00	9.10	4.60	4.60	5.49	
La Turbulente	1703	Brest	Brest	Blaise	50.00	9.10	4.60	4.60	5.49	
Unknown fr Danish Archive	ca 1720				50.30	13.30			3.78	
Average Length:Breadth Ratio 4.08 Median 4.00 Standard Deviation 0.52 Range 3.56 - 4.60										
La Marie-Françoise**	1703	Le Havre	Le Havre	P. Cochois	52/61	16/17.6	7.0/6	7.0/6	3.25/3.46	
La Volage	1693	Dunkerque	Dunkerque	Hendrick	61/60	18/16	6.00	6.00	3.38/3.75	
La Discrète	1693	Dunkerque	Dunkerque	Guillou	57/49	14/16	5.6/6	5.6/6	4.07/3.06	
La Fouine	1693	Dunkerque	Dunkerque	Guillou	62/60	14.6/16	5.6/7.6	5.6/7.6	4.24/3.75	
L' Allumette	1693	Dunkerque	Dunkerque	Hendrick/ Houvens	57/47	14/11.6	5.6/6	5.6/6	4.97/4.05	

\* Boudriot lists lengths from outside of the stem to stem post and breadth as master-frame without hull planks. For comparability the Le Compte, Danish and French archival document dimensions are provided in the same manner.

\*\* Not included in statistical analysis because of discrepancies in dimensions

maximum breadth easily falls within the range for all barque longues. Furthermore, based upon the archaeological remains *La Belle's* actual breadth is 15 feet, matching exactly the median for all barque longues. The Danish ship's breadth is 13.30 feet.

While falling within the range, it is 1.70 feet less than the median.

On these bases, when comparing *La Belle* with all barque longues, it falls within the normative ranges, albeit slightly less on length. The Danish ship does not fare as well falling outside the norm on both length and breadth. Only five other ships are the same or less in length and only seven are the same or less in maximum breadth.

In his analysis Boudriot compared the shape of *La Belle's* hull to that of the Danish drawing, which he considered the classic barque long type. Based upon the differences in their shape, he concluded that *La Belle* was not a barque longue (Boudriot 2000:43). Boudriot (1990:8) also suggested that the Danish-drawn barque longue was likely built in Dunkerque. Mistaken about the probable date of the drawing, which he attributed to 1670-1710, he may also be incorrect about its origins. If the Danish drawing is of a classic Dunkerque-built ship, how well do its salient dimensions and length-to-breadth ratio compare with those ships? Using the same information from Figure 2-16 but extracting only those built in Dunkerque for which there is data, the following information emerges (Figure 2-17).

The average length-to-breadth ratio for all Dunkirk barque longues was 3.90:1, the median was 3.97, the standard deviation is .3141, making their length-to-breadth range 3.59 to 4.21. The average length of these ships was 61.78, their median was 60.50, their standard deviation is 3.91, making their range 57.87 to 65.59 feet. Their average breadth was 16.10, their median was 16.60, the standard deviation is 1.79, and their range is 14.31 to 17.89.

**Figure 2-17: Length Breadth Ratios of Barque Longues Constructed at Dunkerque Arsenal**  
(after Le Conte 1935 and Boudriot 1990)

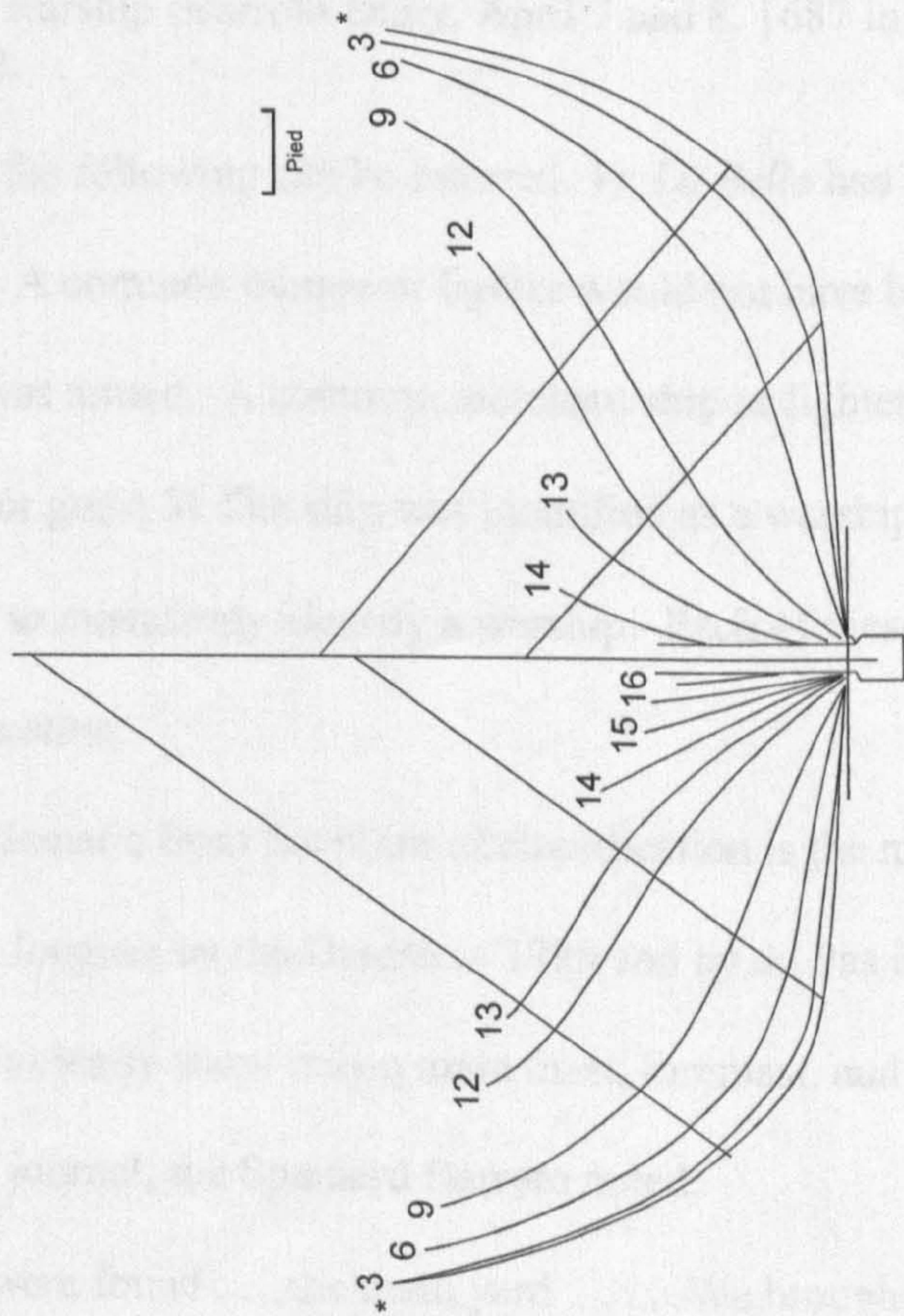
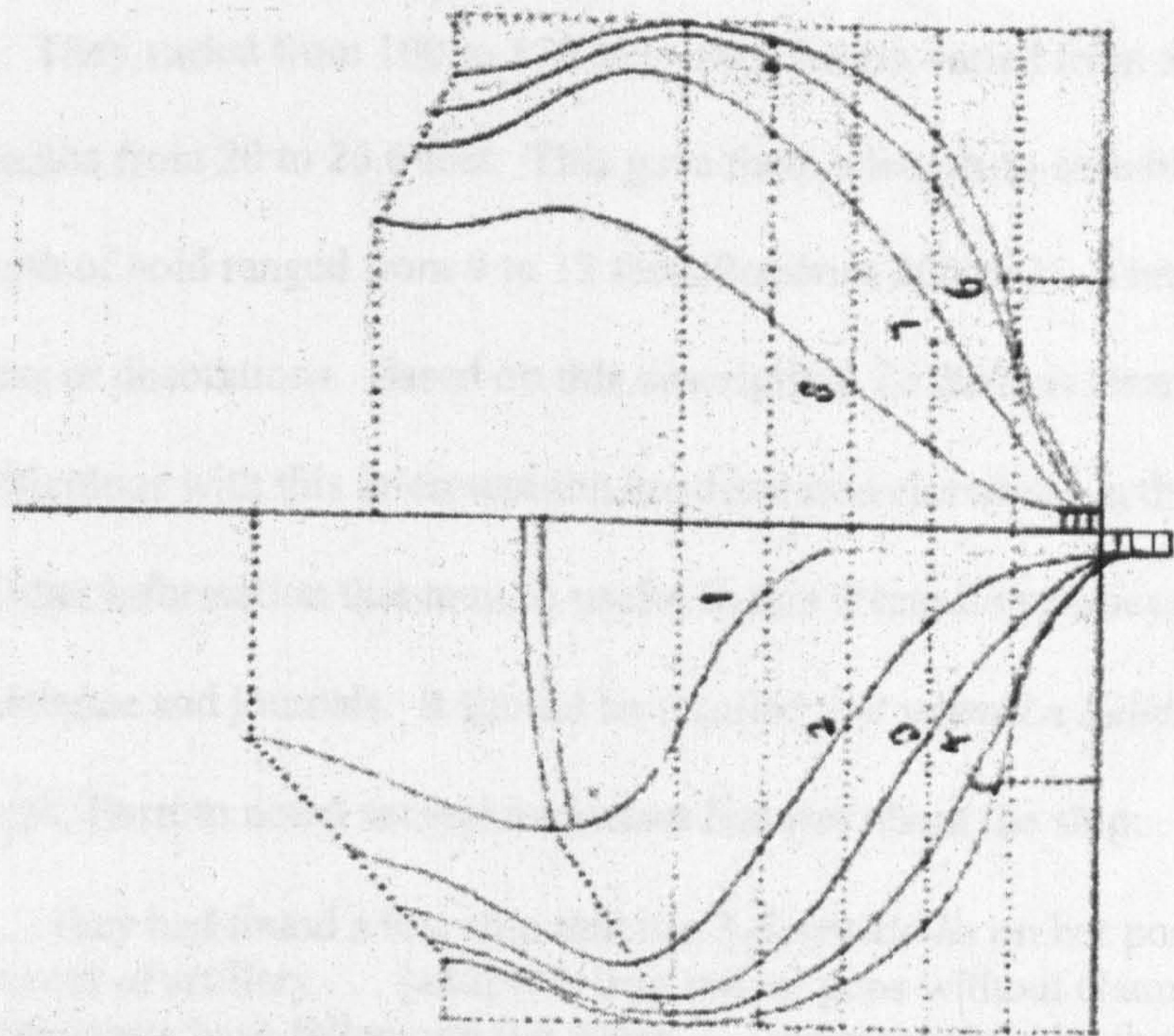
Name	Date of		Construction	Place of	Builder	Length*	Breadth	Depth of	
	Construction	Year						Hold	Breadth Ratio
La Subtile	1689		Dunkerque			61.60	20.00	8.30	3.08
L' Hautaine	1693		Dunkerque		Hendrick	61.00	18.00	6.00	3.38
L' Agile	1707		Dunkerque		Le Vasseur	64.00	17.60	7.00	3.63
La Cigale	1707		Dunkerque		Le Vasseur	64.00	17.60	7.00	3.63
La Levrette	1707		Dunkerque		Le Vasseur	64.00	17.60	7.00	3.63
La Vipère	1707		Dunkerque		Le Vasseur	64.00	17.60	7.00	3.63
La Commode	1691		Dunkerque		Houvens	62.00	16.60	5.30	3.73
L' Agathe	1675		Dunkerque		Hendrick	54.00	13.60	5.60	3.97
La Dorade	1691		Dunkerque		Houvens	66.00	16.60	5.60	3.97
La Nymphé	1692		Dunkerque		Guillou	60.00	16.60	5.60	3.97
La Prompte	1692		Dunkerque		Guillou	60.00	16.60	5.60	3.97
La Vedette	1691		Dunkerque		Houvens	60.00	15.00	7.00	4.00
La Fine III	1693		Dunkerque		J. Houvens	60.00	15.00	7.00	4.00
La Biche	1691		Dunkerque		Houvens	60.00	14.60	5.60	4.10
La Choquante	1690		Dunkerque		Hendrick	70.00	17.00	7.60	4.11
L' Émeraude	1691		Dunkerque		Cochois	70.00	17.00	7.60	4.11
L' Utile	1689		Dunkerque		Hendrick	55.00	13.00	5.60	4.23
La Boussole	1691		Dunkerque		Cochois	60.00	14.00	7.00	4.28
La Flèche	1691		Dunkerque		Cochois	60.00	14.00	7.00	4.28
La Trompette	1691		Dunkerque		Cochois	60.00	14.00	7.00	4.28
Unknown fr Danish Archive	ca 1720					50.30	13.30		3.78

Average Length:Breadth Ratio 3.90    Median 3.97    Standard Deviation 0.3141    Range 3.59 - 4.21

By comparison, the Danish-drawn ship's length-to-breadth ratio was 3.78:1, placing it within the average for all Dunkerque-built ships. However, its length at only 50.30 feet was approximately 11 feet shorter than the average for all Dunkerque-built ships and it was also well outside their length range. Similarly, its breadth at only 13.3 feet was 3 feet less than the average for all Dunkerque-built ships and it was also outside their breadth range. Of the ships built at Dunkerque, only two others are less than 60 feet in length, and only two others are less than 14 feet in breadth. Furthermore, the Danish-drawn ship was the smallest of the entire Dunkerque assemblage.

What is clearly reflected in Figure 2-17, is that the Danish-drawn ship is not typical of those from Dunkerque and, therefore, is not representative of the classic type as defined by Boudriot. Given this finding, the Danish ship should not be considered a Dunkerque classic barque longue. Neither should the ship be regarded as the norm to which to compare the construction of other so-called barque longues. As previously noted, the drawing may date as late as 1720 when the longer, sleeker corvette was in clear ascendancy, which further impairs its usefulness as a normative model. There is no question that a comparison of the half-section lines of this ship and *La Belle* reveals clear differences (Figure 2-18). But to suggest, therefore, that *La Belle* was not a barque longue based solely upon the Danish drawing, given all of the data presented, is ill advised.

In evaluating the question of *La Belle*'s naval classification, other interpretations of the data and salient features of the ship should be considered. Boudriot suggested that *La Belle* was classified as a barque longue only because the term barque was considered inelegant and unrefined (John de Bry pers. comm. 1999). Further, he postulated that *La Belle* was a *chatte*, or lighter (Boudriot 2000:43). The lighter was a well-known ship



**Figure 2-18:** Half breadth comparison of *La Belle* 1684 (left) and the Danish barque longue ca 1720 (right). The Danish ship hull form is very similar to that of the corvette of the period.



type used in harbors in support of the general operations of the marine. These were both decked and undecked to facilitate loading and unloading of equipment, ordnance, and supplies. They varied from 100 to 150 tons, their length varied from 56 to 74 feet, and their breadths from 20 to 26.6 feet. This gave them a length-to-breadth ratio of 2.8:1. Their depth of hold ranged from 9 to 12 feet (Boudriot 2000:43). There is no mention of armaments or decorations. Based on this description, *La Belle* is clearly not a match. Other difficulties with this interpretation are discussed elsewhere in this study.

Other information that may be useful in this discussion comes from correspondence and journals. It should be recalled that when *La Belle* was discovered by the Spanish, Barroto noted several important features about the ship:

. . . they had found a lost ship that has 3 *fleurs-de-lis* on her poop; six pieces of artillery . . . [and] two iron swivel guns without chambers . . . . The masts have fallen into the water . . . we recognized by these things that she was a warship (Barroto Diary, April 7 and 8, 1687 in Weddle 1987:171-172).

From this description the following can be inferred: 1) *La Belle* had a stern decorated with the *fleurs-de-lis*. A common barque or lighter would not have been decorated in this manner; 2) The ship was armed. A common merchant ship or lighter was not likely to have either gun ports or guns; 3) The ship was identified as a warship. Knowledgeable seamen were unlikely to mistakenly identify a warship. Each of these add support to the barque longue classification.

The most problematic from the point of classification is the masting. The two illustrations of barque longues by the Danish in 1720 and by du Pas in 1710 (refer to Figures 2-12 and 2-13) clearly show only a main mast, foremast, and a bowsprit. However, in the same journal, the Spaniard Barroto noted:

On the beach were found . . . the main yard . . . . We brought this yard

and that of the fore topsail for making oars, and from that of the foresail a boom was made for ours. Captain Pedro de Yriarte took that of the mizzen also (Barroto Diary, April 7-8, 1687 in Weddle 1987:171-172).

From this information it can also be inferred that *La Belle* had three masts: a main mast with topsail, a foremast with topsail, and a mizzen mast. Further support for this masting arrangement comes from the journals of Henri Joutel and the engineer Minet. In both journals a mizzen mast is mentioned when describing an accident on the night of December 17, 1684 when *La Belle* and *L'Aimable* collided (Foster 1998:64; Bell 1987:92). Although neither man was on board *La Belle* and neither was familiar with ships, both men specifically mention the mizzen mast. Joutel's and Minet's lack of knowledge might result in a misidentification of the masts, however a seaman as knowledgeable as Barroto was unlikely to make such a mistake.

Given this apparent contradiction in the masting of *La Belle* with the generally-accepted masting of the northern barque longue, what can be inferred about its masting? It should be kept in mind that both the Danish and du Pas illustrations were made nearly 30 years after *La Belle* was built when the corvette type was on the ascendancy. Both were also drawn in northern ports. Additionally, the masting document is for a barque longue built in 1693 at Dunkerque (refer to Figure 2-14). These examples may be reflecting temporal and regional differences or variations on the type. Support for variation comes from du Pas' illustration of the corvette (1710) with only two masts and a bowsprit (refer to Figure 2-11) and Ollivier's description of a corvette with three masts and a bowsprit (1736:156-116). Given the demonstrated relationship between the two types, it is reasonable to suggest that the barque longue may also have had some variability in its mast configurations.

Because *La Belle* was built in Rochefort and, as already noted was not a

Dunkerque-type barque longue as defined by Boudriot, reexamination of locally-built ships may be useful. Although the Jouve illustrations did not include a barque longue, they did reflect ships built and used in the Rochefort-La Rochelle region circa 1680. Those ships were shown with two or three masts, depending upon their size and tonnage. The two ships that are the closest to *La Belle*, based on archival and archaeological evidence, have three masts and a bowsprit (refer to Figures 2-6 and 2-7). In fact, their masting configuration closely matches the description by Barroto, that is, a foremast with topsail, a mainmast with topsail, and a mizzen mast (Weddle 1987:171-172). With these ships as a regional template, it is not surprising that *La Belle* had three masts and, while not mentioned in any archival documents, a bowsprit.

Of the 84 barque longues that were recorded (refer to Appendix A), only 7 were constructed at southern yards. Given other differences in shipbuilding traditions between the North and the Southern and Mediterranean coasts of France and the demonstrated variability in masting of its descendant type, it is possible that there was a regional difference in hull form and masting of the barque longue as well. For *La Belle*, the number of masts likely reflected a southern preference for ships of that size. While the hull form, including gun ports and royal decoration on the stern, reflect those of a warship suitable for “. . . discoveries, escorts for ships, and for trade and commerce” (du Pas 1710, ref Figure 2-12). Today, as in the past, classification of naval ships was not based solely on masting configuration, but on size, armaments, and purpose.

While *La Belle* was not built at the Dunkerque arsenal, it exhibited the key characteristics of the barque longue: low castles forward and aft, gun ports, a decorated stern and beak, a weatherly sleek hull, and a masting arrangement that facilitated speed and permitted close inshore sailing and maneuverability. When these data are combined

with the official Naval documents previously discussed, there is little reason to dispute *La Belle*'s French marine classification and hull configuration as that of a barque longue.

## Chapter III. The Archaeological Remains

### Introduction

The hull is the largest and most visible object from the site. After 311 years underwater it is also a composite artifact no longer just composed of wooden hull timbers, wood and iron fasteners, fibrous caulking, and both a lead-based and pitch sealant. It now includes dissolved chlorides and other chemicals from the sea, the worm casings from *teredo navalis*, iron oxides, traces of lead, gunpowder, concretion, and sand all of which permeated its timbers and affected its preservation. Before reaching stasis with its environment, the hull was subjected to pounding, wrenching and cracking as the ship broke apart, losing its masts, upper works, deck, and nearly all of its port side. In the 20<sup>th</sup> century, the impact of shrimp fishing in the bay took its toll with heavy nets dragged across its barely protruding timbers. The outcome was the nearly complete burial of the hull and very limited exposure of its structural remains above the sea floor.

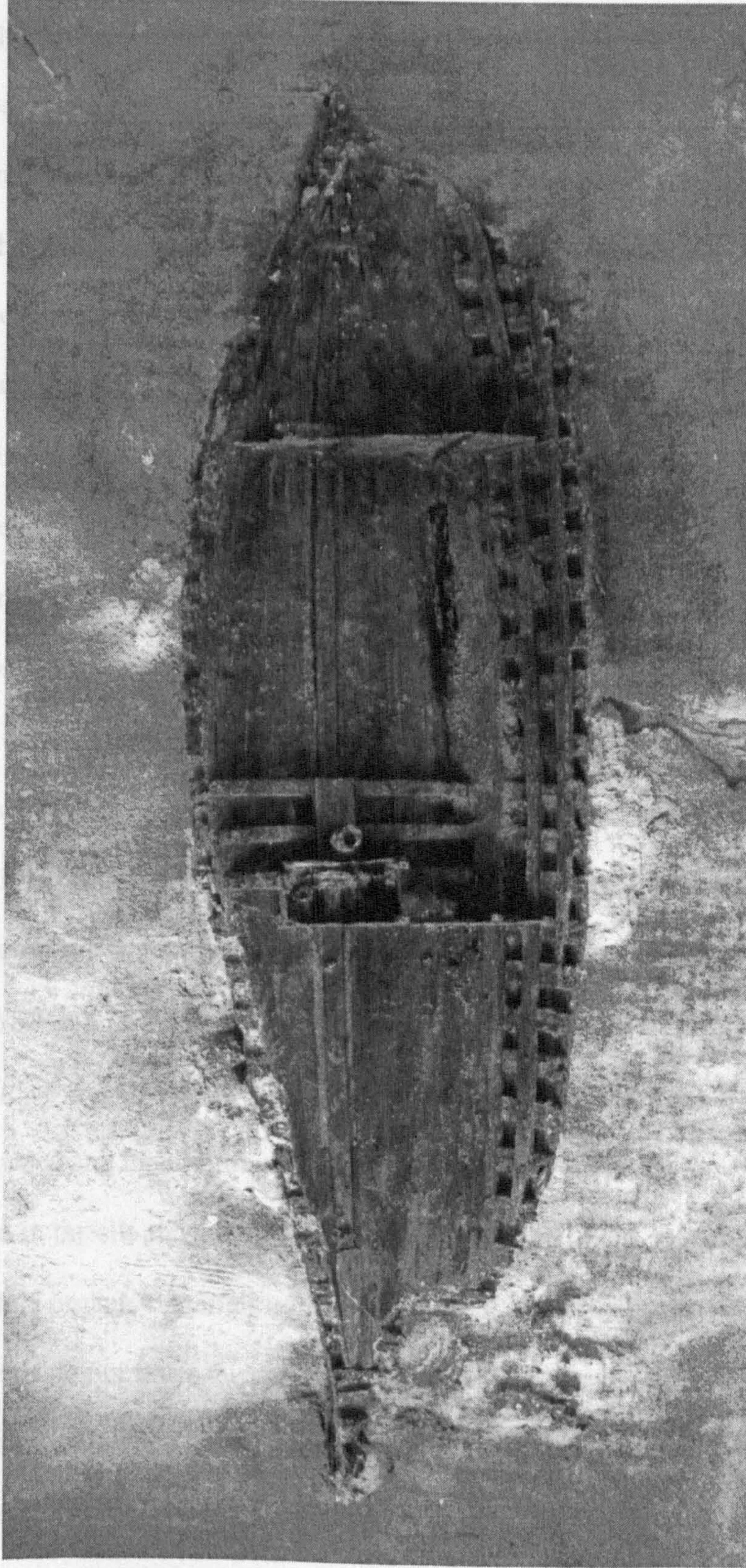
Despite the loss of approximately 60% of the structure, the conceptual expression of *La Belle* is revealed in the assembly of its component parts. From the simple, yet elegant, numbering system of the frames to the surprising tongue and groove bulkhead in the stern, the ship displays both technical and artistic skills required of the shipwright. Visually a small, simple vessel *La Belle*'s assembly provides more than just a blueprint of a 17<sup>th</sup> century ship, it provides an insight into the attitudes and workmanship of a profession in transition.

The surprising results of the dendrochronological analysis, discussed elsewhere, and the detailed examination of individual timbers introduced the potential for reuse of many of its components. This type of information, not generally addressed in the context of hull analyses, also raises issues relating to design, the speed of assembly, shortages of timber in the dockyard, and whether *La Belle* was a new or rebuilt ship.

### **Site Description**

The archaeological remains provide direct evidence for a single-decked two-masted shallow-draft sailer that was both capacious and maneuverable (Figure 3-1). During excavation its three remnant bulkheads, the pump well and a pump tube, a forward hold platform deck, the fore and main mast steps, and a small partial deck or bunk on the starboard side in the bow, were revealed. Bulkhead three (aft) was removed in late December 1996, before the hull was completely excavated, due to its poor condition and minimal structural support. The partial deck or bunk was also removed at an early stage of the excavations to simplify excavation in the bow. As a result, these two interior structures do not appear in photos of the ship when completely excavated.

According to the notarized ship registry of *La Belle's* relevant proportions, discussed in detail elsewhere, the ship was built with a maximum beam of 14 *pieds* (4.55 m/14 ft 9 in) and an overall length of 51 *pieds* (16.57 m/54 ft 4 in) (SHMR 1L<sup>3</sup>19, f. 88v-89r). In its position on the sea floor, leaning to starboard at a 21-degree angle and down at the bow by approximately 1.7 degrees off a level keel, these measurements translated to an overall preserved length of 15.93 m (52 ft 3 in). At the master frame, from the starboard side at the top of the preserved frames to the port side at the turn of the bilge,



**Figure 3-1:** An overview of the excavated hull with the bow at the right side of the image. Bulkhead three (aft) and the bow platform deck were removed before the hull was completely excavated. Photo courtesy Texas Historical Commission.

the maximum width was 4.42 m (14 ft 5 in). This latter measurement slices across the ship at a diagonal to its upright orientation and so bears no relation to its maximum beam. Its position on the sea floor also accounts for the apparent bulge in site photographs.

An anaerobic burial environment promoted the stability of organic materials. Because the ship was constructed of several types of wood, these survived according to their particular species characteristics. The largest structural timbers, stringers, hull and ceiling planking, are strong sturdy oaks that are very resistant to rot and deterioration. Not surprisingly, those timbers exposed for the longest period before burial in the sea floor -- the hull planking, stem and stern assembly, keel, and the topmost components of interior structures -- were attacked by the ubiquitous shipworm (*Teredo navalis*); planks, keel, cutwater, and stem are in especially poor condition. However, timbers protected by the ship's cargo and then covered by silt are in excellent condition. For example, the ceiling planks are hard and were removed with little mishap, unlike the hull planks that broke easily during disassembly because of their soft spongy condition. Good preservation is present at the platform deck in the bow. Because those planks were covered by anchor rope and silt, they were minimally affected by their prolonged burial. The main mast and its assembly, bulkheads, foremast assembly, pump well and pump tube are eroded and have some shipworm damage. Nevertheless, those areas that were well buried in the silt and not exposed to the surface are in good condition.

While organic materials comprising the hull are well preserved, anaerobic environments do not favor the survival of many metals. The iron fasteners used throughout the ship were generally weakened and easily broken. A noticeable difference between fasteners was observed during dismantling. Those fasteners used for attaching ceiling planking, hull planking, constructing the bulkheads, the forward hold deck, and



even toenailing the ends of the buttresses on the main mast, were simply concretion and rust; all traces of the iron were gone. These fasteners were square in cross section and ranged in size from .5 cm to 1.2 cm. Larger square-sectioned fasteners, used in fore and aft fastening, ranged in size from 1.9 cm to 2.5 cm. They were so deteriorated that gentle pressure from a nylon wedge or slipping a 1/8-inch thick piece of flatiron between the frames and gentle rocking easily broke them. The largest fasteners on the ship, those that held the keelson, frames, and keel together, and anchored the main mast riders, locking timbers and buttresses were in better condition. Round in cross section and ranging in size from 2.6 cm to 3 cm, these fasteners were so solid that only repeated aggressive rocking, forceful lateral pressure, and lifting with the help of a crane eventually caused them to break. These are not only the largest, but also most protected of all the fasteners, which likely accounts for their remarkable condition.

Structural damage to the surviving ship timbers was most evident on the starboard side. Several first futtocks, supporting the ship at arguably its most vulnerable location -- the turn of the bilge -- were deeply cracked or completely broken. Undoubtedly this resulted from both the wreck event and the subsequent wrecking processes as the ship came apart. Evidence that the ship was spreading open from side to side was also present. It was particularly noticeable in the starboard bow area where the hull planks were separated from the frames. Not as noticeable was the sagging of the forward section of the keel. Other evidence of warping or shifting was revealed along the starboard side at the position of the bulkheads, which no longer fit snugly against the ship's side.

## Limitations of the Archaeological Evidence

Because the ship came to rest on the sea floor with a list to starboard and down in the bow, the starboard and forward areas of the ship are better preserved. The port side is preserved only to the turn of the bilge. Complete floors extend from seven forward of the master frame to two aft, while floors three and four aft have lost approximately 10 cm of length. On the port side, 25 of the 30 frames retain part of their first futtock, while on the starboard side frames are preserved up to their third futtock.

The questions of just how much below the level of the deck and how much of the side is preserved may be roughly deduced from the proportions document. That document listed the height above the keel at the ship's maximum beam as 6 *pieds* 3 *pouces* (2.05 m/6 feet 7 in) (SHMR 1L<sup>3</sup> 19, f. 88v-89r). This measurement is accepted as the point at which the ship begins its inward curve or tumblehome. The document also provided a measurement of the depth of the hold of 7 *pieds* 3 *pouce* (2.37 m/7 feet 8 in). The latter measurement is generally interpreted to be the distance from the top of the keel to the top of the deck beam, which is also the underside of the deck planking. Therefore, the 1.85 m of the preserved starboard side above the keel represents nearly three-fourths of the height of the side at that location. It is also only 15 cm below the point at which the hull starts its inward arc or tumblehome and 52 cm below the height of the deck.

The proportion document also provided measurements for the height of both the stem and stern posts. The stem, according to this document, was 12 *pieds* (3.9 m/12 ft 8 in), while the stern was 11 *pieds* 6 *pouces* (3.77 m/12 ft 4 in). The remains of the stem are only preserved to a height of 1.15 m, representing less than one-third of its original height. Similarly, the surviving portion of the stern post is only 90 cm high, which is less than one-quarter of its original height. Preservation is also affected by a 2.5 degree

downward tilting of the forward section of the keel. This resulted in additional preservation of nearly 44 cm of the bow elements, when compared with the stern.

The differential preservation extended to the interior structures and ceiling planking. None of the bulkheads are complete and the forward bulkhead (bulkhead one) averages 80 cm high while the aft bulkhead (bulkhead three) averages only 20 cm. Only part of the ceiling plank at the turn of the bilge is preserved on the port side while on the starboard side all of the ceiling planking, up to and including the filler (covering board), is preserved. The starboard side also retains two longitudinal stringers that were below the main deck beam clamp. No remains of the clamp or deck beams were discovered during excavation.

No remains of the ship's deck, transom, rudder, beak, or upper works (aft cabin and forward shelter-deck) were preserved. Only two masts can be archaeologically confirmed, the foremast and main mast. A mizzen mast, confirmed through journals and letters, was stepped into the aft deck and not into the keel. The same applies to a bowsprit mast, which was stepped into the deck forward. No evidence of either was discovered during the ship's excavation. Only limited evidence of the ship's rigging remained. Several well preserved single sheave blocks, with rope still running through them, were recovered along with a remnant of the main mast. No other mast fragments and no yards were recovered.

Despite the limitations imposed by the loss of the entire port side and upper works, the remaining ship represents approximately 40 percent of the hull. The preservation of the master frame, particularly the full width of the floor with its complete first and approximately one-half of its second futtocks, provides key information for understanding the conception of the hull. Because the ship's timbers were still

articulated when excavated, nearly all the guesswork that necessarily accompanies a heavily damaged and scattered wreck were removed.

### **Hull Assembly**

One of the principal goals of this research was to analyze and describe the hull's assembly and to compare it to contemporary shipbuilding practices. Because *La Belle* was completely disassembled, a rarity among shipwreck investigations, a necessary component of this research effort was the creation of precise three-dimensional drawings of each timber. Tool marks, fastener types and patterns, bevel angles, tree characteristics, and assembly evidence were all recorded. This level of documentation was essential to reconstruct the design, create lines plans and other drawings, and to understand the construction and assembly.

The documentation effort and analysis revealed the presence of surmarks used as construction aids, the locations of ribbands, and possibly the construction cradle, all providing insights into shipyard manufacturing processes. It also uncovered unused and anomalous fasteners and treenails and fastener patterns. In the process, surprising physical differences between the frames were revealed, leading to the conclusion that some came from an older, dismantled ship. This finding had direct implications for the results of the dendrochronological analysis, hull assembly, and design analysis.

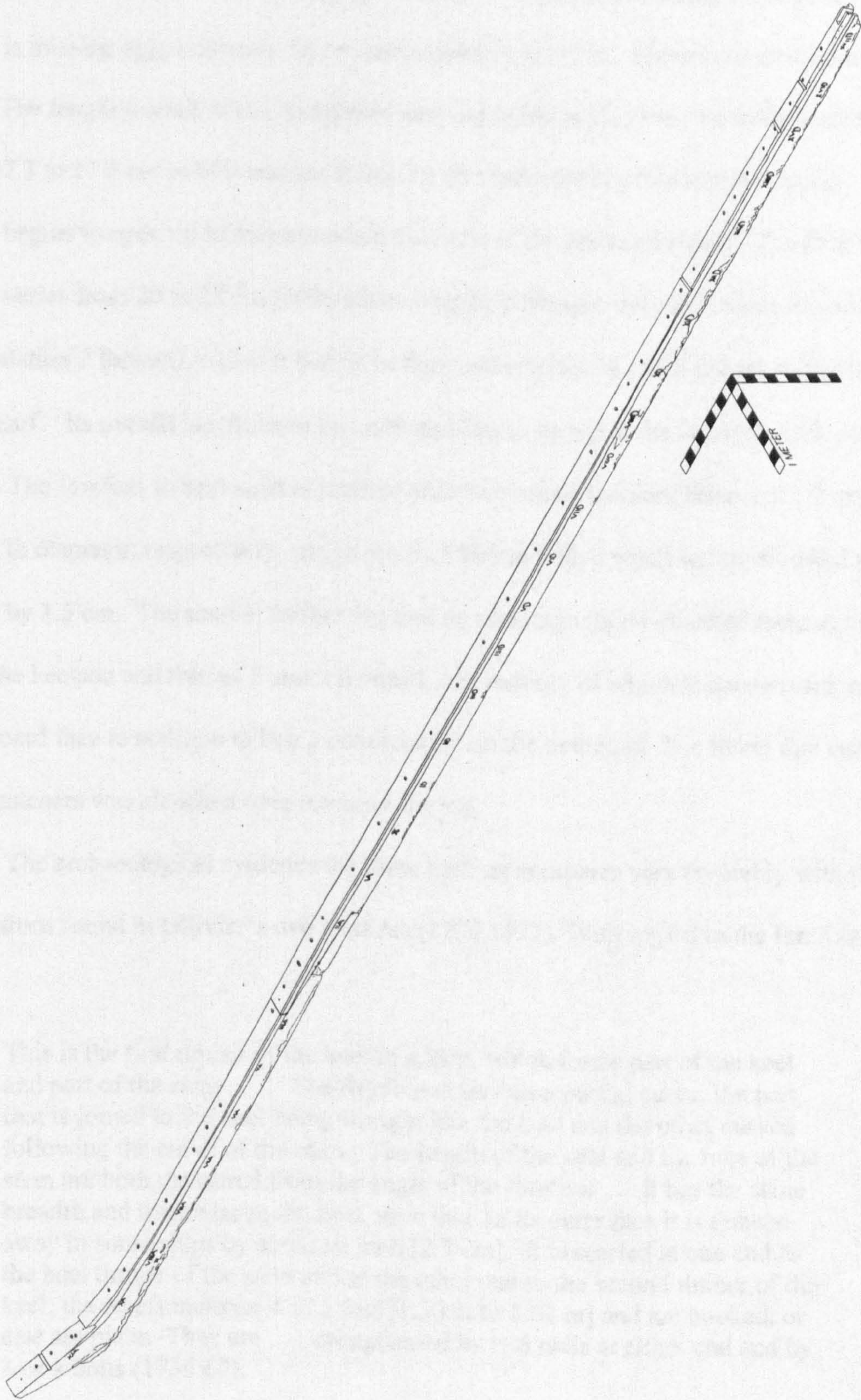
Comparison of *La Belle*'s archaeologically-documented assembly to contemporary treatises depended heavily on the writings of Blaise Ollivier (1736, 1737). He approached the subject of shipbuilding not just from the theoretical, but from the functional day to day needs of construction practices in the yard. Ollivier's detailed descriptions of individual ship elements, their assembly, and comparisons to the practices

of the Dutch and English (1737) together with his comprehensive descriptions of French shipbuilding practices (1736) are nothing less than shipbuilding primers. By comparison, other contemporary authors including Fourier (1667), Dean (1670), Anonymous (1691), Dassié (1695), and du Monceau (1752) among others, addressed themselves to the theoretical conception, proportions of timbers, lists of supplies, and occasionally to examples of ship construction. For purposes of the following discussion on assembly, therefore, these latter treatises were generally less useful.

The creation of a ship follows a logical and time-honored order that is three-dimensional and complex in its execution and elegant in its result. Unfortunately, the written word is linear and often inelegant. In an attempt at clarity and for ease of discussion and visual presentation, rather than keeping with the actual construction order the following discussion of *La Belle's* assembly proceeds from the keel through the keelson then moves backwards slightly to address the frames. The discussion continues with the interior and exterior planking and longitudinal stringers, the main and foremast step assemblies, interior structures beginning with the bulkheads and pump well and concluding with the platform deck and shelf in the bow. Lastly, a discussion of fastenings patterns and the numbering system completes this section.

### **Keel through Keelson**

The keel element is composed of two pieces, the keel proper and a forefoot that continues the keel forward then curves upward to form the lower part of the stem. The forefoot and stem pieces articulate with a Z (hooked) scarf measuring 85 cm (Figure 3-2). The scarf from the forefoot to the keel is a simple 1.10 m-long overlapping joint that



**Figure 3-2:** Keel isometric. Drawing by Taras Pevny.

fastened using paired round and square-shanked fasteners. The forefoot is complete and measures 5.22 m overall. The keel proper, which is broken at the sternpost mortise and tenon, is missing approximately 36 cm and measures 11.09 m. There is no evidence of a skeg. The length overall of the articulated keel assembly is 15.31 m. Its width varies from 17.3 to 17.6 cm until it reaches frame 12 aft where the top face narrows as the rabbet begins to open up to accommodate the twist of the garboard strake. The keel's height varies from 20 to 22 cm for its entire length; it changes only as it starts to rise at frame station 9 forward, where it begins to flare and reaches 34 cm at the aft end of the stem scarf. Its overall height from the outboard flat to its top at the forefoot is 61 cm.

The forefoot to keel scarf is secured with two round-shanked fasteners 2.9 cm and 2.7 cm in diameter, respectively, which are each paired with a small square-shanked nail 1.3 cm by 1.5 cm. The scarf is further secured by two large round-shanked fasteners that holds the keelson and frames 2 and 3 forward, one fastener of which is countersunk on the inboard face in addition to being countersunk on the outboard. It is likely that each of these fasteners was clenched over roves on the top.

The archaeological evidence for these timbers compares very favorably with their descriptions found in Ollivier's two treatises (1736,1737). With regard to the forefoot he noted:

This is the first timber of the keel in a ship, which forms part of the keel and part of the stem . . . . The forefoot describes a partial curve, the part that is joined to the keel being straight like the keel and the other curved following the curve of the stem. The length of the keel and the rake of the stem are both measured from the angle of the forefoot .... It has the same breadth and thickness as the keel, save that on its outer face it is dubbed away in some ships by about an inch [2.7 cm]. It is scarfed at one end to the heel timber of the stem and at the other end to the second timber of the keel; the scarfs measure 4 to 5 feet [1.30 m to 1.62 m] and are hooked, or else are plain. They are . . . strengthened by two nails at either end and by 3 or 4 bolts (1736:67).

It must be kept in mind that Ollivier was describing the practice for warships. However the dimensions he provided are only slightly greater than those used in *La Belle*. The forefoot is the same breadth and thickness as the keel for most of its length. The forward stem scarf is hooked, while aft it overlaps the keel, i.e., it is a plain scarf, only 20 cm shorter than indicated in the manuscript. The presence of a forefoot rather than a stem vertically half-lapped to the keel was apparently uniquely French; Ollivier (1737:46, 209) noted that the English and Dutch both chose the latter method and did not use a forefoot.

When describing the English and Dutch practice of scarfing multiple keel timbers with a side by side join, Ollivier (1737:45) noted that he much preferred the French practice of using an overlapping join because that scarf was less likely to leak.

Elsewhere Ollivier described the particulars of the French keel as:

These timbers are assembled one to the other with long scarf 4 to 5 feet long [1.30 m to 1.62 m], which many builders fashion with a hook. The keel scarfs are strengthened at either end by a nail and by three bolts driven up from below and clenched over roves on top. Some builders drive the bolts right through the keelson as well . . . The width of the keel is from top to bottom [e.g., height] and is 20 to 22 inches in the vessels of the first rank, first order, 19 to 21 inches in the vessels of the first rank second order . . . Its thickness athwart ships [e.g., width] is in all ships about 2 inches less [than the height] . . . There is a rabbet in either side of the keel to receive the garboard strakes. A mortice is cut close to the after end of the keel for the tenon of the stern post (1736:284).

Comparison of this description to the keel in *La Belle* reveals many similarities. The scarf length is only slightly less and, surprisingly, the height-to-width dimension of the keel is similar to that of the largest ships in Ollivier's description. The length of the keel timber falls within the dimensions described above.

The stem (Figure 3-3) has a Z-scarf on its bottom face to integrate with the forefoot. It is attached to the keel with five round-shanked fasteners, the third aft of





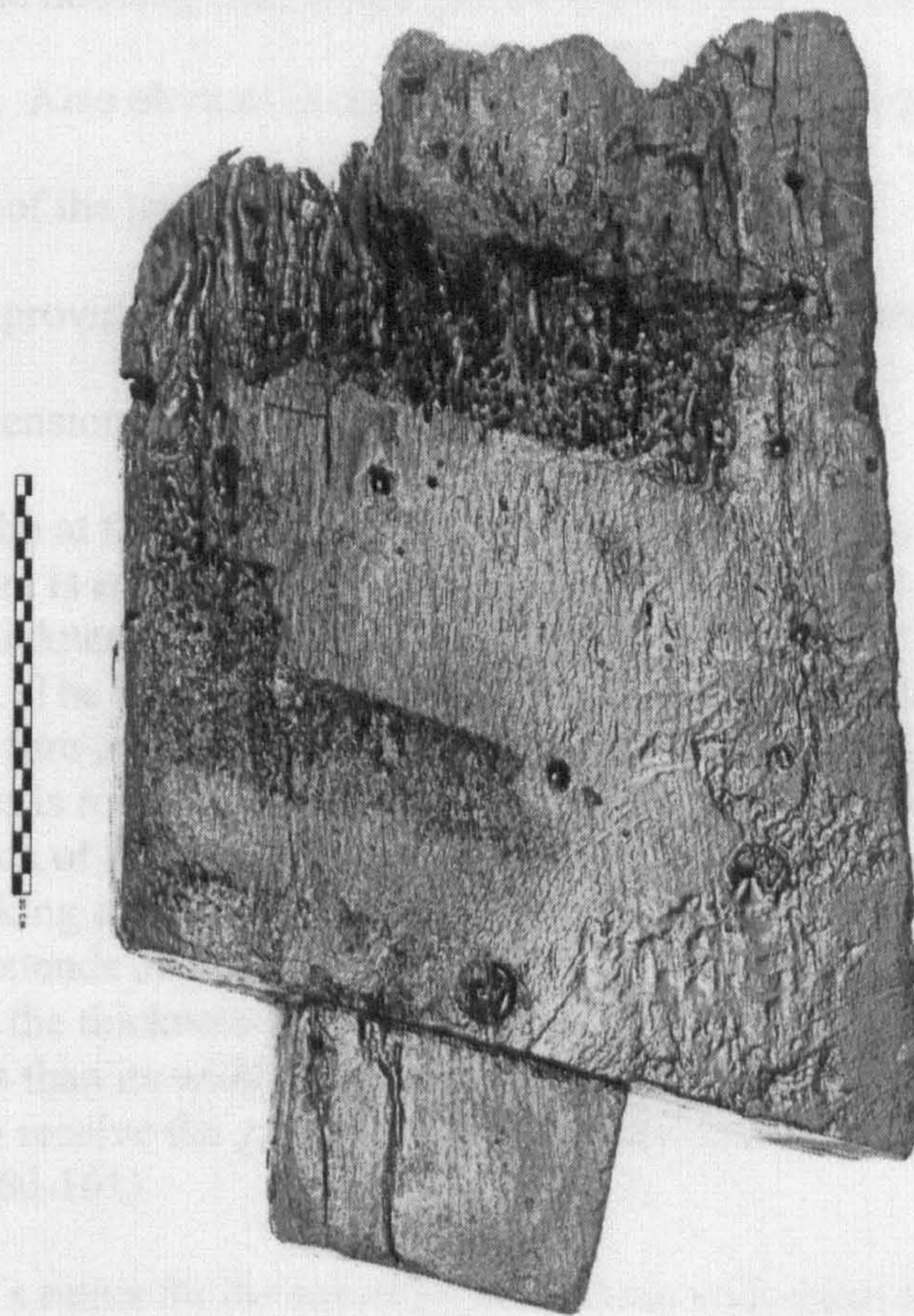
which is countersunk suggesting it was driven from the top and was the fastener initially securing the stem. Broken at the height of the preserved forward deadwood, the stem's length overall is 1.42 m, is 14 cm wide on the inboard (or top) face, and varies between 14 and 16 cm on the outboard. Its widest preserved molded dimension is 30 cm, while the overall height of the surviving portion is 1.10 m. The width of the rabbet is 10 cm at the base of the stem and gradually narrows to 8 cm as it arcs upwards. Ollivier had this to say about the stem:

This is a timber curved to the arc of a circle, raised so that it projects beyond the end of the keel to form the head and complete the length of the ship . . . Its fore-and-aft width is equal to the height of the keel from top to bottom and its thickness is also equal to the thickness of the keel. The stem is composed of three timbers in First Rates and of two timbers only in other ships and frigates . . . The scarfs are 4 to 6 feet long [1.29 m to 1.95 m] according to what the timber allows, and some Builders hook these scarfs. The scarfs . . . are strengthened at each end by a nail and by bolts which also run through the apron. There is a rabbet on either side of the stem . . . this rabbet is the same width and depth as the rabbet of the keel. Most Builders fashion this rabbet in the middle of the thickness of the stem, others place it one or two inches inside the middle line in order to leave a greater projection of the stem beyond the planking of the hull. This is the older method and the least esteemed . . . In bomb ketches, sloops-of-war and other small vessels the stem rises to the height of the forecastle (1736:163).

In *La Belle*, the width of the surviving stem is 30 cm while the height of the keel is only 20 to 22 cm, a clear discrepancy when compared with Ollivier's description. This difference is also present in the timber's thickness with respect to the keel dimension.

The description of the placement of the rabbet, however, accurately reflected that which was found on *La Belle*. Of that practice Ollivier noted:

. . . today all our shipwrights leave 4 or 5 inches [11 cm to 14 cm] of the width of the stem within the rabbet, and some even half the width of the stem. Our practice in this respect is to be preferred to that of the English shipwrights, for the stem is better fastened to the vessel, the sea finds less purchase on its outer edge, and the planking has beyond compare a more solid fastening (1737:46).



**Figure 3-4:** The sternpost has a simple mortise and tenon joint. The heavily worm-eaten wood marks the former location of two iron gudgeon straps. Photograph by George Vandervlugt.

Lastly, The sternpost mates with the keel by a common mortise and tenon joint (Figure 3-4). It is preserved to a height of 61 cm and measures 39 cm front to back at the base. The front-to-back dimension of the sternpost narrows slightly toward the top measuring 35 cm suggesting a slight tapering. Conversely, this timber increases in its thickness from 10 cm at the base to 12 cm at the top, suggesting a slight flaring. Although the mortise on the keel is incomplete, the tenon is undamaged and measures 15 cm front to back, 11 cm long, and 4 cm thick. Very little evidence of the rabbet for the ends of the planks survives, but what is apparent are the small nail holes along the forward edge of

the timber for the hooding ends of the planks and two treenails with several nails for the garboard strake. Also obvious is the very worm-eaten and damaged wood that marks the former location of the iron gudgeon strap for the rudder.

Ollivier provided a great deal of information on the sternpost, including the appropriate dimensions of the tenon.

Its breadth at the heel is as great as the timber . . . will furnish, its breadth at its head is equal to the breadth of the keel and its thickness is the same as the thickness of the keel. . . The heel of the sternpost is morticed into the keel. The length of the tenon is about two fifths of the breadth of the keel; its fore-and-aft width is one and a half times its length and its thickness is roughly equal to a quarter of the thickness of the keel . . . On either side of the sternpost a rabbet is cut to receive the hooding ends of the planking of the bottom and of some of the planks of the stern. This rabbet extends only as far as the rabbet of the wing transom; its width is equal to the thickness of the bottom planking and its depth is about half an inch less than its width. On either side of the heel of the post is another score, to receive the garboard and the strake next to the garboard . . . (1736:160-161).

Ollivier's ratios for the tenon in comparison with those found on *La Belle* are clearly at odds. If the length of the tenon was  $2/5$  the breadth of the keel, that would result in a measurement of 7 cm, rather than *La Belle's* 11 cm. A similar problem arises with the front to back measurement, which would result in 10.5 cm rather than 15 cm. Lastly, the thickness of the tenon would have resulted in a measurement of 5 cm rather than the 4 cm found.

Another problem arises in this timber. In providing information on the practice of the English with regard to their sternposts, Ollivier contradicted himself. Of the English practice he stated:

. . . the sternpost of the English ship has not the same thickness at the head as at the heel. At the heel this thickness is reduced to the siding of the keel . . . yet at its head the sternpost takes on the full thickness . . . that the keel possesses at the middle of its length, which only serves to weigh down needlessly the stern of the vessel; for the sternpost has no need of

greater strength at the head than at the heel. In our French ships the thickness is the same at either end, and our practice in this regard is clearly better than that of the English shipwrights (1737:63).

The sternpost on *La Belle* clearly tapers from its base (heel) toward its top (head) in its front-to-back dimension. However, it also flares from its base toward its top in its thickness. In this case, the sternpost found on *La Belle* is more similar to the English practice and may, in fact, reflect an older French practice. Throughout Ollivier's remarks on 18<sup>th</sup> century shipbuilding practice he alluded to this phenomenon. For example, he noted the English “. . . diminish the breadth [of the keel] toward the stern, starting one third along its length . . . In France we also for a long time committed this same error . . . nor have we rid ourselves completely of it . . .” (Ollivier 1737:63).

The forward deadwood is attached to the stem and keel by five round-shanked iron fasteners placed between frame stations (Figure 3-5) . The deadwood is deeply notched to accept frames 7, 8, and 9 forward and slightly indented for frames 10 and 11. The bottom face on both the port and starboard edges are beveled inward to meet the keel while the inboard face swells slightly at frame stations 7, 8 and 9. The length overall of the deadwood is 3.30 m, extending from frame 6 to just beyond frame 12 forward. The width varies between 15 and 16 cm on the bottom face and 18 cm on the top face. The thickness is 12 cm at the aft end, which gradually increases to the turn of the deadwood arc to a maximum of 20 cm, then slowly tapers to 14 cm at its forward end.

The stern deadwood is composed of two pieces; the aft portion of which rises to form the stern knee. A simple butt joint connects the two pieces, over which a filler piece is located creating the notch for frame 14. The forward section is attached to the keel with three round-shanked fasteners placed between the aft frame stations. The forward piece extends from just aft of frame station 9 to frame station 14. It is notched to accept



frames 10 through 13. The aft section is attached by three fasteners to the keel, placed between frame stations, and one extant fastener to the stern post. It is notched to accept frames 15, 16, and 17, which is the fashion piece. With the exception of the fastener at the filler piece, all are countersunk on the inboard face, suggesting they were driven from that direction. The thickness of the forward section is 11 cm at its forward end, increasing to 14 cm at its full thickness toward the aft end. The stern knee, at the location of and including the filler piece, is also 14 cm thick. Together, the two pieces are 4.10 m long to the rake for the sternpost, are 17 cm wide on the inboard face, and narrow to 11 cm on the outboard as the rabbet for the garboard strake opens up to become more vertical.

Referred to as the rising wood by Ollivier, his description of these timbers is similar to that found on *La Belle*.

One distinguishes the three parts of the rising wood, called the rising wood of the fore-body, the rising wood of the after-body and the rising wood of the middle body. The rising wood of the fore-body is scarfed at one end about 2-1/2 feet [81 cm] to the apron and at the other end it butts squarely to the rising wood of the middle body. Its length is determined by the position of the last floor of the fore-body, its breadth athwart ships is equal to the breadth of the keel, its thickness at the end which meets the apron is equal to that of the apron, and at the end where it meets the rising wood of the middle body it is about 5 inches [11.3 cm] in First and Second Rates . . . and 3 inches [8 cm] in frigates. The rising wood of the after-body is scarfed at one end about 2-1/2 feet [81 cm] to the deadwood knee, and at the other end it butts squarely to the rising wood of the middle body; its length is determined by the position of the last floor timber of the after-body, its scantling is the same as that of the rising wood of the fore-body. . . . Its breadth is equal to the thickness of the keel and its thickness from top to bottom is 5 inches in First and Second Rates . . . and 3 inches in frigates. Many Builders only employ the rising woods of the fore-body and after-body in warships and do not employ at all the rising wood of the middle body; this practice is older than the other. The . . . rising wood is at first only fastened with nails or treenails, for it is later solidly fastened to the keel by means of the bolts of the floors, the keelson and the riders which all pass through the rising wood. Scores are cut in the rising wood to receive the floors and crotches (1736:113)

The forward deadwood is incomplete at its upper end and no evidence of the scarf to the apron survived, so it is not possible to verify either the length of the scarf or the thickness of the apron. It is reasonable to hypothesize that the thickness of the apron was close to that of the surviving deadwood element, given the next piece of information provided by Ollivier. Just as he described it, the forward end of the timber ended just beyond frame 12, which is just beyond “. . . the last floor of the fore-body . . .”(Ollivier 1736:113).

Other dimensions provided by Ollivier, however, were surprisingly smaller than found on *La Belle*. For example, the thickness of the deadwood forward on the first rates was equal to 11.3 cm, while the thickness of the deadwood forward in *La Belle* is 12 cm. It is possible that overall heavier construction and the presence of deadwood in the middle body would allow for a smaller timber forward in ships of the line by 1736. There is no deadwood in the middle body on *La Belle*. The absence of this middle body timber, noted by Ollivier above as an older practice, supports the hypothesis that in its absence a heavier timber forward might be required. No other contemporary authors provide insights to this question.

The aft deadwood pieces do not have a scarf join, as described above, rather they are “. . . butted end to end . . .” more like multiple pieces of the middle body (Ollivier 1736:113). The stern knee also ends at the last floor timber of the after body at frame 17. Once again, the thickness of these timbers exceeds slightly that of the first rates. The forward section’s thickness is not uniform. It is 11 cm at its forward end increasing to 14 cm at its full thickness toward the aft end. The stern knee, at the location of and including the filler piece, is also 14 cm after which it quickly increases to become the stern knee. Allowing for some flexibility, the location of the measurement that Ollivier

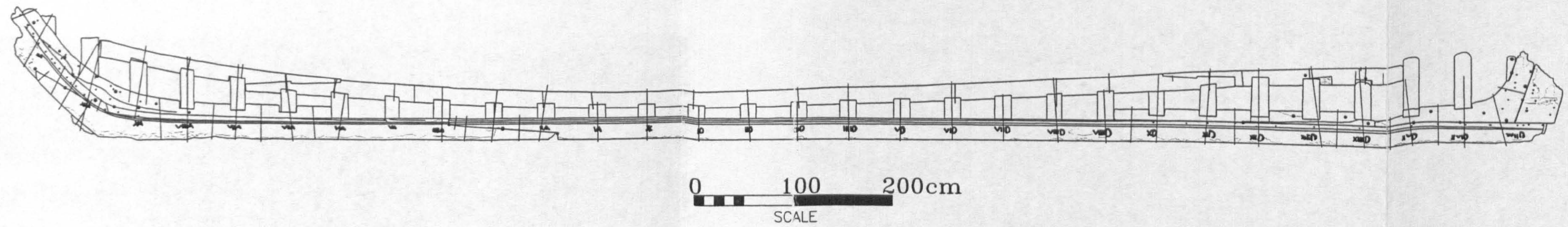


provided and an average thickness of 12.5 cm, this dimension still exceeds that of the first rates. The greater thickness of these aft timbers might, again, be required in the absence of a middle body section of deadwood.

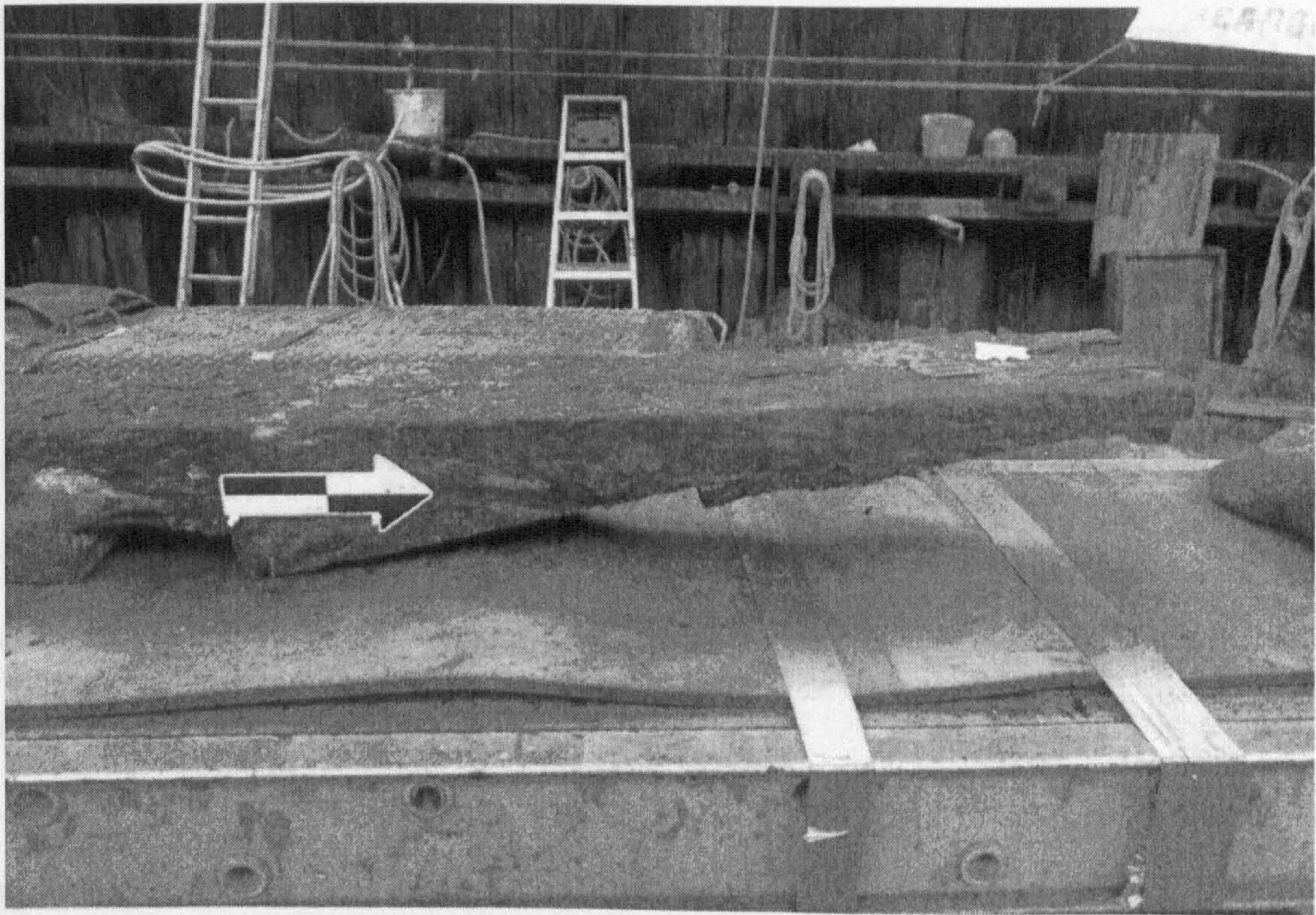
The keelson is composed of three pieces that together measure 14.91 cm long (Figure 3-6). The forward piece is 20 cm wide and 17 cm thick at its forward end. At the scarf it increases to 21 cm wide and the two pieces together are 23 cm thick. Aft of the scarf the middle timber continues to be 21 cm wide but is reduced to 17 cm thick throughout its length. At the aft scarf the two timbers are 18 cm thick and 21 cm wide. The aft timber is reduced in size to 17 cm thick and after the scarf it narrows to 17 cm wide.

The keelson abuts the aft face of frame 11 forward running to the forward face of frame 15 aft. The forward piece is both scarfed and notched on the bottom face (Figure 3-7). The 95-cm hooked scarf at the aft end articulates with the central piece and is notched to fit onto frames 8, 9, and 10 (Figure 3-8). The central timber is scarfed at both ends on the top face to articulate with the forward and aft keelson sections. It is notched to fit onto frames 7 forward through 11 aft. Similar to the forward section, the aft section of keelson is both scarfed and notched on the bottom face. The hooked scarf is 71 cm long and is notched to fit onto frames 12 through 14 aft. The scarfs were attached using a combination of paired round- and square-shanked fasteners. The forward scarf uses two sets of fasteners, while the aft scarf has only one set of fasteners with an additional square-shanked nail at the forward tip. Two of the three round-shanked fasteners in the scarfs are countersunk and also serve to bind the keelson, frames, and keel together.

The centerline round-shanked fasteners on the keelson are not uniformly countersunk on the inboard face and they are not all through-bolted to the keel. Through



**Figure 3-6:** Centerline longitudinal assembly of keel through keelson. Drawing by Taras Pevny.



**Figure 3-7:** Forward section of keelson with the overlapping Z-scarf aft. Photograph by Toni L. Carrell.



**Figure 3-8:** Center section of keelson with Z-scarf on upper face and notches for frames on the lower face. Photograph by Toni L. Carrell.

bolts are present on frame stations 10, 9, 8, 7, 4, 3, 2 forward, the master frame, 2, 3, 4, 6, 8, 10, 11, 12, 13, and 14 aft. Of these, 17 of the 19 through bolts are countersunk and two of the blind nails were also countersunk. It is apparent from the pattern of through-bolting that square-shanked nails were used to hold the keelson in place until the larger round-shanked fasteners could be installed. Whether it was intentional or accidental, in this process frame 5 forward was never through-bolted to the keel either prior to or after the installation of the keelson. The only fastener that holds this frame in place on the centerline is a 3-cm round-shanked countersunk bolt driven from the keelson partially into the floor below.

The overall configuration of the keelson is not much different from that described by Ollivier:

In ships, frigates, fireships, bomb ketches and storeships [the keelson] runs from the third crotch of the fore-body to the fourth or fifth crotches of the after body, and describes in its vertical plane a curve which is determined by the rising of the floors and crotches. The keelson is scored down 2 or 3 inches [5.4 cm to 8.1 cm] over the floors and crotches and forms a single body with the keel by means of the bolts which run through the keel, the floors and the keelson. There is one bolt in each floor or crotch, and they are driven from beneath the keel and clenched over roves on the keelson . . . . The breadth of the keelson is equal to that of the keel or exceeds it by 2 inches [5.4 cm], its thickness is about 6 lines [1.35 cm] for every inch of its breadth; the timbers of which it is composed are 35 to 50 feet in length [11.37 m to 16.24 m] and give shift to the scarfs of the keel; they are joined by flat scarfs, and each scarf is 3 1/2 to 4 feet long [1.13 m to 1.30 m] . . . The keelson is scarfed at the stern to the sternson knee and at the bow to the stemson, or if there be no stemson, it simply butts against one of the crotches of the fore-body or is scarfed to the throat of an inclined crotch. In all ships where the mortice of the heel of the mainmast is cut in the keelson, the timber is wider and thicker at this place than at the two ends . . . The keelson is usually made of oak (1736:82).

The differences from Ollivier's description are minor. For example, rather than running from the third frame of the fore-body to the fourth or fifth frame of the after-body, in *La Belle* the keelson runs from the second frame from the stem to the third

frame from the stern. The depths of the notches for the frames are slightly less, measuring only 3 cm to 6 cm in depth. The lengths of the scarfs are also less than described. The width of the keelson is the same as the keel, as described, but its thickness in relationship to its breadth, according to the formula provided, should have been 28.31 cm rather than its actual thickness of only 17 cm. However, Ollivier was describing the practices and formulae used for ships of the line and the differences found in *La Belle*, taken as a whole and on a much smaller ship built 52 years earlier, are minor. With regard to fastening the keelson through the frames and to the keel, the practice of driving the bolts from below and clenching them over roves on the inboard face of the keelson is born out by the archaeological evidence.

### **Frames**

The ship contains 30 equally-spaced frame sets, including the master frame and fashion piece (Figure 3-9). Noticeably absent is the use of cant frames. Twenty-six of the frames retained their futtock components for a total of 117 individual elements. The master frame is composed of a single floor, scarfed in line with a second futtock, and paired fore and aft first and third futtocks (Figure 3-10). Forward and aft of the master, the frames consist of double sawn elements scarfed in line with a second futtock and single in-line first and third futtocks placed on either the forward or aft face of the floor, depending upon their relationship to the master frame. Each frame set, therefore, has a floor, and two first, second, and third futtocks. The futtocks are attached to the floors with fore and aft iron nails and the occasional treenail. None of the floors are notched with limber holes.

The frame construction found in *La Belle* was, apparently, typical of French

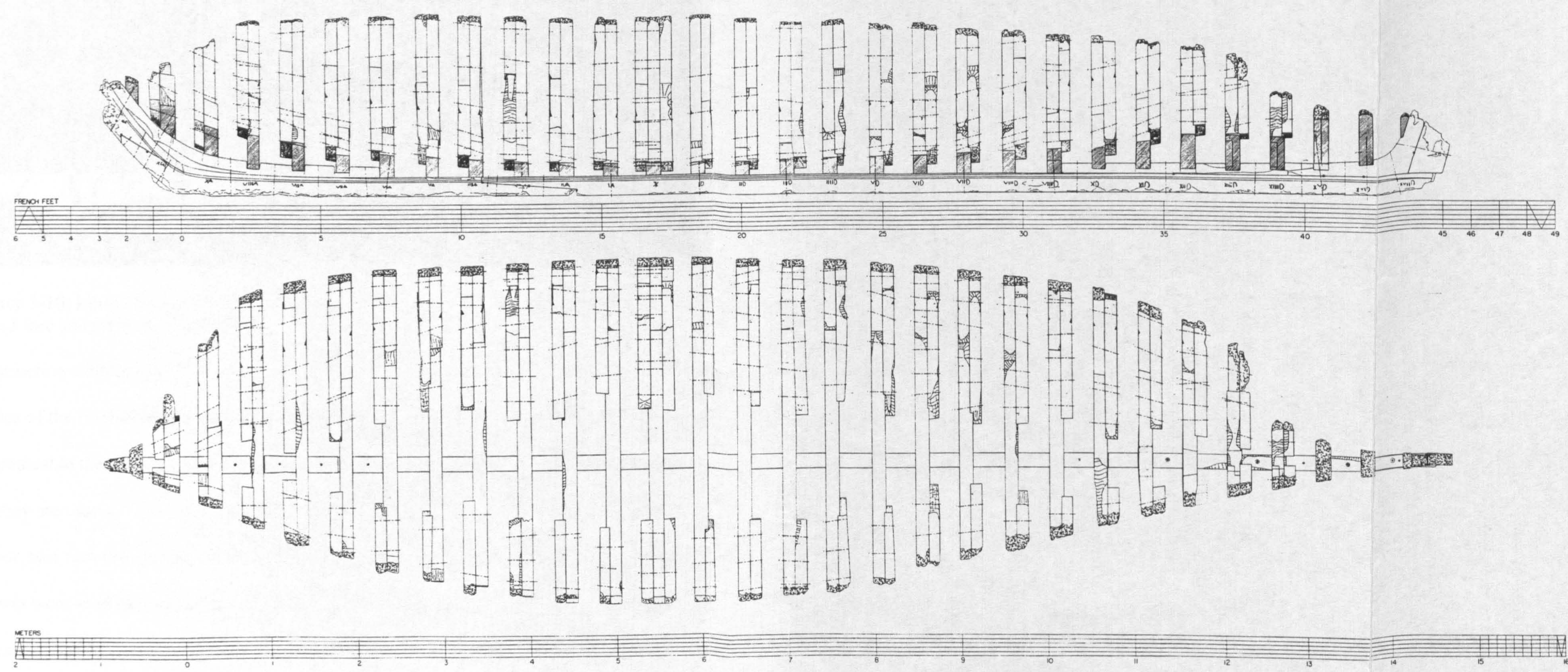
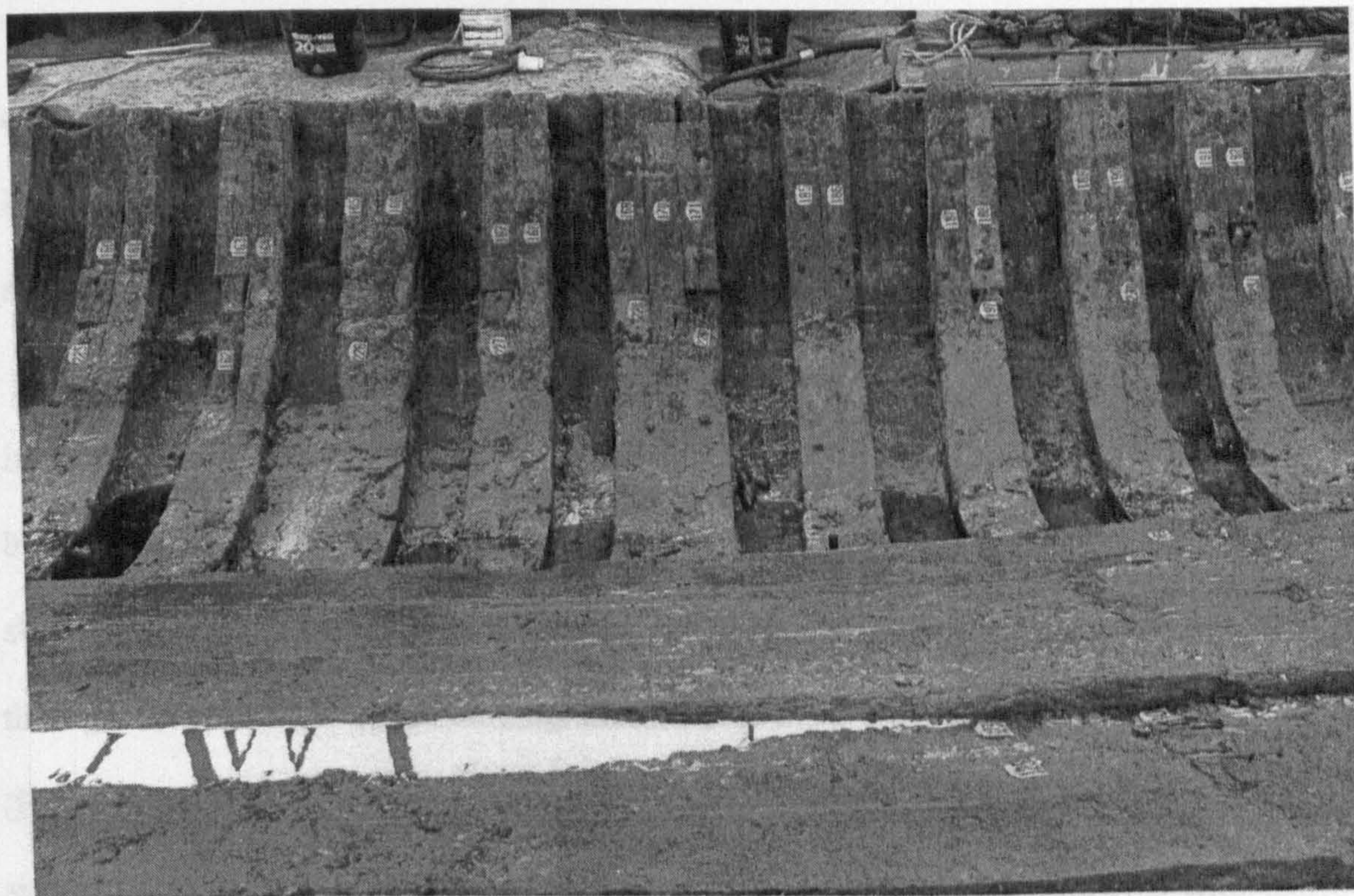


Figure 3-9: Framing plan and profile views. Drawn by Taras Pevny.



**Figure 3-10:** Master frame (center with three tags) with in-line second futtocks and paired fore and aft third futtocks. Photograph by Toni L. Carrell.

construction well into the 18<sup>th</sup> century. Ollivier (1737:67) remarked that, “. . . The frames of the English ships from athwart the riding bitts to the hawse-pieces and from the mizenmast to the fashion pieces are not placed at right angles to the keel as in our ships . . . they are canted.” He also noted in French ships that each frame set was composed of a floor, two first futtocks, two second futtocks, two third futtocks, and so forth, and these timbers were scarfed together for one half of their length (Ollivier 1736:117). The equal spacing of the frames was alluded to in a description of the number of frames in ships of the line:

. . . the number of frames is always the same or nearly so and the difference resides only in their scantling . . . according to whether the distance which is left between the frames be greater or smaller. This distance is called the room, it is of 3 to 4 inches in first rates, 4, 5, or 6 inches in second and third rates, 5, 6 or 7 inches [ 13.5 cm to 19 cm] in fourth rates and frigates (Ollivier 1736:117).

This spacing, of course, is not the same as that found in *La Belle*, which varied from 34 cm to 36 cm [12.56 *pouces* to 13.30 *pouces*], but it does appear that apart from changes in spacing due to canted frames, all of the frames in French ships were as evenly spaced as humanly possible.

The absence of limber holes is surprising if for no other reason than they greatly increase the efficiency of the pumps in keeping the bilges dry. The use of limber holes by the English in 1671 was noted by the Hollander Nicholas Witsen. In describing the skill of the English shipwrights and their ships, he reported that they placed chains through the limber holes that were agitated to keep the drain holes from clogging (Hoving 1986:35). This comment suggests that limber holes were also familiar to Dutch shipwrights. They were also used by the French. Ollivier noted the following with regard to limber holes:

These are notches that one makes in the floor timber and cant-frames a foot and half from the keel to guide to pump the water that the vessel makes. One names them Bitonnières, Lumières and Vitronnières but limber hole [*anguiller*] is more common. They have about 2 inches of width [5.4 cm] and 2 inches or only an inch and half of depth (1736:16).

They were described by Ollivier as round-shaped rather than square notches:

Round holes are made at the bottom of the hold in the way of the pumps. The diameter of these holes is equal to the small end of the barrel of the pumps; their depth extends to 2/3 or only 1/2 of the thickness of the frame timber, and to prevent the action of the pumps from sucking the caulking from the seams, the space between the frames in the way of each pump is lined with a length of plank (1736:271).

No other contemporary authors mention the use or absence of limber holes. Their absence on *La Belle* is, at present, inexplicable.

With the exception of eight frames, all of the floors sit directly on top of the keel. Those that do not, frames 7 through 11 forward and 10 through 12 aft, are notched on



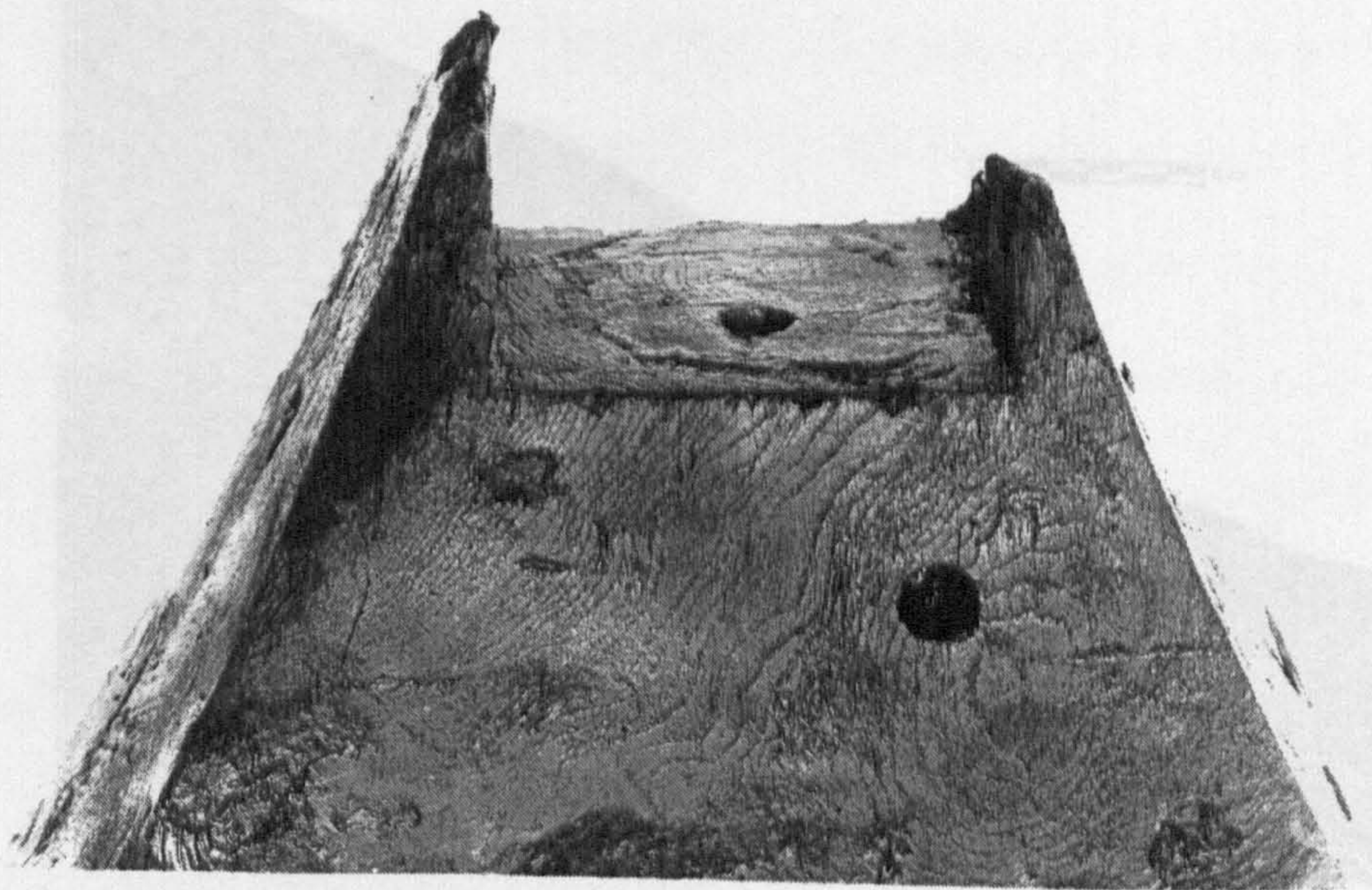
their bottom faces to accommodate the keel (Figure 3-11). Ollivier (1736:351) referred to this practice, “. . . In some ships the floors are simply laid over the keel and in others they are scored down 2 inches [5.4 cm] and half-lapped over the rising wood .” The depth of scoring down is extremely close to that which was found in *La Belle*.

Nearly all of the floor timbers are notched to accept the first futtock (Figure 3-12). The shape and even the length of the futtocks at their lower end is irregular. Some are finished pieces, squared off with the floor neatly notched. In others the futtock terminus is little better than a log, cut flat on the end and the floor rebated to accept the futtock. At those frames immediately forward and aft of the master frame, floors are trimmed with a slight notch to accept the first futtock. Where the futtock is irregularly shaped, the floor appears notched only at the terminus of the futtock. However, upon closer examination these floors are reduced in their sided dimension and carefully shaped along their length to accommodate the futtock. Individually carved rather than cut, the results can be quite elaborate (Figure 3-13).

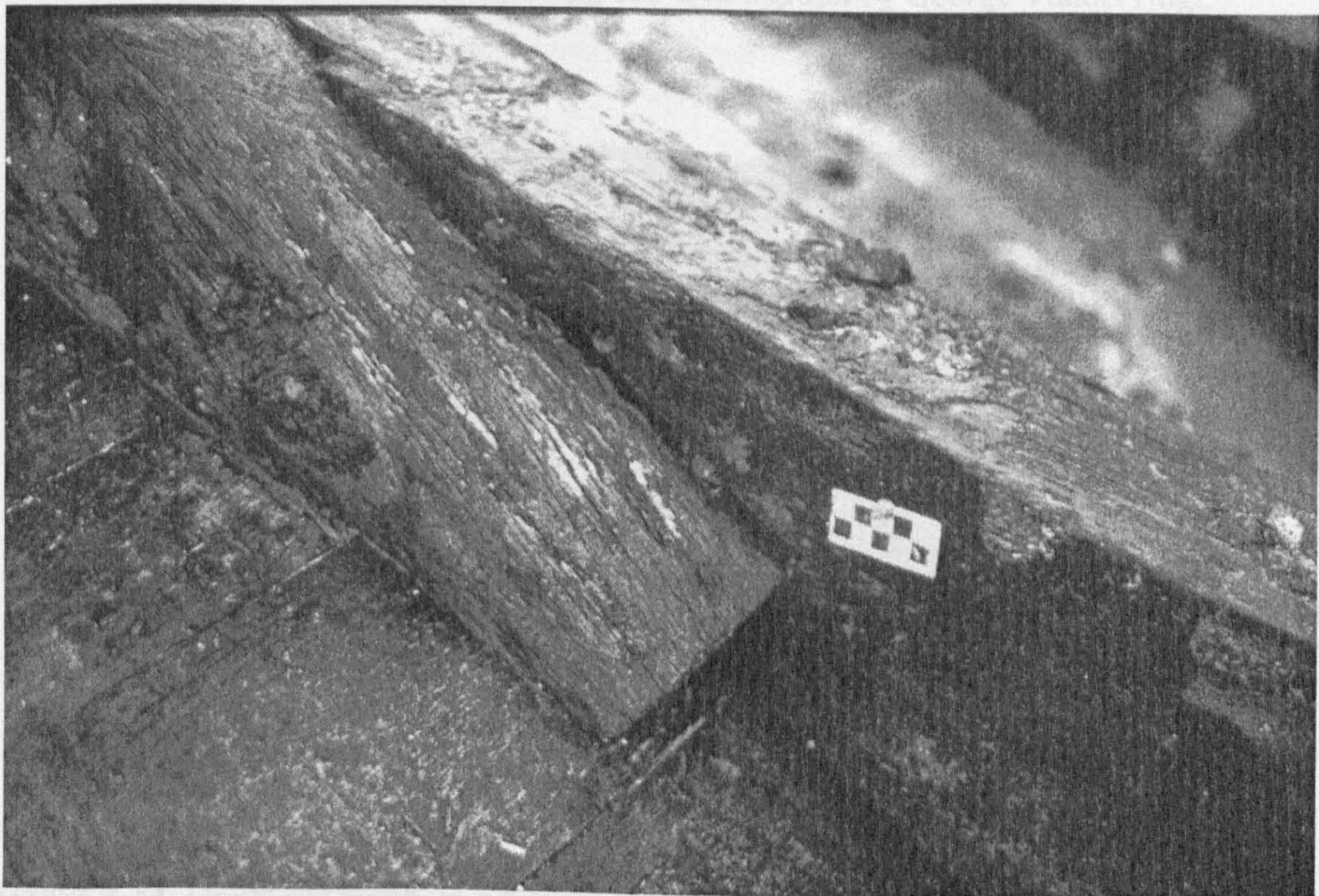
The first futtocks are notched to accept the filler pieces at the top of the ceiling planking to ensure a snug fit. Depending upon its location forward or aft, the notch was either a simple shelf or a complex double shelf, resembling a V (Figure 3-14). A similar notch does not appear at the locations of the stringers.

### **Built-Up Floors (Crotches)**

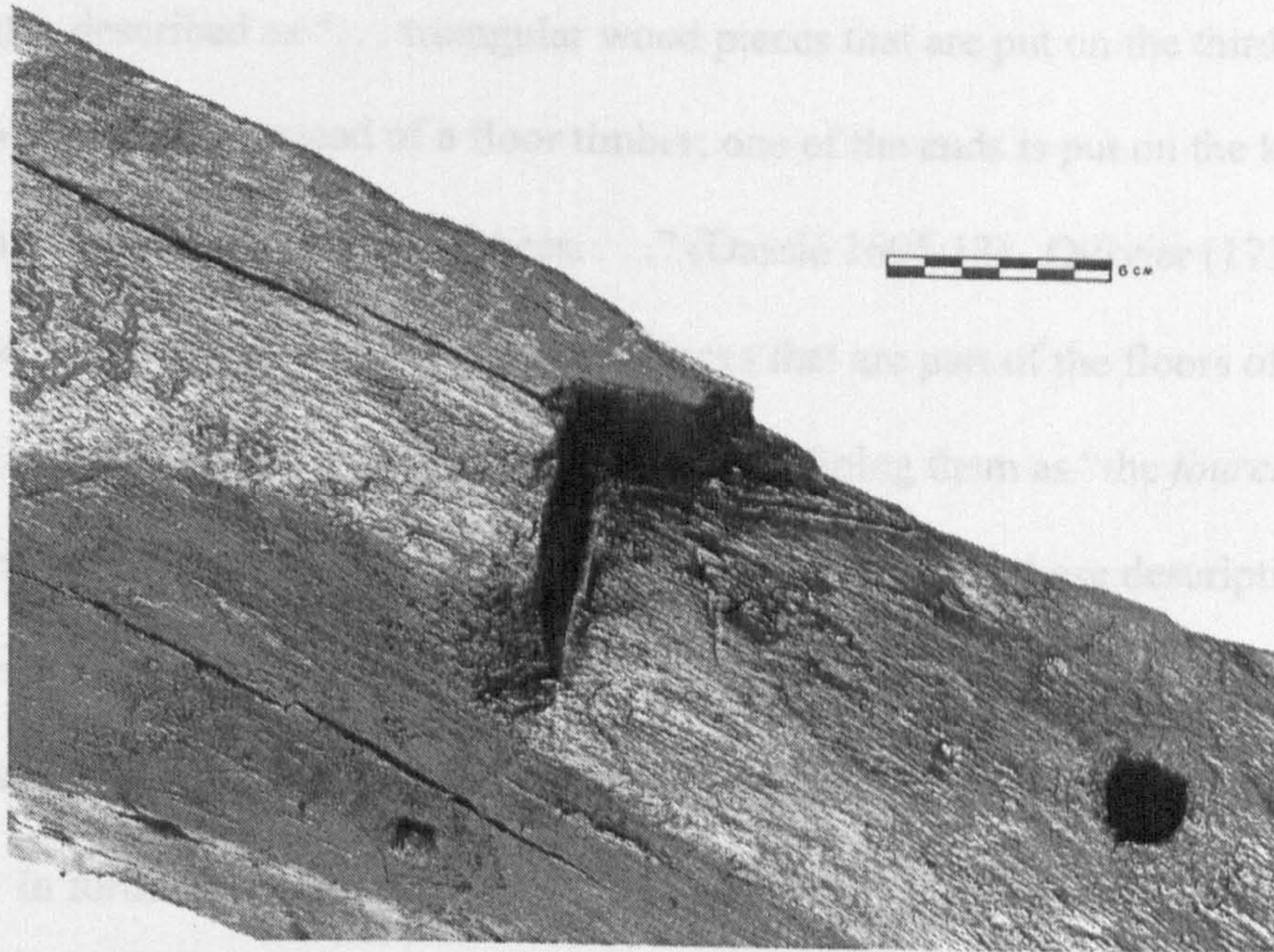
The deep floors in the bow and stern of French ships were called *fourcats* by several contemporary authors. They were “pieces serving . . . to finish the runs to the stern and prow. They are called by this name because their branches, while narrowing and making a sharp angle, take the shape of a pitchfork” (Anonymous 1691:51). They



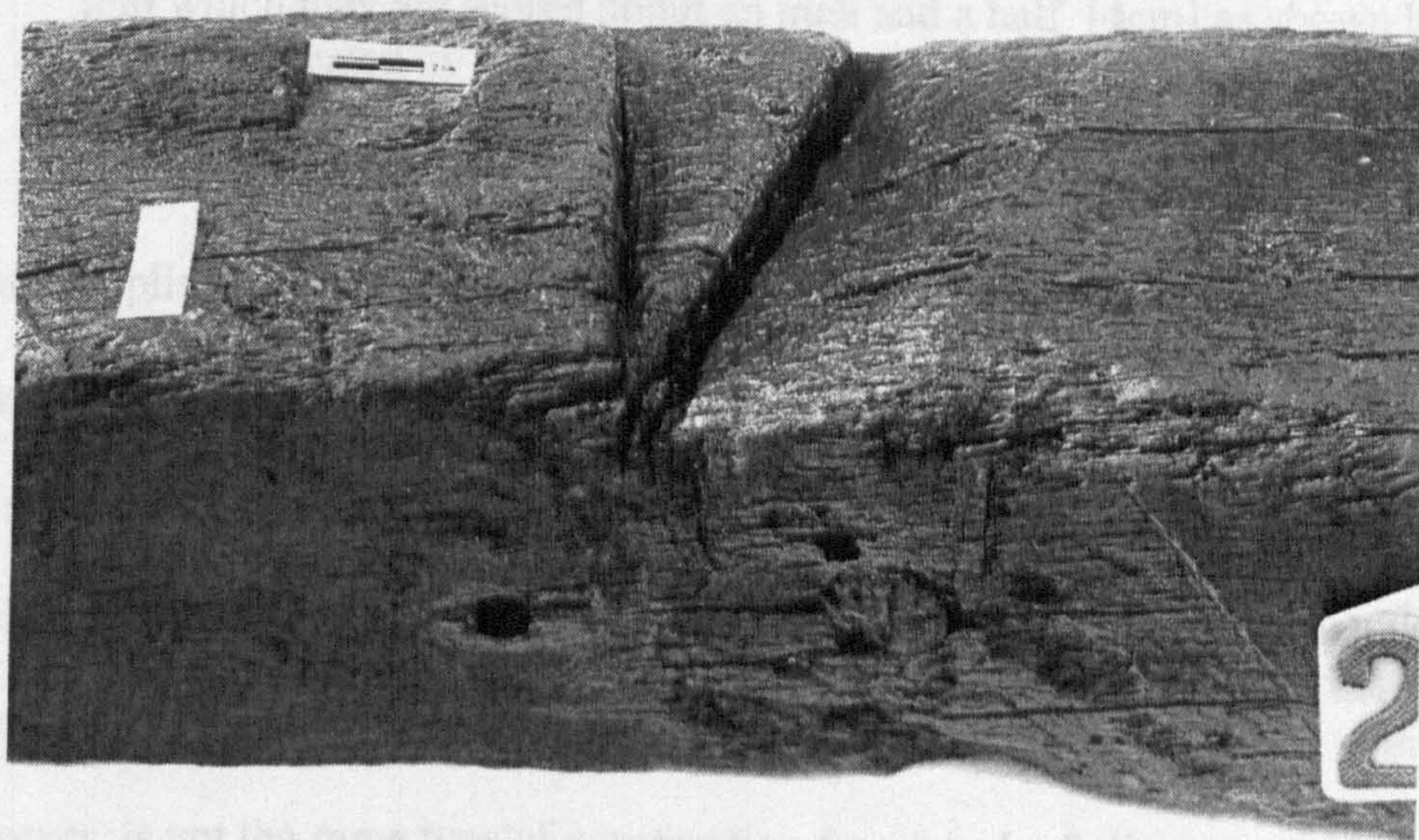
**Figure 3-11:** Notched base of deep floors. Photograph by George Vandervlugt.



**Figure 3-12:** The lower ends of the first futtocks are irregular, with some very little modified from their original log shape. Photograph by Toni L. Carrell.



**Figure 3-13:** The futtock notch in this floor is typical of those where futtock terminus has not been modified much beyond squaring off. Photograph by George Vandervlugt.



**Figure 3-14:** Double V notch on a futtock for the filler piece. Photograph by George Vandervlugt

were also described as “. . . triangular wood pieces that are put on the third part of the keel toward the aft instead of a floor timber; one of the ends is put on the keel, and the two on in top join with reverse knees. . . .” (Dassié 1695:13). Ollivier (1736:176) noted that the *fourcats* were “. . . forked wood pieces that are part of the floors of a vessel.” While Lescallier (1791:np) was more specific, defining them as “the *fourcats*, or floor timbers placed in the aft and fore holds.” It is quite clear by these descriptions that these timbers are the deep V-shaped floors, sometimes called crotches or Y timbers placed in the bow and stern to facilitate the rising and narrowing of the hull.

In further describing *fourcats*, Ollivier (1736:176) remarked that they could be made of several pieces. This type of multi-timber or built-up construction was common in both the English and French yards. Ollivier described this type of construction by the English shipwrights at Woolwich Yard:

The crotches [*fourcats*] of the cant-frames in the English ships have no floors; the lower [first] futtocks butt against the deadwood timbers . . . into which they are scored about an inch and a half [4cm] as shown by the futtock indicated by the letter B in Fig. 19; this they do when the timber is not of sufficient scantling to run full down to the keel. In this case, which is the most common, a filling-piece is fayed to the outside . . . (1737:68).

To accomplish this, the English built up their deadwood and attached the first futtock directly to it without a floor element, the deadwood serving that purpose. This avoided the problem of trying to find a timber whose molded dimension was sufficient to create a V-shaped deep floor (crotch). If the timber was too short to reach the keel, then another timber was fayed into the outboard face to ensure sufficient stability and strength. This, however, is not the same type of construction found in *La Belle*.

In this ship the multi-timber *fourcats* appear only in the stern at frame positions 13, 14 and 15 aft. The design of floors 13 and 14 are identical, consisting of two

interlocking pieces that are integrated so that the port arm sits on a small shelf created by a notch cut into the forward face of its partner, which also forms the starboard arm (Figures 3-15 and 3-16). The starboard piece, therefore, consists of the base, which sits on the keel, and the starboard arm. The design of floor 15 is completely different; the two elements fit together so that the bases of both sit on the deadwood (Figure 3-17).

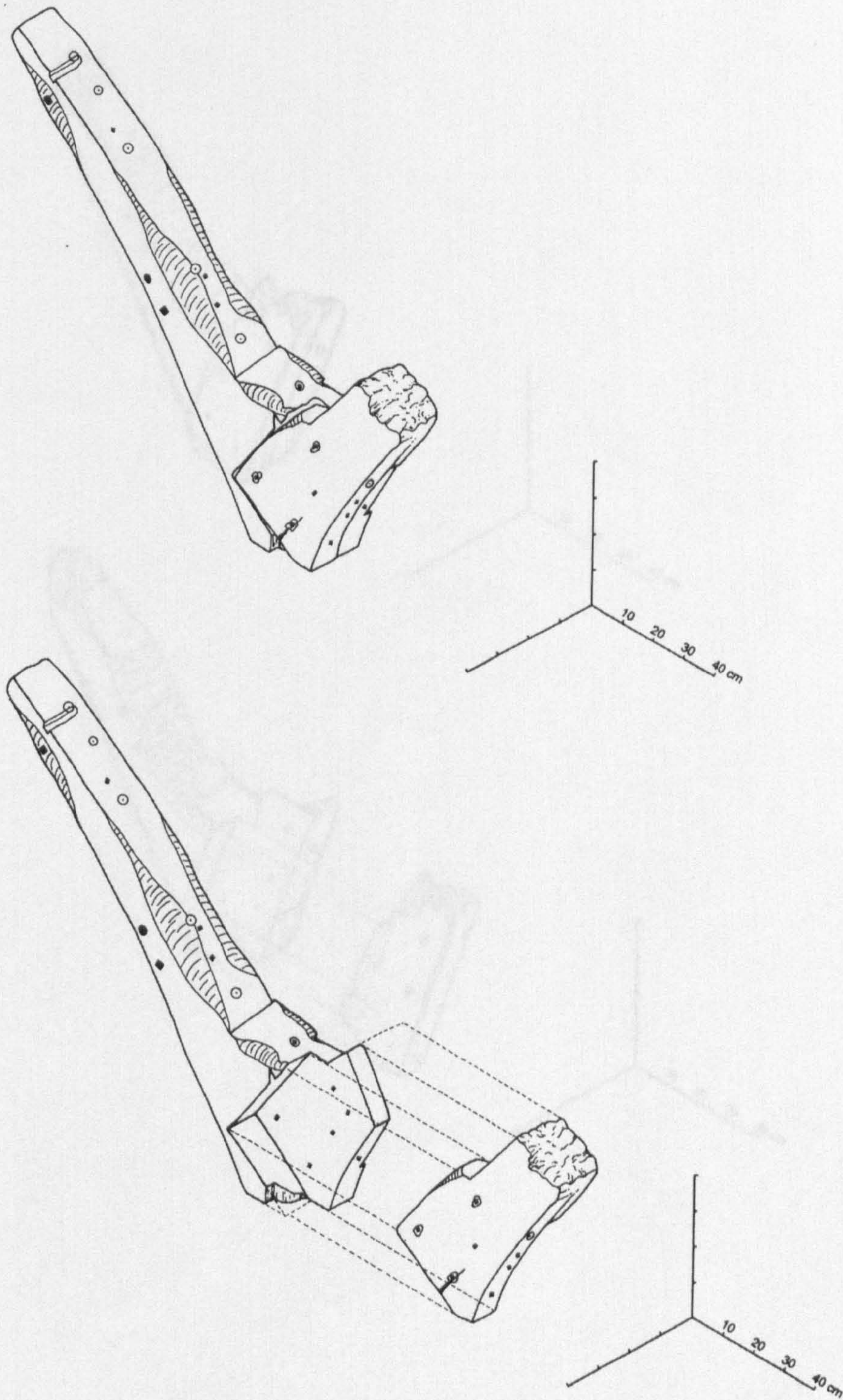
The construction of floor 15 aft is very similar to the French *fourcats de plusieurs pieces* described by Ollivier:

These are the crotches of the runs forward and to the rear that are composed of 3 or 4 pieces. . . . One constructs a crotch of several pieces in the following manner. One works the two branches of the crotch according to the given mold, approaching them so that the two have the whole figure of the crotch together; one then puts on the flat [forward or aft face] of these two pieces one or two other wood pieces, called guards, that extend the whole width of the foot of the crotch and that are indented with a dovetail and attached with four iron nails to the flat, or only with two nails and two treenails. Most constructors prefer the crotches of several pieces to those of only one piece (1736:176).

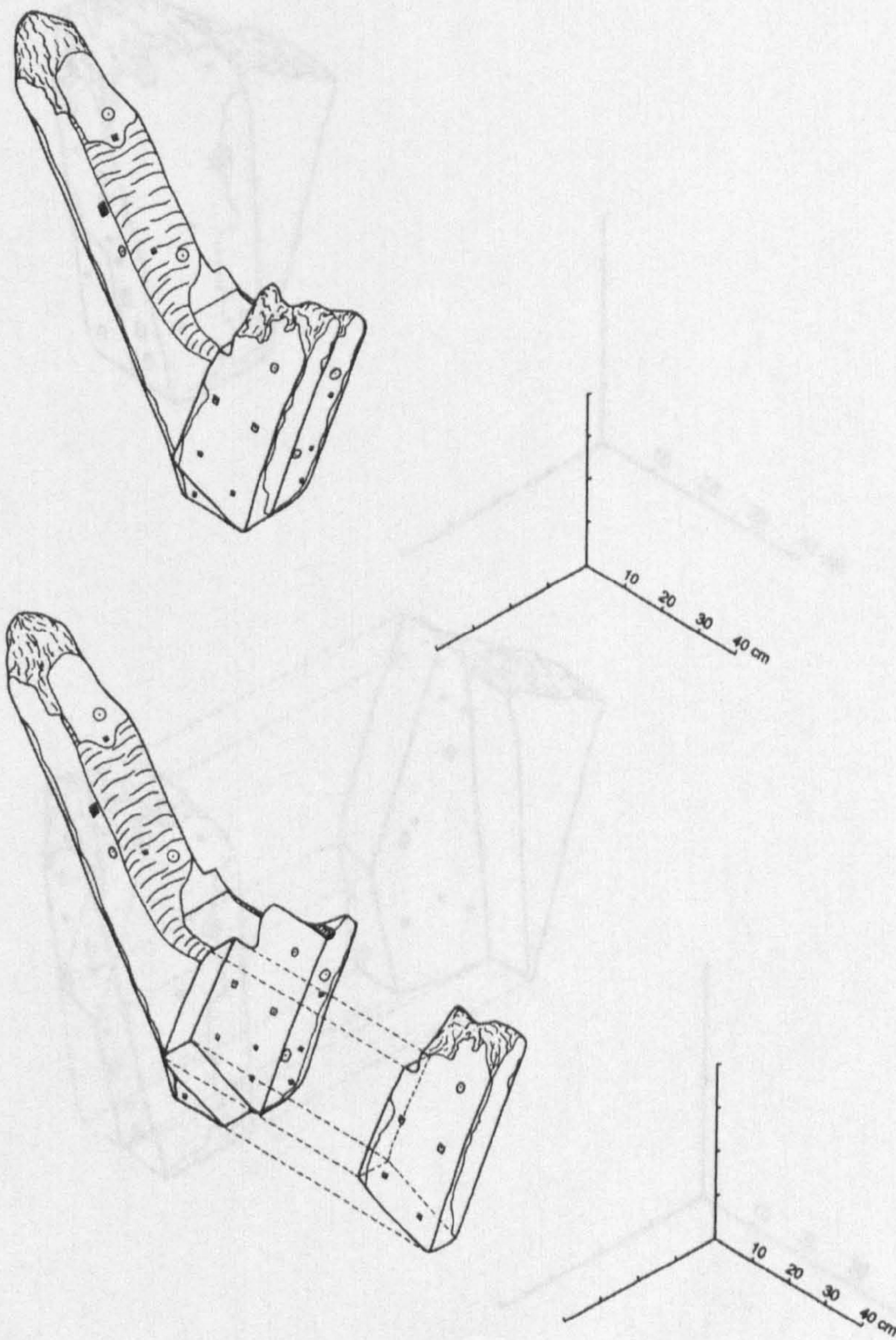
Apart from the guard pieces, this is a reasonable description of the design of the floor at 15 aft. Although it does not reflect the design of floors 13 and 14, it does provide a clear indication of the concept that was employed in their construction.

### **Frames at 3rds**

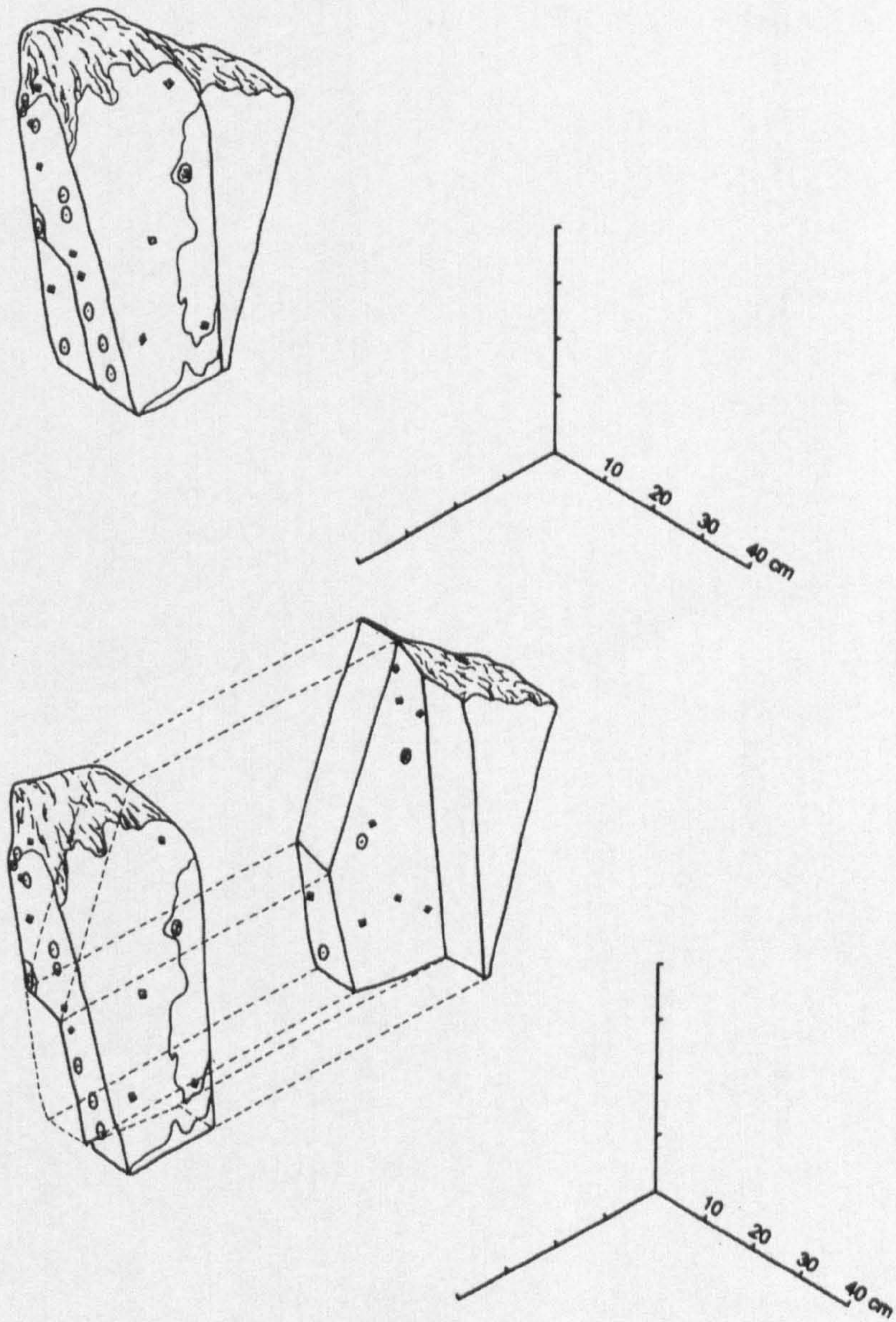
During the course of timber documentation, it became clear that the frames appearing at 3, 6, and 9 forward and 3, 6, 9, 12 and very possibly 15 aft played an important role in the construction of the ship (Figure 3-18). Two physical features set these frames apart; the first is the presence of design marks, sometimes referred to as surmarks, on the exposed faces of either their floors or their second futtocks. The function of these design marks is discussed elsewhere. The second feature is the angle of the fore and aft fasteners (refer to Figure 3-9). The majority of the fasteners on these



**Figure 3-15:** Assembled and exploded isometric views of the crotch at frame 13 aft. Note the angled shelf for the port arm. Drawing by Marie-Andrée Marchand.



**Figure 3-16:** Assembled and exploded isometric views of the crotch at frame 14 aft.  
Drawing by Marie-Andrée Marchand.



**Figure 3-17:** Assembled and exploded isometric views of the crotch at frame 15 aft.  
Drawing by Marie-Andrée Marchand.



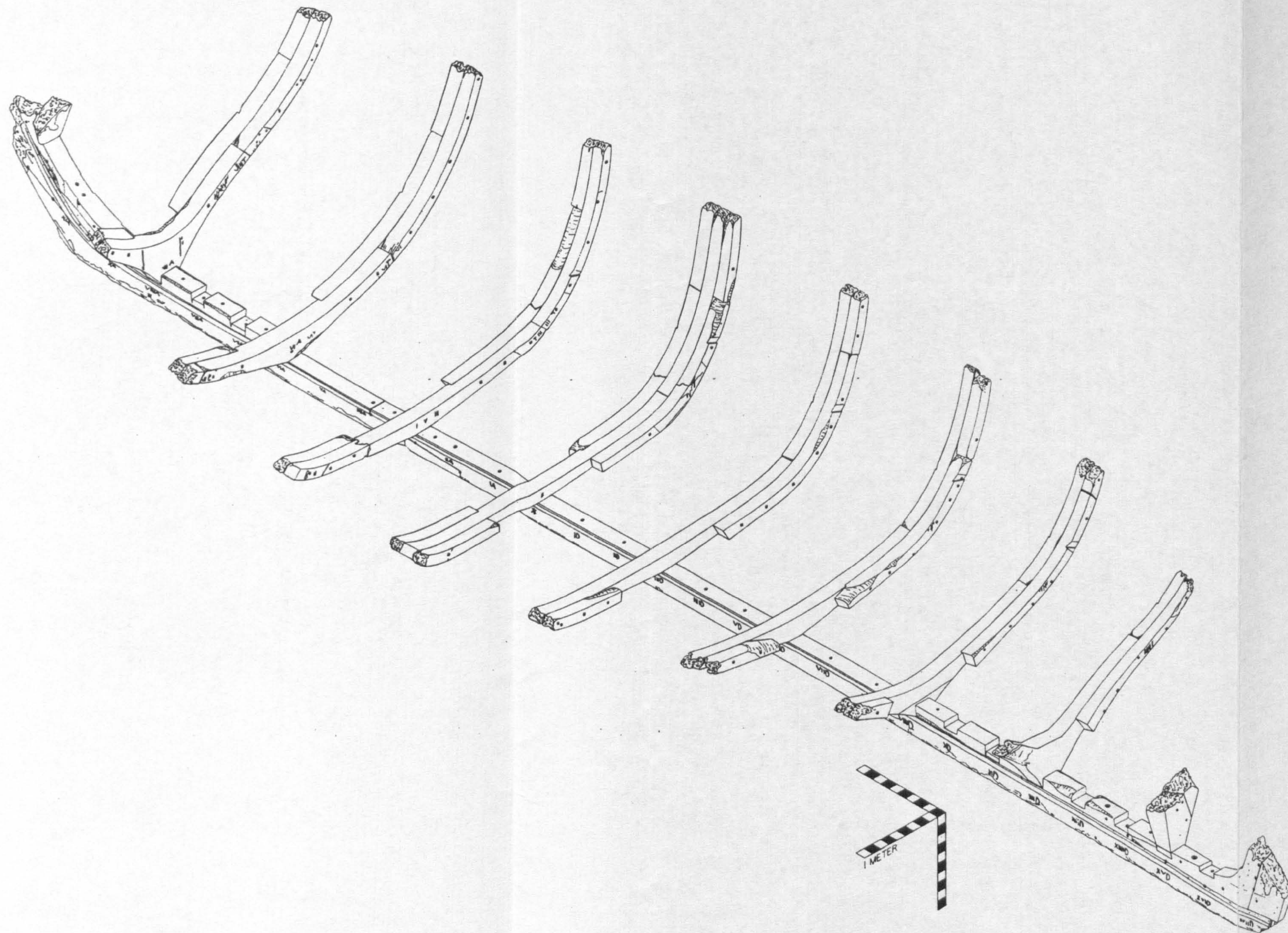


Figure 3-18: Isometric view of preassembled frames. Drawing by Taras Pevny.

frames run perpendicular to the fore and aft face. This fastening pattern is most often found on the master frame, which is generally preassembled to the level of the first futtock, at minimum, and is the first frame set in place on the keel. In the case of these frames at every third position on *La Belle*, the telltale perpendicular orientation to the fore and aft face of these fasteners is the clue to their pre-assembly before placement on the keel. This process was described in detail by Ollivier:

. . . The assembly of the timbers is done on a piece of flat ground, or if the ground is uneven it is corrected by means of blocks, the upper faces of which are perfectly level over the whole area taken up by the frame. The floor timber is laid over these blocks with the second futtocks at the same level, one at either end of the floor, and the two fourth futtocks at the heads of the second futtocks and finally the two top timbers at the heads of the fourth futtocks . . . The floor and the futtocks are then secured in position by means of nails which are driven one on the inside and the other on the outside of each timber into each block. The mold and the rules are removed. The first futtocks are laid on top, half over the floor and half over the second futtocks, the third futtocks next, half over the second futtocks and half over the fourth futtocks; and finally, the fifth futtocks, half over the fourth futtocks and half over the top timbers . . . Once these timbers are positioned [and checked] . . . the timbers which make up the frame are fastened together by means of square bolts, and because the frame cannot be lifted whole, only some of the timbers are bolted together and only the holes are bored for the square bolts of the others so that the frame can be taken apart (1736:118-119).

Because the frame components were drilled while on the ground, the angle of the drilled hole must naturally run parallel to the fore and aft face.

This contrasts with the procedure for the assembly of the filling frames, also described by Ollivier:

The filling frames are merely assembled timber by timber as the work progresses. Their floors are placed as soon as they have been shaped and they are chocked in place over the keel and against the ribbands; next, all the first futtocks are set up, followed by the other timbers up to the top timbers. Care is taken when placing the filling frames to distribute their fourth and fifth futtocks and their top timbers so that these timbers form the sides of the gun ports (1736:119).

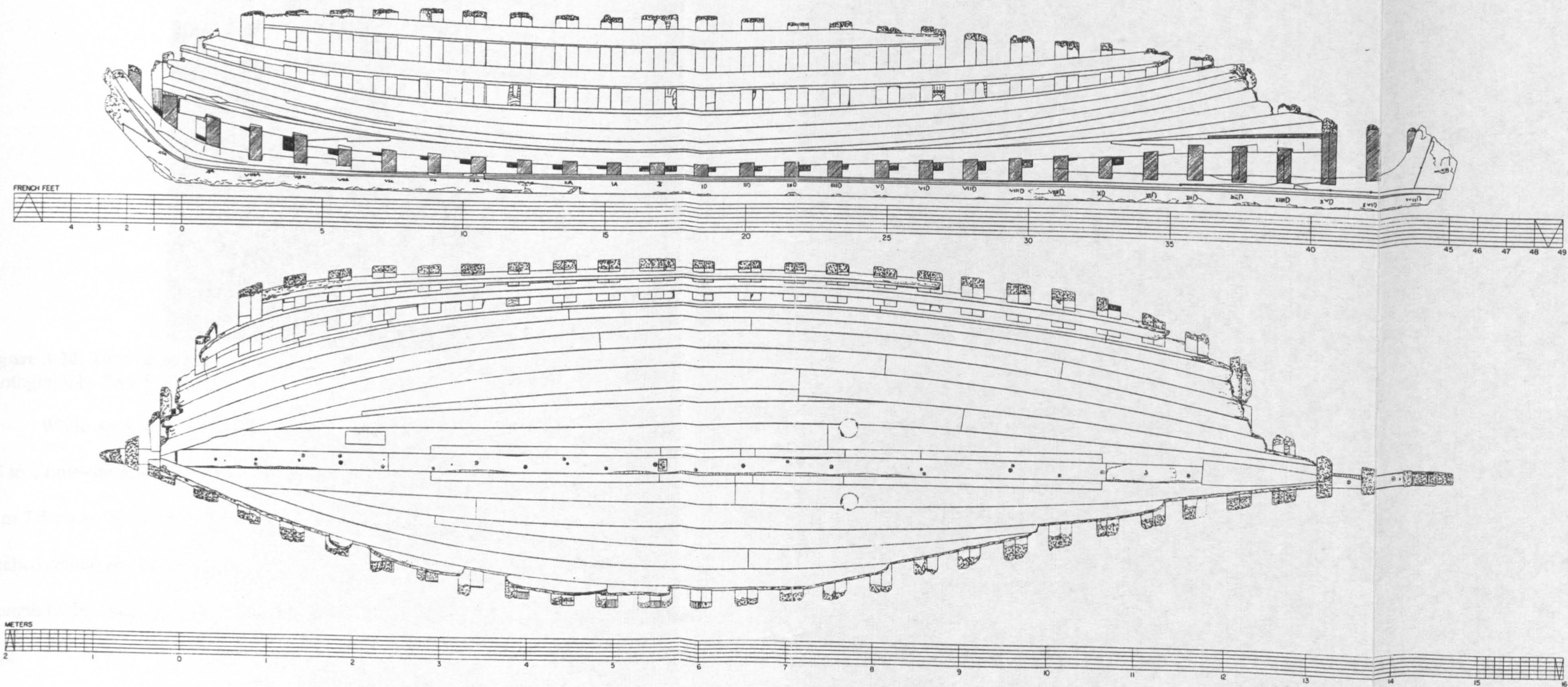
This description implies and is borne out archaeologically on *La Belle* with the oblique angle of the fasteners to the fore and aft face of the frame assemblies.

### **Interior and Exterior Planking and Stringers**

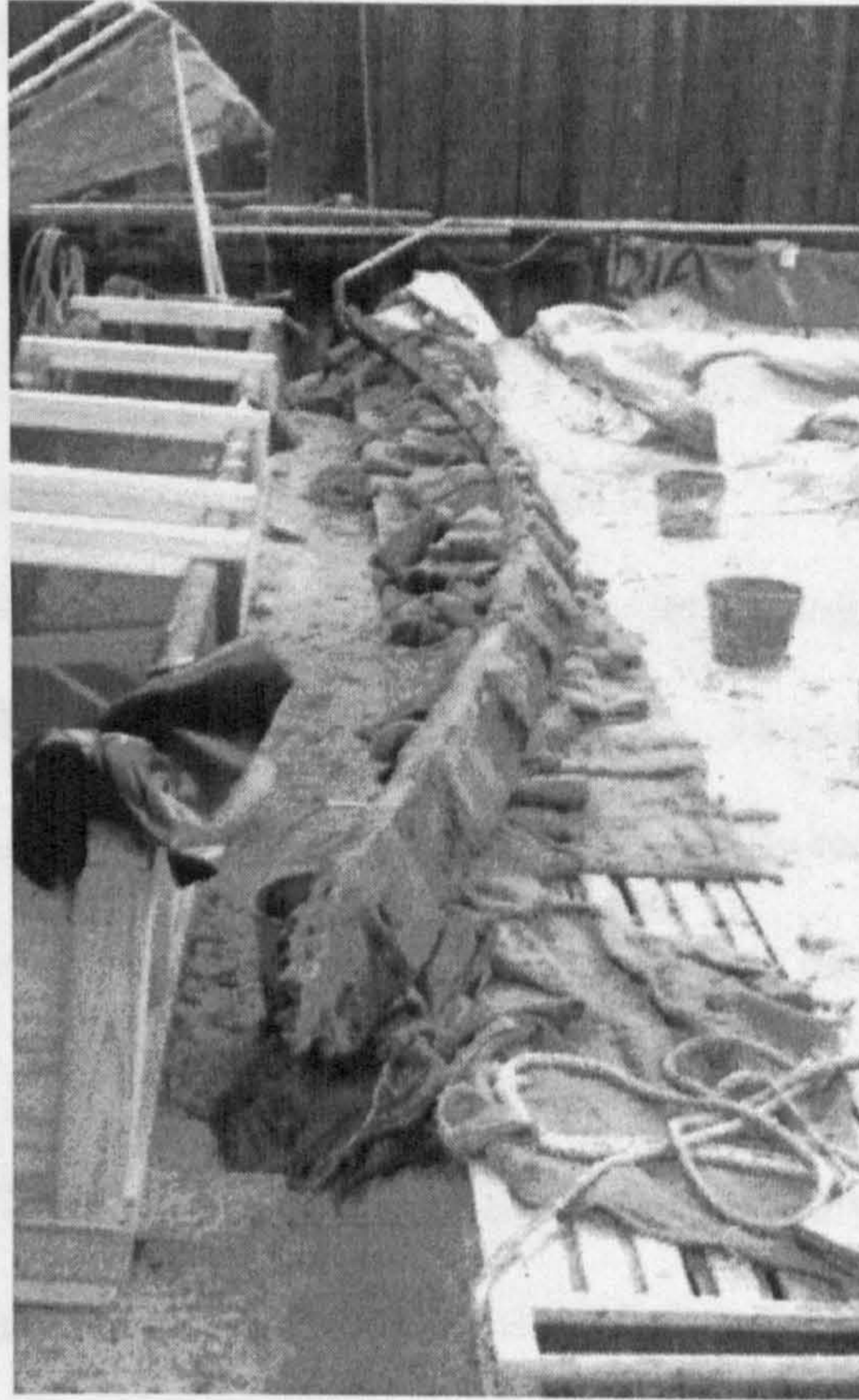
Overlaying the frames are limber boards and ceiling planks (Figure 3-19). A total of 11 limber boards extend from frame position 10 aft to 5 forward; six on the starboard side and five on the port. Not surprisingly, they are fitted into place without nails or other means to hold them in position.

The most notable feature of the oak ceiling planks is that two of the runs are notched to fit over the frames (Figure 3-20). The first run is at the turn of the bilge, while the second is the uppermost ceiling plank. The practice of notching, or “letting down” the plank over the frame, was mentioned by Ollivier (1737:50). This “let down ceiling” or *vaigrage de liaison* was common practice until about 1718 when it was abandoned in favor of oblique planking. However, the oblique planking was “. . . esteemed less by most builders than a let down ceiling” (Ollivier 1736:343). Ollivier described how these let down ceiling planks or “thick stuff” were used:

The type which was used in warships consisted of eight or ten strakes assembled in pairs one over the other and arranged so that the plain butts of one strake made shift with the butts of the other. The first pair of strakes ran at the height of the rungheads [turn of the bilge] and the others were distributed between the first pair and the shelf, so that there was a space of 10 to 13 inches between each pair of strakes. They were scarfed at their forward end to the breast hooks and aft to the sleepers and the transom knees, thus forming a continuous belt running right round the ship; they were let down 3 inches with a square mortice over the frame timbers, fastened with bolts driven through the outer planking of the hull and clenched over roves set against the planking on the inside. The timber used for this thick stuff was of oak and measured 25 to 50 feet long. Their breadth was 13 to 14 inches in First and Second Rates, 12 to 13 inches in Third Rates, 11 to 12 inches in Fourth Rates and 10 to 11 inches in frigates. Their thickness was equal to the bottom planking, plus 3 inches (1736:343).



**Figure 3-19:** Interior planking profile and plan views. Drawing by Taras Pevny.



**Figure 3-20:** The notched ceiling plank at the turn of the bilge exhibits a deep curve. Photograph by Toni L. Carrell

While not as robust as those described for warships, in *La Belle* these planks are 1.5 to 2 times thicker than the regular planks. They vary in their maximum thickness from 7.5 cm to 10 cm, between frame positions, and average 5.1 cm in the notches. The notched ceiling planks are clearly serving as longitudinal stringers adding rigidity and strength to the hull at two vulnerable locations: the turn of the bilge and where the ceiling stops.

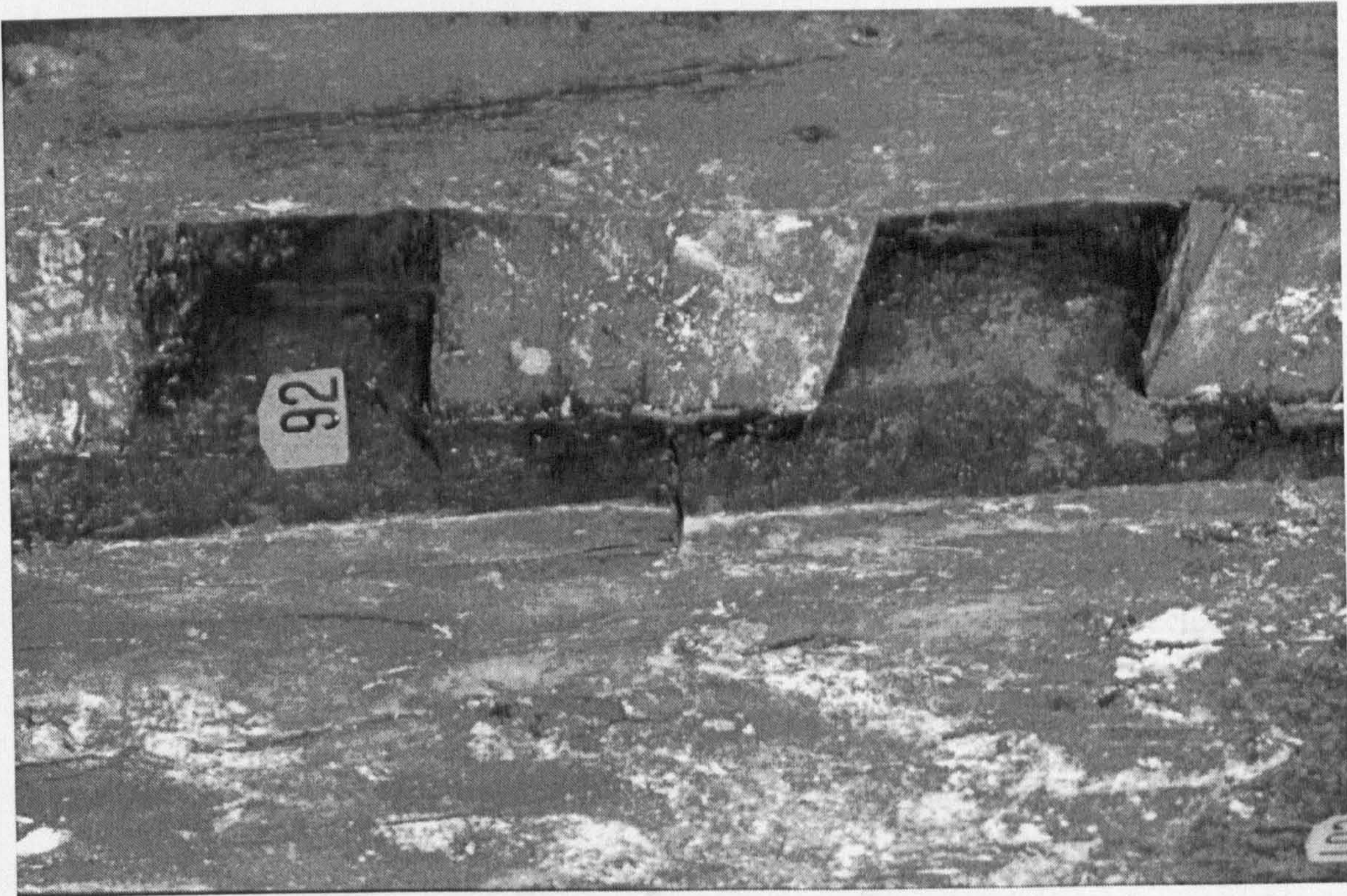
Above the level of the ceiling planks are two easily-recognizable longitudinal stringers, also part of the ship's thick stuff. Notched to fit over the frames like the let down ceiling, the lower stringer reinforces the join between the first and third futtock, while the upper provides intermediate reinforcement just below the level of the deck and

clamp. The stringers average 5.2 cm thick in the notches, 8 cm thick between frames, and are 22 cm wide. While both the notched ceiling planks and the notched stringers are thicker than the unnotched ceiling planks, neither rise above the level of the ceiling on their inboard face. That is, all of their thickness extends into the space between the inner and outer hull planking, resulting in a smooth inner face.

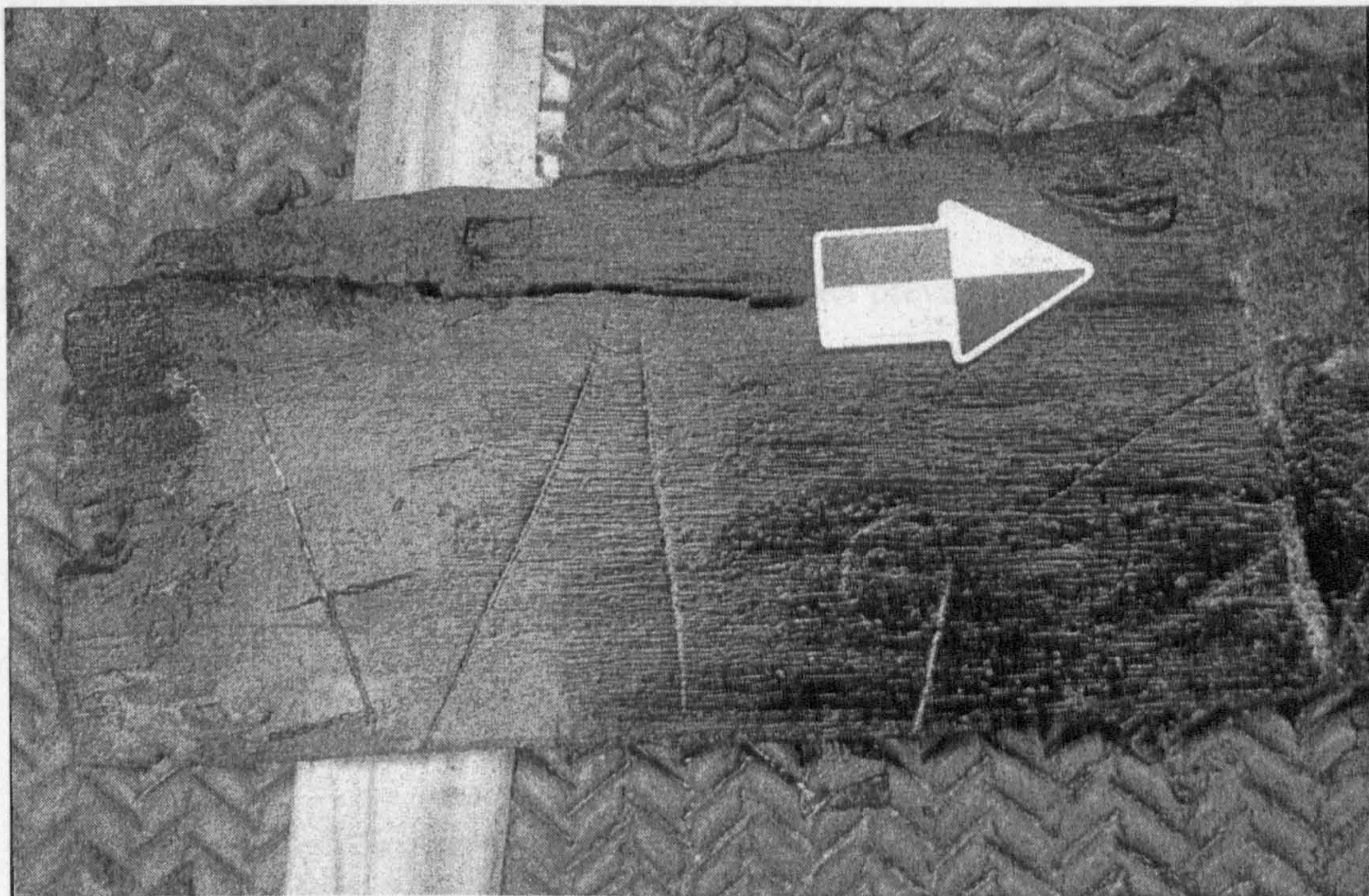
The ceiling planks were laid down using an overlapping scarf joint. These range in length from 62 to 43 cm, with most averaging 56 cm. The ceiling was attached to the frames with a combination of treenails and square or slightly rectangular-shanked fasteners. The treenails ranged in size from 2.3 to 2.8 cm in diameter while the fasteners ranged in size from .9 to 1.3 cm. The generally flat-headed fasteners were wrapped with oakum and the spaces between the ceiling planks were packed with caulking and oakum.

The ceiling planks extend up the side of the hull approximately 60 cm and are finished off with a carefully carved filler plank notched to fit over the frames (Figure 3-21). This plank effectively seals the top edge of the ceiling preventing debris or ballast from entering the space between the outer hull and ceiling planking. Only seven filler planks on the starboard side survived, all of which were nailed to the frames using square or slightly rectangular-shanked nails from .9 to 1.3 cm in cross-section.

Of interest was the discovery of marks on one of the planks that are probably not the doodling of an idle shipwright (Figure 3-22). They appear on the protected face in the overlapping scarf of a ceiling plank. This plank was laid down first, with its scarf exposed, waiting to be matched with the next plank on the run. Part of an unknown code, these marks could only have been made by the shipwrights in the yard. They may indicate an adjacent plank designation. The next plank up in the hull is the notched ceiling plank that appears at the turn of the bilge. The tip of the V points toward the



**Figure 3-21:** Timber 92 is a filler plank at the top of the ceiling. Note the extent of notching. Photograph by Toni L. Carrell.



**Figure 3-22:** Marks on the protected face of a ceiling scarf. Photograph by Toni L. Carrell.

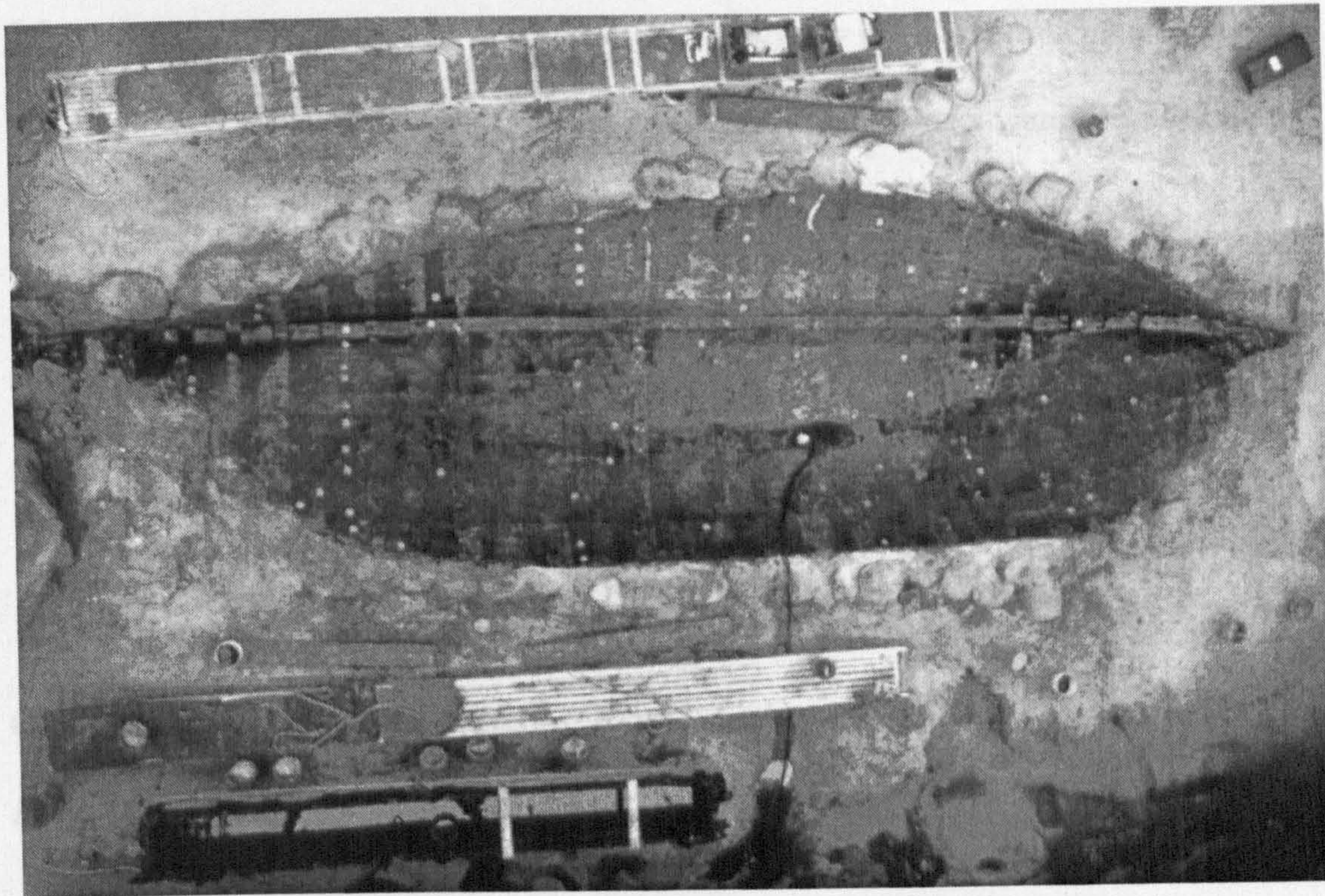
future location of the notched ceiling and so may be an indicator for the shipwrights. This plank is located on the port side and is the fourth plank from the keel; the scarf is at the location of frame two aft. The marks do not appear to relate to its location in the hull. Absent the key to the code and any similar markings on other timbers, the exact purpose of these marks remains a mystery.

A small triangular-shaped plank in the stern served to fill in the V-shaped space formed by the meeting of the ceiling planks (refer to 3-19). This was the only example of the use of spruce that survived. At only 1.5 cm thick, the piece it was not selected for its strength. The bottom was carefully beveled to fill in and sit directly on the ceiling planks, preventing debris from collecting here. Perhaps as importantly, the tail piece leveled this space for easier stowage of cargo and standing.

The exterior of the hull is sheathed with oak planks that range from 5.5 to 5.8 cm thick and from 23 to 28 cm wide (Figure 3-23). All are joined with a simple Z-scarf that ranges in length from 72 cm to 36 cm, with the majority averaging 55 cm (Figure 3-24). The plank edges were slightly beveled to ensure a tight fit and then packed with oakum and sealed with a tar or pitch-like substance to further prevent leakage. Fire-bending of the strakes that required a complex curve or twist to meet the stem or stern post was evident. Both garboard planks clearly exhibited this treatment. The garboard did not end at the rabbet, but extended to the after edge of the sternpost. This practice was mentioned by Ollivier (1737:90) as common in French construction.

According to Ollivier (1737:52), the hull planks were added only after first planking the ceiling: “We lay the planks of the hull after first planking the ceiling, while the English shipwrights on the contrary plank before laying the ceiling.” The hull planks were attached to the frames using a combination of treenails, ranging in size from 2.5 to





**Figure 3-23:** The excavated hull with only exterior planking in situ. The timber tags are clearly visible. Photograph Toni L. Carrell.



**Figure 3-24:** Hull plank Z scarf. Photograph by Toni L. Carrell

2.8 cm in diameter, and round-headed square or slightly rectangular-shanked nails, ranging in size from .9 to 1.3 cm in cross-section. The fasteners were countersunk and packed with caulking then sealed with a tar-like substance.

Caulking was found in the seams of both the interior and exterior hull planks, a practice to which Ollivier also referred:

One caulks on the outside all seams of the hull planks to the freeboard, those of the wales and ribbands of the quarterdeck, and inside one only caulks above the first and the second seams of the thick stuff the decks and of the forecastles and all seams of the hull planks of the decks, forecastles and poop deck (1736:75).

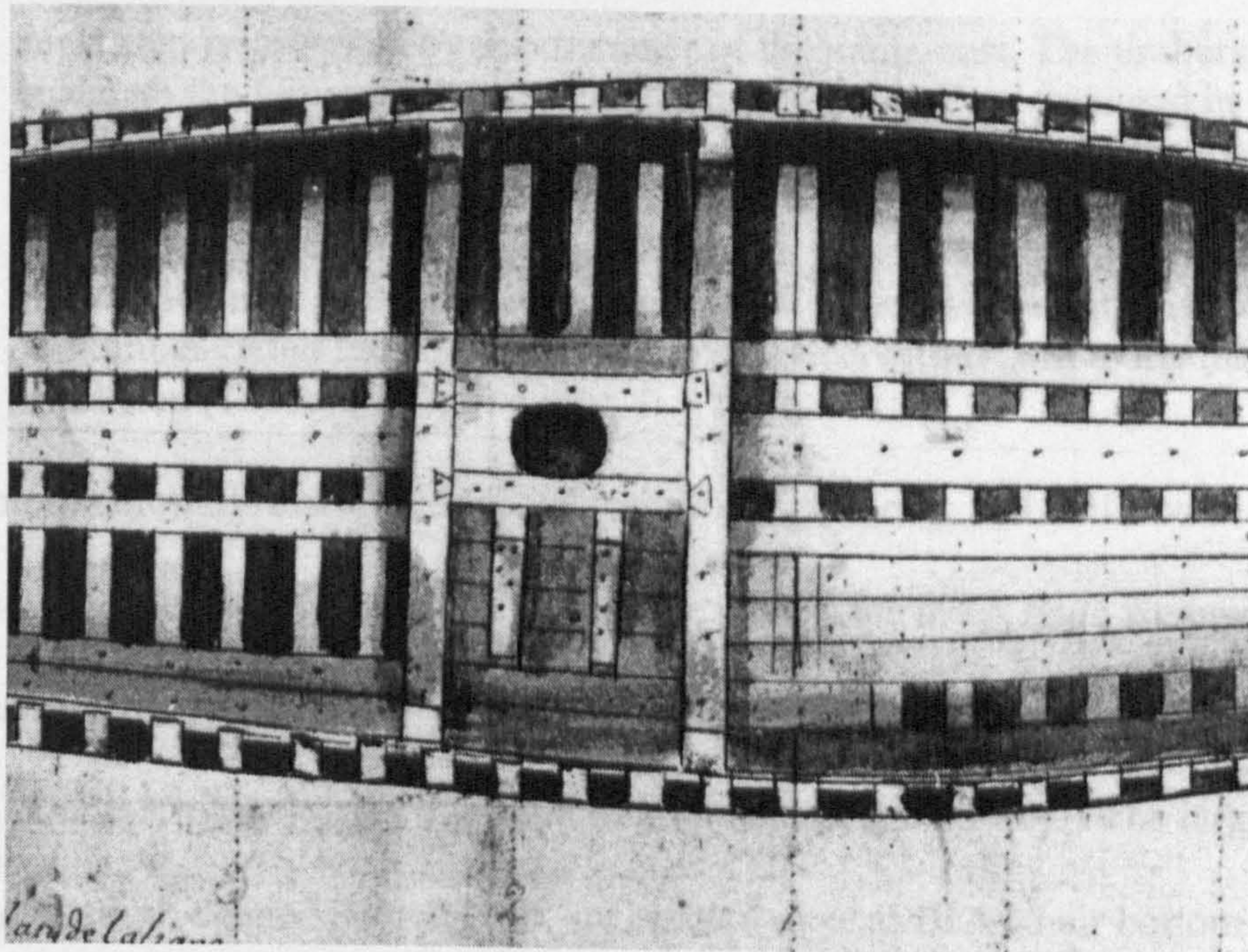
Ollivier's description of the caulking on interior planking differed from that found on *La Belle*; all of the ceiling planks were caulked.

### **Main Mast and Foremast Step Assemblies**

There is no information on the construction of mast steps in the treatises by Fournier (1667), Dean (1670), Anonymous (1691) and Dassié (1695). These focus on the proportions of masts and yards rather than the construction of their steps. The only detailed information came from Ollivier in the context of English shipbuilding practice:

The mast steps of the main and foremasts in the English ships present us with an object lesson in economy that deserves our attention. We form both of these mast steps using a floor rider of the same or greater scantling than the ordinary floor riders, with two mast step carlings or side-pieces that are very broad and 5 or 6 feet long [1.62 m to 1.95 m], two filling timbers, and two or four large wedges. All of these timbers, save only the filling timbers, are fastened to the bottom of the hull with more than 20 iron bolts (1737:87).

This multi-timber construction is illustrated in a contemporary image of a flute drawn and designed by François Coulomb in 1685 (Figure 3-25).



**Figure 3-25:** Main mast step detail from a flute built in 1684. Courtesy Musée de la Marine.

This arrangement was further described by Ollivier:

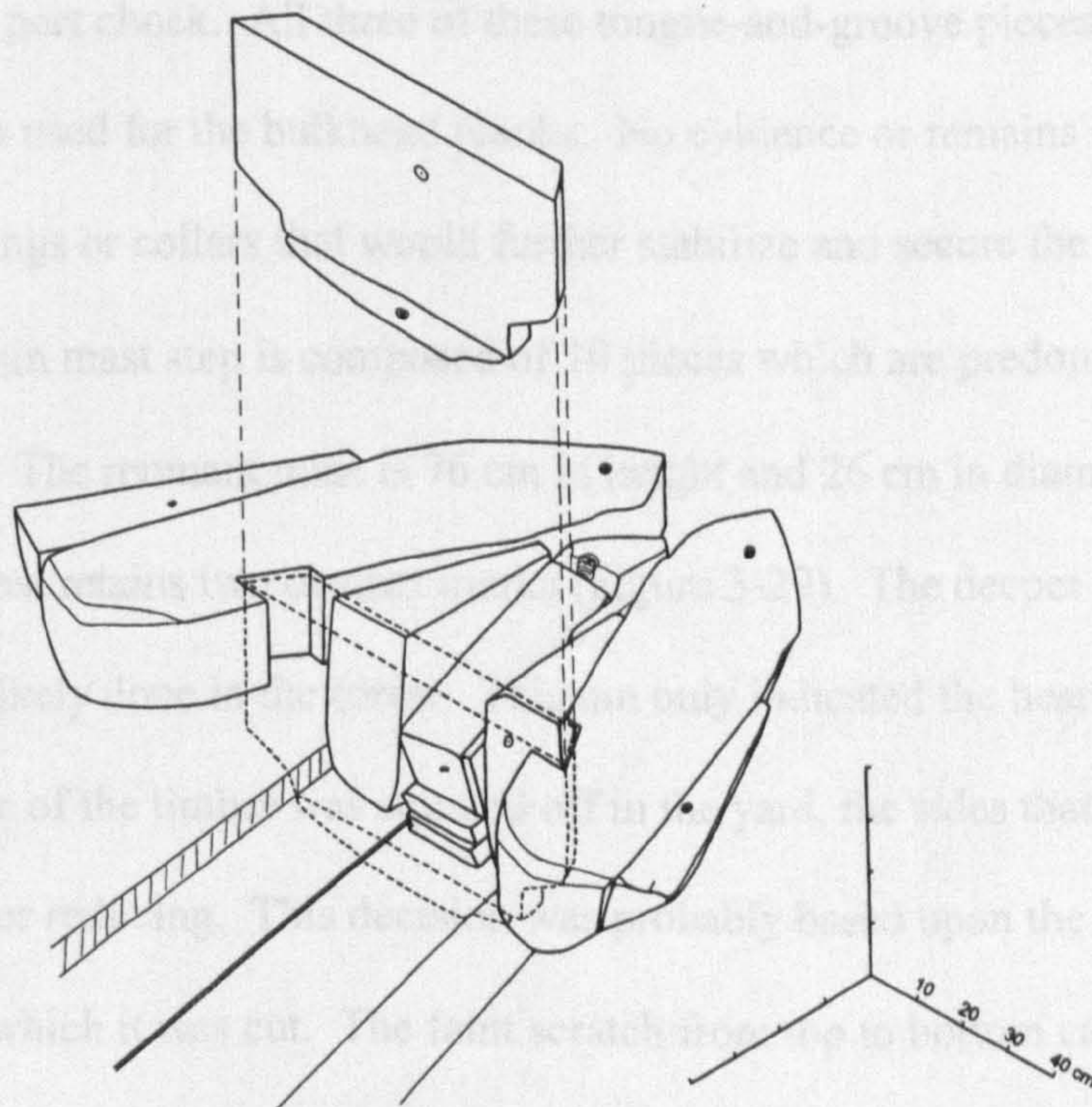
[The main mast step] . . . is a mortice formed in ships by the assembly of several timbers and into which the tenon of the heel of the main mast fits. Its length fore and aft is 2 or 3 inches shorter [5.4 cm to 8.1 cm] than the diameter of the mast; its breadth athwart ships is equal to three quarters of this same diameter and its depth is equal, or nearly equal, to its breadth. Its sides slope outwards by about an inch [2.7 cm]. The timbers that form this step are a floor rider, a false rider, two carlings, two filling pieces and two half-hooks. The floor rider and the half rider are laid over the footwaling 4, 5 or 6 feet apart; this distance may be greater or lesser provided that it exceeds by about a foot [32 cm] the given diameter of the mast. The carlings run from one rider to the other [i.e., fore and aft] and are placed on edge over the footwaling; they form the sides of the step and are separated one from the other by the whole breadth required for the step; the filling pieces form the fore and aft sides of the step and they are separated by the distance required to fit the heel of the mainmast . . . In many merchant ships and all small vessels that are powered by oars the step consists only of a mortice cut in the keelson of which we have already spoken. The step then has the length and breadth which we have already determined, but about half or a third less depth.

[The foremast step] . . . is a mortice formed in ships by the assembly of several timbers to receive the tenon at the heel of the foremast. Its dimensions are determined by the diameter of the mast, just as the main

mast step is governed by the diameter of the main mast. The timbers that make up the foremast step have the same names and are arranged in the same manner as those forming the main mast step. In some ships the foremast step is cut in a rider or in a raked hook laid over the keelson and in former times it was always made thus, as may still be seen in many merchant ships. There are also vessels where the foremast step is cut in the timber called the keelson as we have stated with regard to the main mast step (1736:82-83).

The combination of riders, filler chocks, carlings (partners), and half-hooks (buttresses) accurately represents the manner in which the mast steps in *La Belle* were constructed 52 years earlier.

The foremast step is composed of 13 pieces (Figure 3-26). The largest elements are two teardrop-shaped partners that are elaborately carved on their bottom and side faces to fit into the narrow space at the bow. Both of the partners are notched on their inner faces to accept a two-piece locking timber that slides in from above. The partners

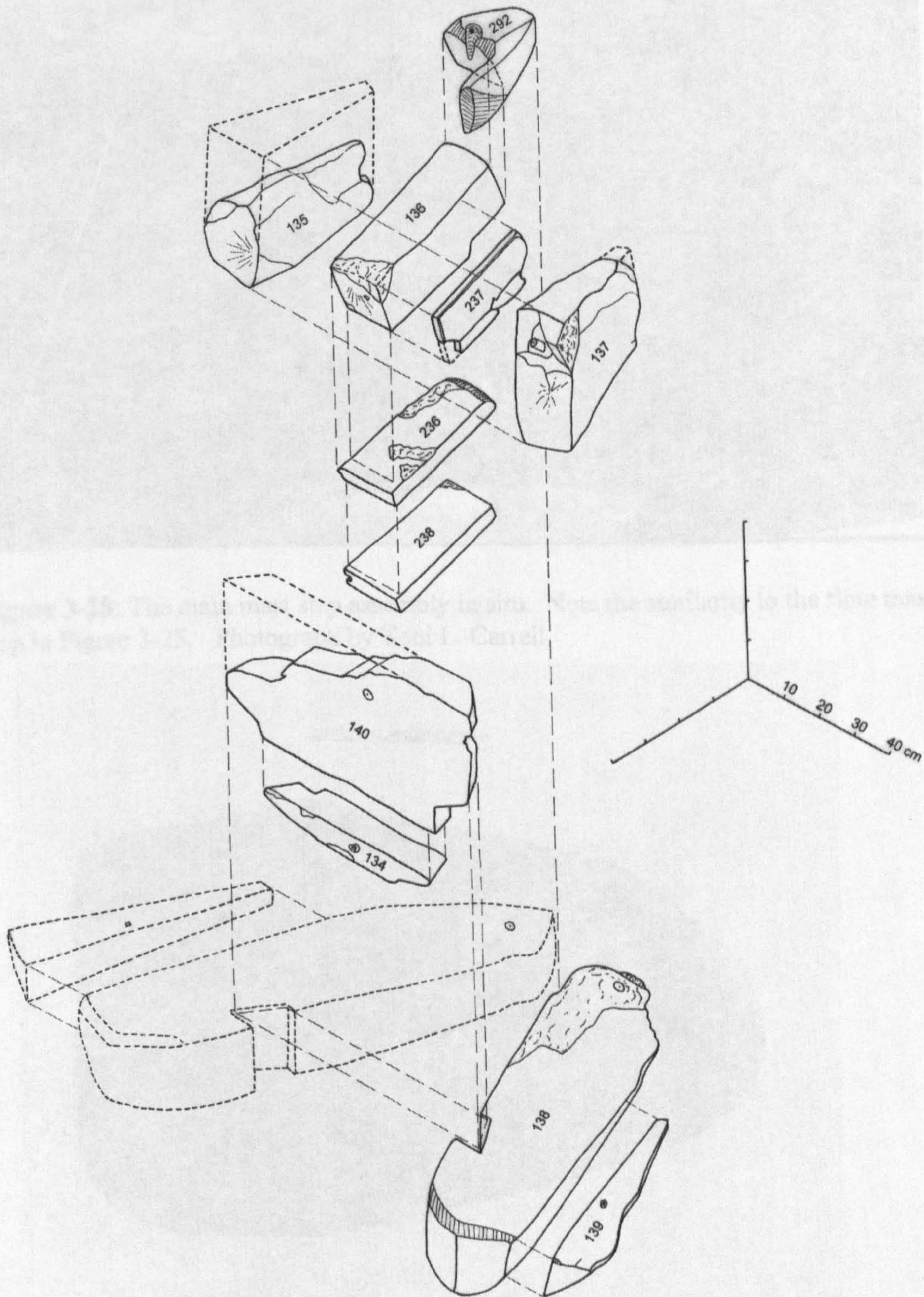


**Figure 3-26:** Assembled isometric of the forward mast step. Drawing by Marie-Andree Marchand.

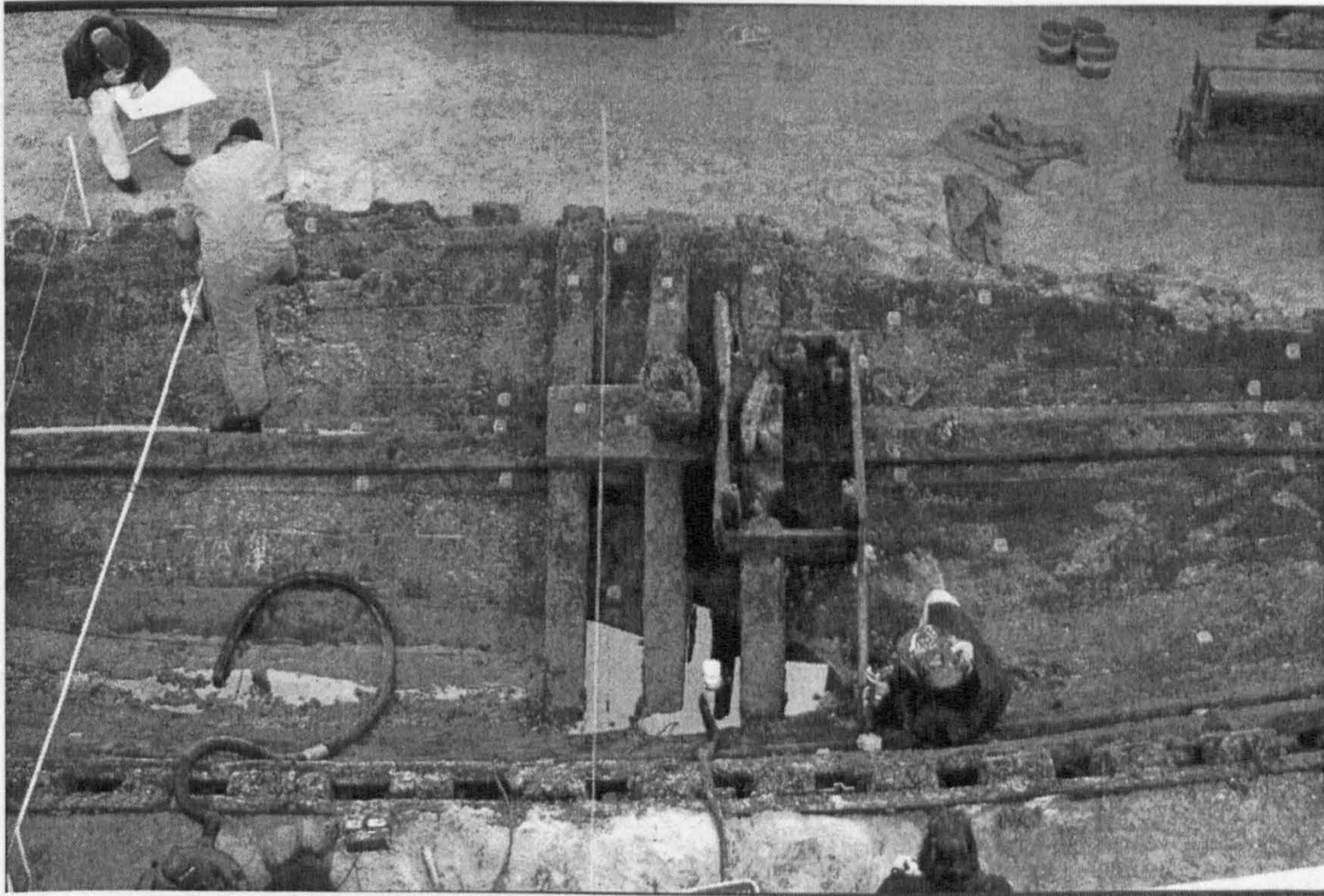
and locking timbers form a neat triangle within which the foremast heel rests. The base of the foremast is further secured by two triangular-shaped chocks on the port and starboard sides and a smaller triangle-shaped chock at the bow. Outboard of the partners are triangular-shaped filler pieces that served to tightly wedge the whole assembly into place.

Perhaps because the angle of the mast heel was unsatisfactory or because the builders wanted to have the flexibility to angle the rake of the mast, they placed two small filler pieces below the mast heel piece (Figure 3-27, timber numbers 236 and 238). Neither of these was specially designed nor manufactured for this purpose. Rather, they are obviously scrap from other uses because they are cut from tongue-and-groove planking and there was no structural reason to use tongue-and-groove for this purpose. Another tongue-and-groove scrap, timber number 237, was used as a filler between the heel piece and port chock. All three of these tongue-and-groove pieces are red pine, a wood type also used for the bulkhead planks. No evidence or remains survived of lashings, bindings or collars that would further stabilize and secure the foremast.

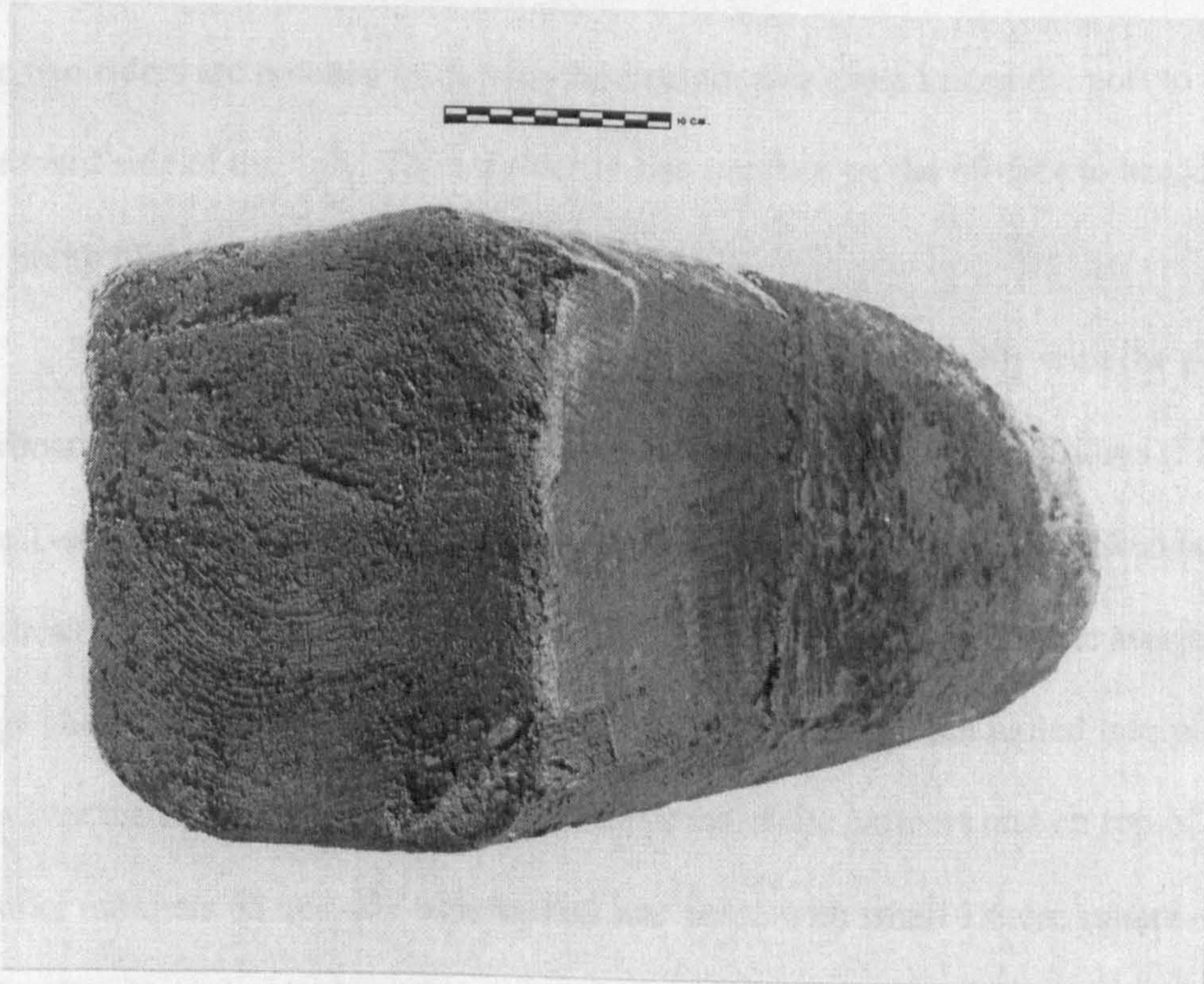
The main mast step is composed of 10 pieces which are predominantly oak (Figure 3-28). The remnant mast is 76 cm in height and 26 cm in diameter. The bottom of the main mast retains two distinct marks (Figure 3-29). The deeper angled cut came first and was likely done in the forest. This not only indicated the heart of the timber but, before the base of the timber was squared off in the yard, the sides that should receive the most shaving or reducing. This decision was probably based upon the overall grain of the tree from which it was cut. The faint scratch from top to bottom came second and was done in the shipyard. This mark aligns with the direction of the keel when the mast is in place.



**Figure 3-27:** Exploded isometric view of the forward mast step. Drawing by Marie-Andrée Marchand.

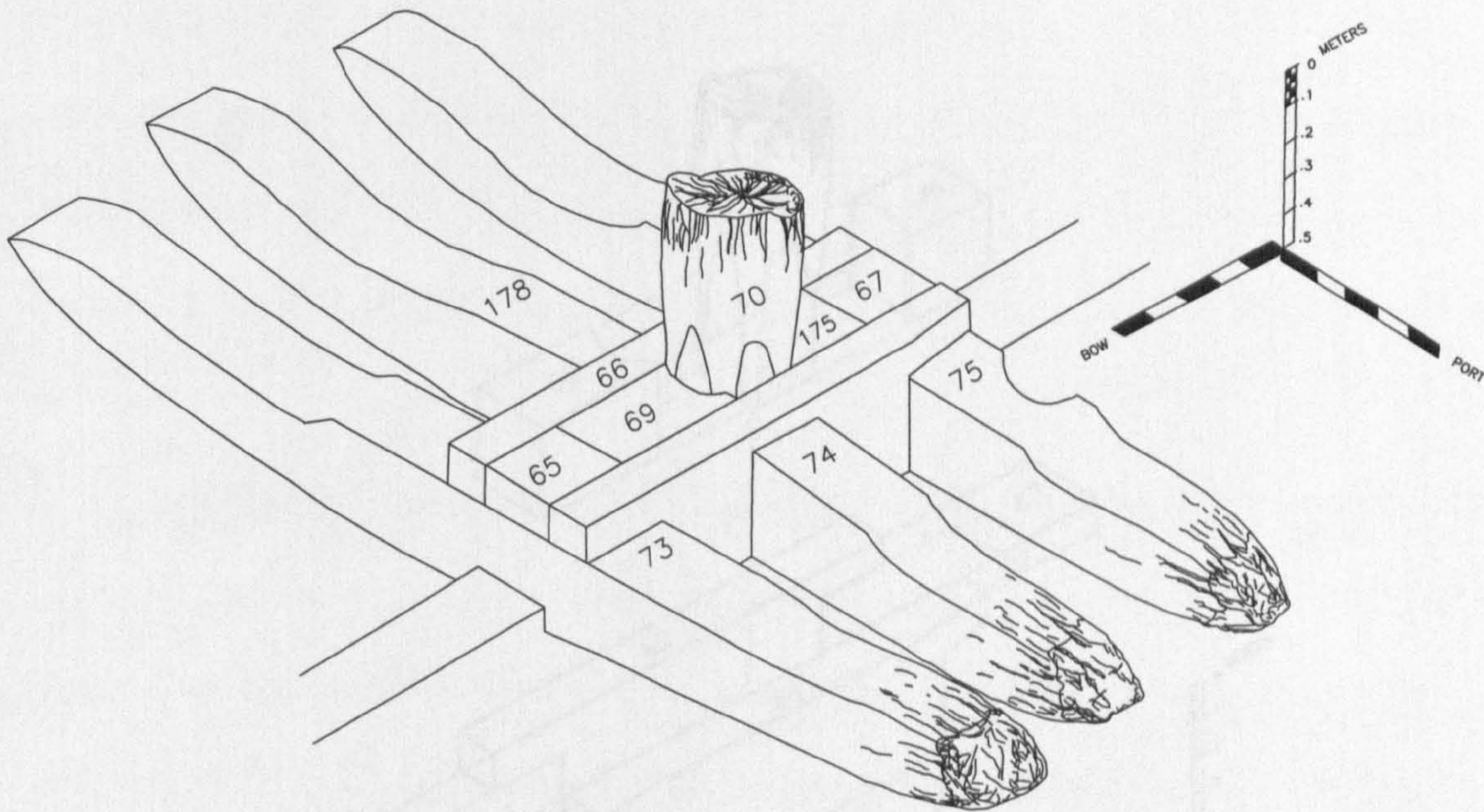


**Figure 3-28:** The main mast step assembly in situ. Note the similarity to the flute mast step in Figure 3-25. Photograph by Toni L. Carrell.



**Figure 3-29:** Base of main mast with scribe marks. Photograph by George Vandervlugt.

The mast is held in place by a combination of chocks, fore and aft of the remnant mast, partner pieces on the port and starboard sides, riders, and buttresses (Figure 3-30).



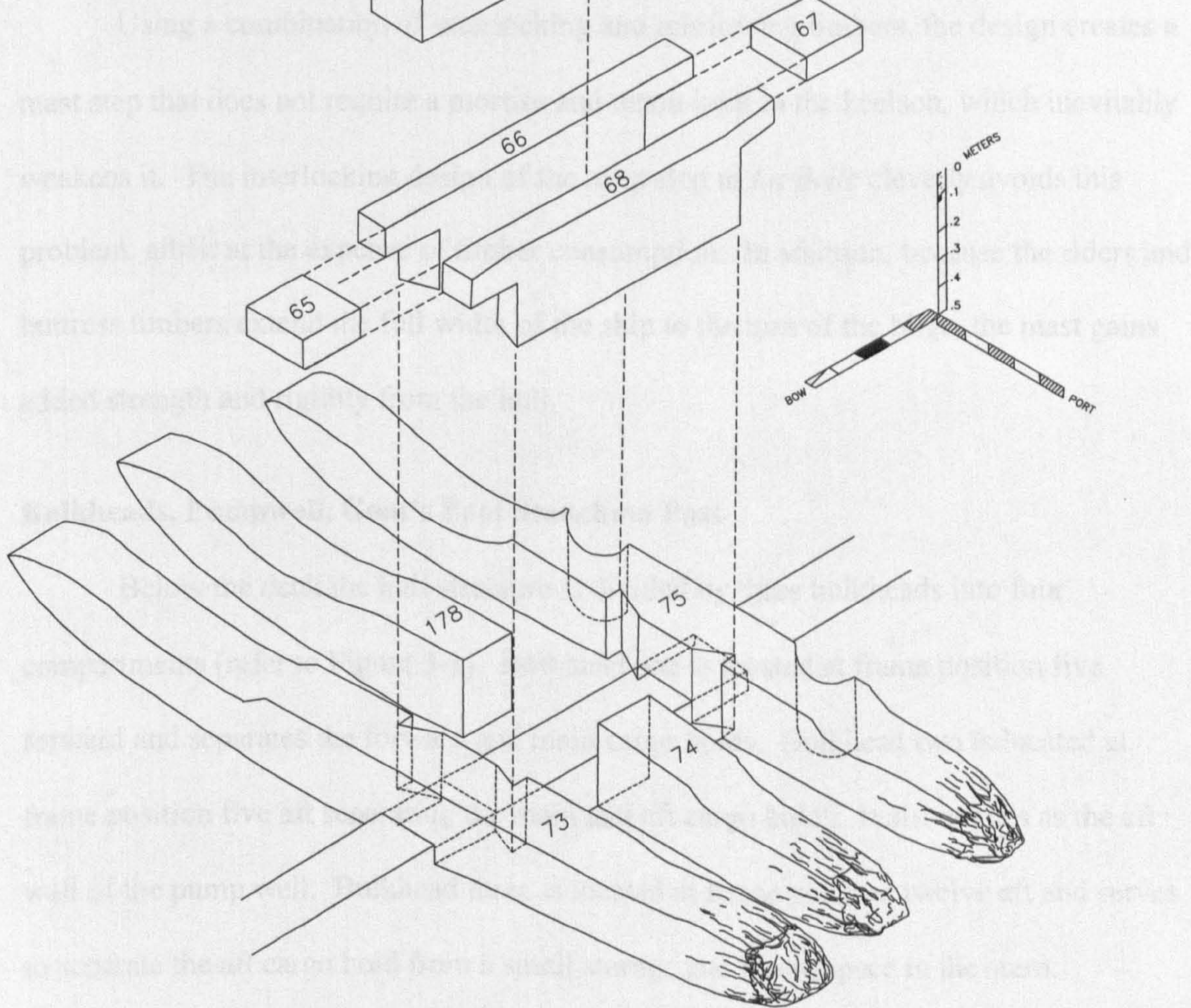
**Figure 3-30:** Assembled isometric view of the main mast step assembly. Drawing by Greg Cook.

The two riders are notched to fit over the keelson and extend from the port to the starboard side of the hull. The aft rider is also notched on the aft face to accommodate the pump tube for the bilge pump.

The main mast step is designed as an interlocking assembly with the port and starboard partners sliding into notches on the facing faces of the two riders (Figure 3-31). The T-shaped partners are fastened to the riders with 2.8 cm round-shanked bolts. Buttress timbers outboard of the partners provide further stability to the assembly. The large chocks or collar blocks forward and aft of the mast are not nailed into place, however the two fillers that sit between the arms of the partners and on top of the riders (timber numbers 65 and 67) were tacked into place with small 1.6 cm square-shanked nails. Surprisingly, the large carved collar blocks for the mast are fir rather than oak.



The buttress timbers and dunnage are fastened to the hull with a series of cross-timber round-headed bolts that range in size from 10 to 12 mm in diameter. The mast is made from the trunk of a red pine tree, 15 cm in diameter. The foot is skillfully beveled to create a regular recess for the dunnage. Prior to assembly, the mast was used to be placed in the hull to determine its 23-cm height above the partner. While not shown, the mast is secured to the hull by a series of bolts at the mast's top.



**Figure 3-31:** Exploded isometric view of the main mast step. Drawing by Greg Cook.

The buttress timbers and riders are fastened to the frames with a series of countersunk round-shanked bolts that range in size from 2.6 to 3.2 cm in diameter. The mast is made from the trunk of a red pine and measures 28.5 cm in diameter. The foot is skillfully beveled to create a roughly rectangular base to sit on the keelson. Prior to disassembly, the mast was noted to be raked aft approximately 3 mm over its 23-cm height above the partner. While not dramatic, this would result in a noticeable rake from perpendicular at the mast's top.

Using a combination of interlocking and reinforcing timbers, the design creates a mast step that does not require a mortise and tenon joint in the keelson, which inevitably weakens it. The interlocking design of the mast step in *La Belle* cleverly avoids this problem, albeit at the expense of timber consumption. In addition, because the riders and buttress timbers extend the full width of the ship to the turn of the bilge, the mast gains added strength and rigidity from the hull.

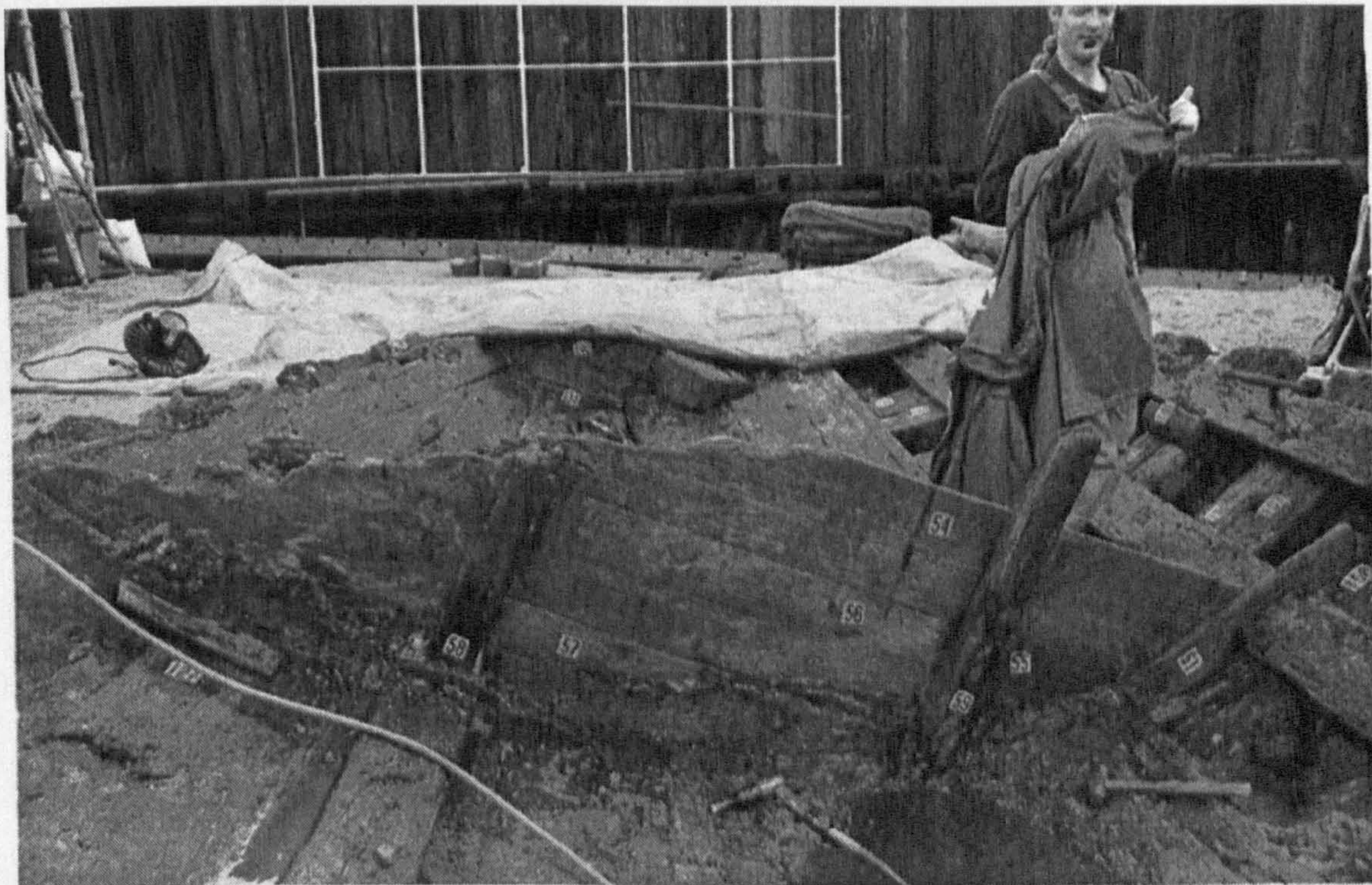
### **Bulkheads, Pumpwell, Goat's Foot Stanchion Post**

Below the deck the hull structure is divided by three bulkheads into four compartments (refer to Figure 3-1). Bulkhead one is located at frame position five forward and separates the forward and main cargo holds. Bulkhead two is located at frame position five aft separating the main and aft cargo holds. It also serves as the aft wall of the pump well. Bulkhead three is located at frame position twelve aft and serves to separate the aft cargo hold from a small storage and living space in the stern.

Bulkhead one is constructed of sawn red pine planks averaging 4 cm thick and 30 cm wide (Figures 3-32 and 3-33). It is supported by three white oak stanchion posts, averaging 11 cm by 9 cm in cross-section, placed on the aft face of the bulkhead. The



**Figure 3-32:** Forward face of bulkhead one. Photograph courtesy Texas Historical Commission.



**Figure 3-33:** Aft face of bulkhead one. Photograph courtesy Texas Historical Commission.

planks were attached to the stanchions using round-headed square-shanked nails that ranged from .4 to .7 cm in cross-section. To provide additional stability where the bulkhead planks met the side of the hull, nailers were placed on the aft face and the planks also nailed to these pieces. The nailers, also red pine, were attached to the ceiling using square-shanked nails similar in size to those used for the planking. In addition to stability, the nailers provided a better seal at the edge of the bulkhead and between the forward hold and the main cargo hold.

Bulkhead two serves two purposes. It is the divider between the main and aft cargo holds and the port half is the aft wall of the pumpwell (Figure 3-34). This bulkhead is constructed in a manner similar to bulkhead one with sawn red pine planking



**Figure 3-34:** Bulkhead two overview. Photograph by Toni L. Carrell

and supporting stanchion posts (Figures 3-35 and 3-36). However, these posts are placed on the forward side of the bulkhead rather than the aft. The planks are slightly thinner than those in used in bulkhead one, averaging 3.5 cm thick and 28 cm wide. The starboard side stanchion post is also slightly different measuring 10.8 cm and square in cross-section. Round-headed square-shanked nails similar to those used in bulkhead one were also used here. Whether it was intentional or a result of some need or incident arising during the voyage, the lowest plank on the starboard side of bulkhead two was absent when this area was excavated and was not discovered elsewhere in the hull. Not only does a portion of this bulkhead serve as the aft face of the pump well, it stops just short of the port side leaving a small passageway to the aft cargo hold (refer to Figure 3-34).

This passageway clearly provided access between the main and mizzen cargo holds. The presence of such passageways was common on ships of the period. Ollivier (1737:148-149) noted that access to the magazine in English and French ships was by means of a passageway and that the magazine in French ships was always in the stern. The storage of powder in the aft part of the ship was borne out during the excavation of *La Belle* where several casks containing a black powder residue were found in the mizzen cargo hold.

The pump well is constructed to incorporate the centerline portion of the aft rider (refer to Figure 3-34). It was assembled with sawn red pine planks and a mixture of red pine and fir stanchion posts. The pump well planks range from 3.7 to 4 cm thick and from 30 to 32 cm wide on the forward and aft walls and up to 38 cm wide on the port and starboard walls (refer to Figure 3-36). The stanchion posts, placed on the inside of the structure, are generally rectangular in shape and average 9 by 6 cm (Figure 3-37). The

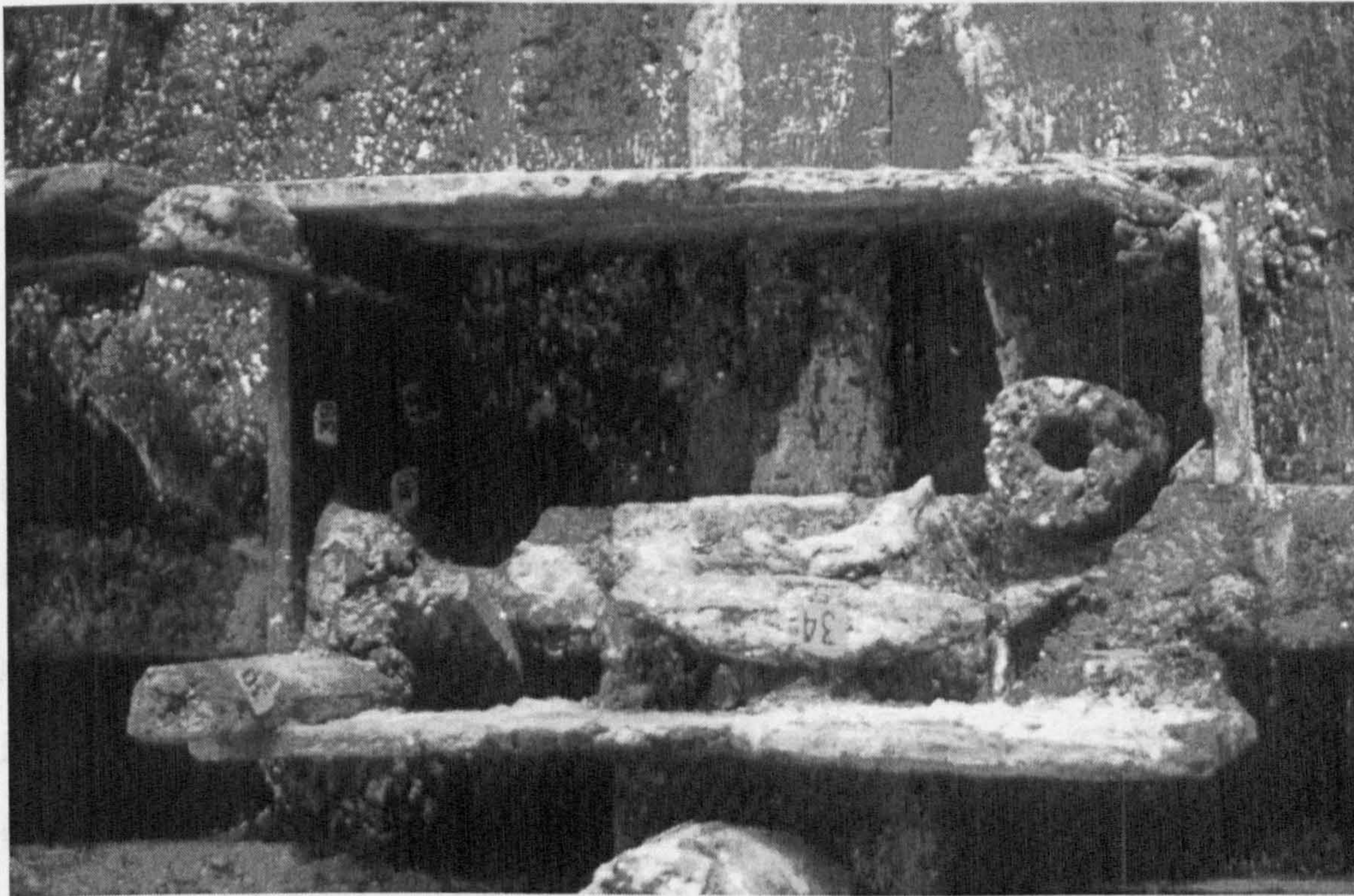


**Figure 3-35:** Forward face of bulkhead two. Photograph by Toni L. Carrell.



**Figure 3-36:** Aft face of bulkhead two. Photograph courtesy Texas Historical Commission.

stanchion post on the starboard side forward corner is the exception. Rectangular at one time, the interior corner was shaved off during construction to more readily fit it into the small space between the front wall and rider. Each stanchion is stabilized at the deck by elaborately carved and beveled base pieces that surround the foot of each post.



**Figure 3-37:** Pumpwell with one of two pumps in situ. Port side to right. Photograph by Toni L. Carrell.

In addition to stanchions, the port and starboard walls have small nailers butting up to the aft side of the rider to which the lower planks are also nailed. Similar nailers are found on the aft face of the forward wall butting up to the mast step partners. These allowed the lowest planks on the wall to be nailed into place.

The arrangement of this pump well is very similar to that described by Ollivier, albeit for a much larger ship:

This is a square compartment which is set up in the hold of a ship about the mainmast. It encloses the mainmast and four pumps and allows the pumps to be inspected, to be removed and to be replaced whenever this

should be necessary . . . . The well affords the same convenience for the mainmast . . . . The well is enclosed by several stanchions raised vertically or nearly so from the planking of the ceiling to the beams, and by planks nailed across these stanchions. Particular care is taken to ensure that the well is long enough and wide enough to contain the four pumps and for their inspection, but no greater, since otherwise that would lose precious space for stowage . . . The pump well has about 8 feet of width in the vessels of the first rank, 7 feet in the vessels of the second rank, 6 feet and half to 7 feet in the vessels of the third rank, 6 feet to 6 feet and half in the vessels of the fourth rank and 5 feet and half to 6 feet in the frigates. In the well of some ships there is a locker placed a little below the level of the gun deck in which the caulker keeps his tools, especially those which he needs to repair the pumps. On either side of the well, or only on one side, there is a sliding door about two feet square which provides access to the well. This door is placed a few inches below the deck (1736:21).

The most obvious difference in *La Belle* is that the pump well does not surround the main mast, but is immediately aft. This area did not include a separate locker for the shot and during excavation both large loose cast iron and small casks of lead shot were packed around the mast and forward of the pump well. In order to keep the shot from interfering with the maintenance of or access to the pump mechanism, the pump well walls extended to the level of the deck. A practice noted by Ollivier (1736:21) was confirmed during excavation when a variety of carpenter's tools were found inside the pump well. No evidence survived of the sliding door that Ollivier referred to. As previously noted, however, the aft wall of the pump well did not extend to the port side and this passageway provided access between holds.

Another difference is that *La Belle* was fitted with two pumps, one each on the port and starboard sides of the keelson (refer to Figure 3-37). A remnant of the starboard pump tube and its lead basket were recovered during the excavation (Figure 3-38). The hollowed out Elm log is 18 cm in diameter and has a center hole 7 cm in diameter. The lead basket at the base kept debris from being sucked up into the tube and protected the valve it contained. Found separately were a spear, or connecting rod, and leather





**Figure 3-38:** Exposed port pump tube in situ. Photograph by Toni L. Carrell.



**Figure 3-39:** Lead strainer. Photograph courtesy Texas Historical Commission.

plunger; no evidence of a valve was found. This was a simple plunger style pump, elegant in its simplicity and reliability of design.

This type of pump is more similar to those found on ships of the 16<sup>th</sup> century, such as *San Juan* (Waddell 1985:243-259) and the Molasses Reef Wreck (Keith, Lakey, Simmons and Myers 1989:90-91), than those on contemporary French ships as described by Ollivier:

The parts of a pump are the barrel, the upper box which is inside the barrel and which serves to raise the water, a lower box which is placed about half way up the barrel of the pump, two clapper-valves which are attached one to the upper box and one to the lower box, a spear which serves to move the upper box, and finally a hose by which the water raised by the pump flows out through the scupper . . . The lower end of the barrel is covered by a plate of lead or copper pierced with several holes and called the rose, which prevents any filth from entering the barrel of the pump . . . There are pumps where the spear works in a tube of bronze and it is thus that most pumps of the King's ships are made . . . The pumps of small vessels such as barks, ballast-lighters, pontoons and such like differ from other pumps in that their brake [handle] instead of being suspended from the mast works in the jaws of a gallows are attached to the barrel of the pump (1737:271-272).

The most significant similarity between the pump described above and that found on *La Belle* is the lead plate, or rose, so clearly described (Figure 3-39).

Bulkhead three was also constructed from sawn red pine planks with an oak stanchion at the centerline for support (Figure 3-40). Beyond that similarity, however, this bulkhead is quite different in its construction details. The lowest plank is notched on the bottom to fit over the keelson and on that edge is cut with a slight bevel to meet the ceiling planks. However, the top edge is cut with a tongue-and-groove join as are both the top and bottom edges of timber four and the bottom edge of timber number five. The top edge of timber number five is cut flat where it slightly overlaps a beam that runs from the port to the starboard side. The planks are 3.5 to 4 cm thick and average 25 cm wide.

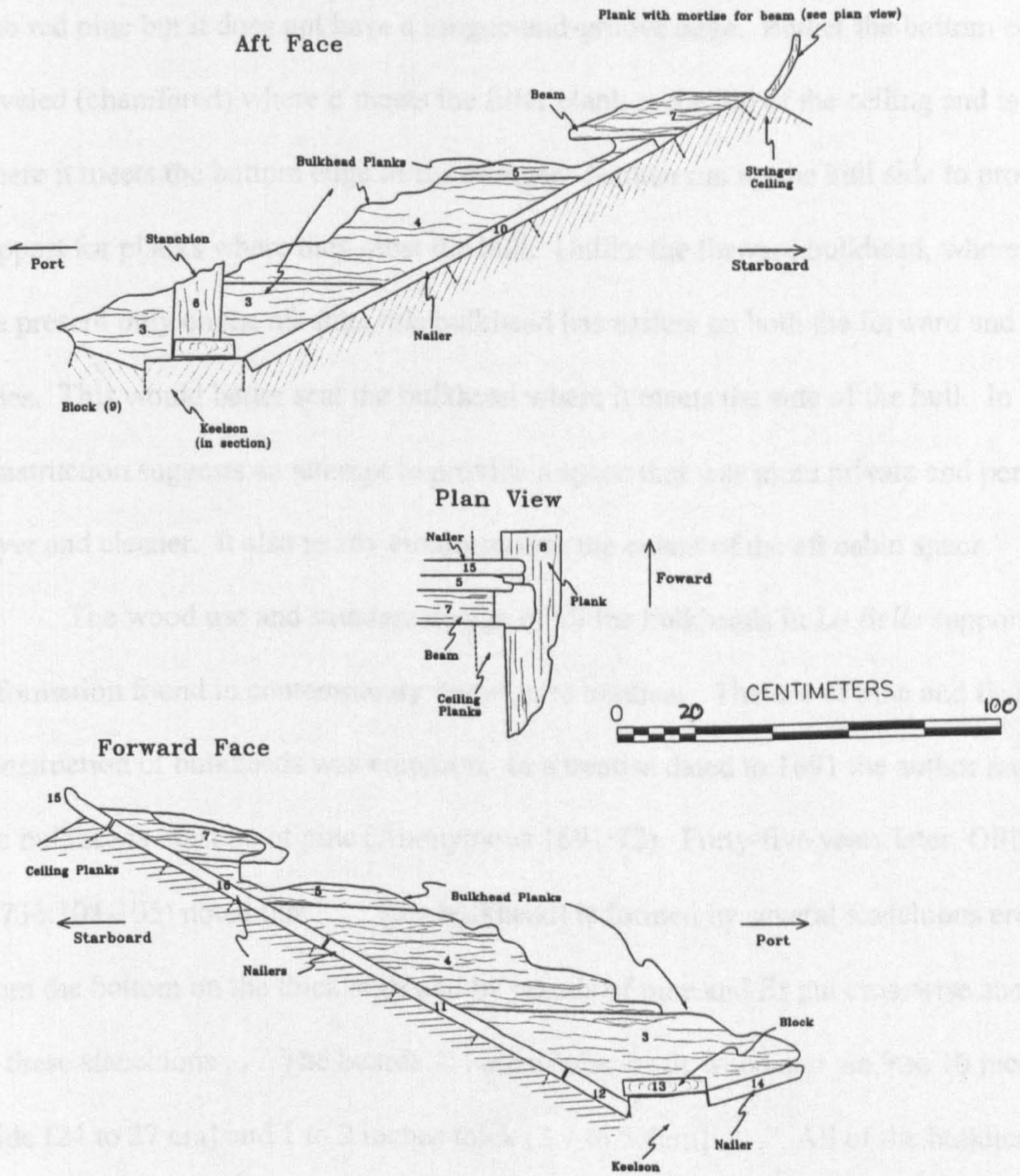


Figure 3-40: Forward and aft faces of bulkhead three. Drawing by Steffan Classen.

The beam is oak and approximately 3.6 by 11 cm.

A plank remnant, still in place on the starboard side, suggested that above the ceiling planks this area was finished. This plank, similar to those used in the bulkhead, is also red pine but it does not have a tongue-and-groove edge. Rather the bottom edge is beveled (chamfered) where it meets the filler plank at the top of the ceiling and is flat where it meets the bottom edge of the stringer. Nailers run up the hull side to provide support for planks where they meet the hull. Unlike the forward bulkhead, where nailers are present only on the aft side, this bulkhead has nailers on both the forward and aft sides. This would better seal the bulkhead where it meets the side of the hull. In all, this construction suggests an attempt to provide a space that was more private and perhaps dryer and cleaner. It also neatly circumscribes the extent of the aft cabin space.

The wood use and standard design of all the bulkheads in *La Belle* supports information found in contemporary descriptive treatises. The use of pine and fir in the construction of bulkheads was common. In a treatise dated to 1691 the author noted that the bulkheads must be of pine (Anonymous 1691:72). Forty-five years later, Ollivier (1736:104-105) noted that “. . . [the bulkhead] is formed by several stanchions erected from the bottom on the thick stuff and by boards of pine and fir put crosswise and nailed to these stanchions . . . The boards . . . are of pine or fir wood and are 9 to 10 inches wide [24 to 27 cm] and 1 to 2 inches thick [2.7 to 5.4cm]. . . .” All of the bulkhead planks on *La Belle* fall within those dimensions.

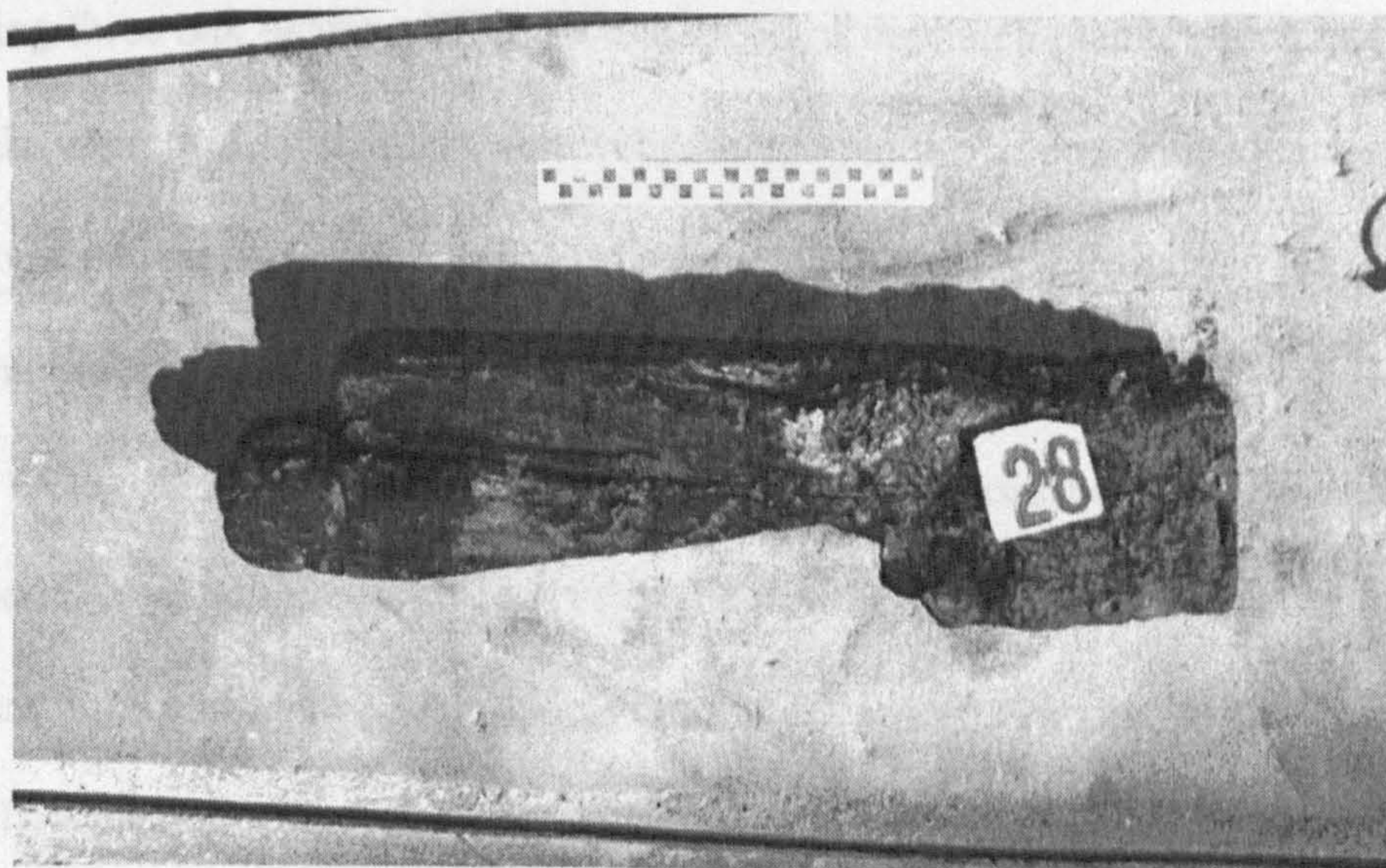
The selective use of tongue-and-groove planking is also mentioned by Ollivier with regard the great room or council chamber and the cabins for the officers:

This bulkhead [for the council chamber] is formed the same as the gun room bulkhead with stanchions and attached panels with bolts and iron hooks that make it easy to disassemble it when one gets ready to fight and

to carry up it after the fight. . . .[B]ut in the vessels of the fourth rank and in the frigates where the captain's room and the second captain are in the great room, this bulkhead is not always made with stanchions and panels. One builds it customarily the same as the other council room bulkheads with boards assembled to groove and nailed to lodgings . . . the bulkheads that form the council chamber, the officer's rooms . . . are made with boards of fir or pine one inch thick, laid up and assembled to *feuillure* (rebate or rabbet) or to groove. . . . (1736:105).

Another element relating to interior structures is a goat's foot or notched stanchion post. It is located on the keelson in the main cargo hold in line with the master frame. This location suggests that it was at the aft end of the main cargo hatch and so provides an excellent clue to the location of that feature. Ollivier (1737:155) mentioned similar notched posts in French ships: “. . . There are two in the hold [of English ships] . . . which are formed by stanchion posts with notches cut in them to serve as steps, like some of the pillars in our own ships.”

The post was manufactured from white oak and measures 13 by 10.5 cm in cross section and retains two steps, the lower of which is at 19 cm from the base (Figure 3-41). The second step on the post rises 33 cm, which would require its user to reach up to a



**Figure 3-41:** Goat's foot stanchion post. Photograph courtesy Texas Historical Commission.

higher step and pull slightly while pushing off to climb out of the hold. The spacing between steps, while not critical, certainly took into consideration the need to retain as much strength as possible.

### **Platform Deck and Shelf**

As evidenced by the discovery of more than 50 meters of extremely well preserved anchor rope and personal belongings, the forward hold served as both a rope locker (or cable tier) and crew quarters. According to Ollivier (1736:175), the cable tier's fore-and-aft length was determined by the distance between the riding bits and the aft beam of the cable hatch. This also determined the size of the forward hold.

The platform deck in the bow provided a level space upon which to store the anchor rope and created additional storage below it for small items (Figure 3-42). Accessed by a small hatch that is little more than a removable section of plank, the storage area was at maximum 29 cm high. The hatch is located on the centerline of the ship directly over the keelson. The deck was constructed of sawn red pine planking overlaying three oak beams. With the exception of the hatch plank, which is 4 cm thick, the planks average 3.5 cm thick. All were fastened to the beams with square-shanked nails ranging in size from 5 to 8 cm. All of the planks are beveled along the edge that meets the inward curve of the bow.

Other than differences in their length, each of the oak beams is beveled on their bottom ends to match the inward curve of the bow and are toenailed into the frames. All are 10 cm thick and 15 to 17 cm wide. The exception is a short reinforcing piece at the hatch. This piece is only 8.8 cm wide and 3.3 cm thick. It extends under the long planks on either side of the hatch, keeping both the hatch plank and the one immediately aft



**Figure 3-42:** Platform deck in bow. Photograph by Toni L. Carrell.



**Figure 3-43:** Shelf on the port side. View is toward the bow. Photograph courtesy Texas Historical Commission.

from collapsing downward. Below this piece there is a 27-cm high rectangular stanchion that is 12 by 6.5 cm. The thinness of the support piece likely necessitated the stanchion for reinforcement. A second short stanchion is present on the keelson below the longest deck beam on the forward side of bulkhead one. This piece is also rectangular in cross section, but it is larger measuring 17.5 by 11 cm. Both stanchions are oak.

The partially preserved remains of a shelf/bunk complete the archaeologically-recovered interior structures (Figure 3-43). The bunk, located on the starboard side in the forward hold, is constructed of sawn red pine planks supported by two fir chocks along the starboard side and a short beam running perpendicular to the side. The planks are similar in thickness to those found elsewhere measuring 3.5 cm on average and from 7 cm to 29 cm wide. The planks were fastened to the support beam with square-shanked nails ranging in size from .5 to .8 cm. The support chocks were toenailed into the side. Located at the level of the upper stringer, the chocks place the bunk at approximately 1.10 m above the platform deck.

Together the planks measure 66 cm in width. This is enough room to accommodate an adult, albeit not terribly comfortably by modern standards. There is also the possibility of one missing plank, which would make this space a little wider and therefore more comfortable. The longest surviving plank is only 1.14 m, but the space available from the bulkhead to the bow is close to 2 m, more than enough room for an adult to lie down.

### **Fastenings**

As wooden ships developed into complex machines that required high-sided built-up hulls, two types of fastenings quickly prevailed: iron nails and wooden treenails. Both



types were used in the construction of *La Belle*.

### **Iron Fasteners**

Arguably the most crucial component of a hull's construction is its iron fasteners. Unfortunately, this artifact class rarely survives due to the typical ocean burial environment and when it does, it is rarely studied. As a result, other than a brief notation of fastener patterns, this category remains under studied. A notable exception is the Molasses Reef Wreck, ca. 1525. Excavated and researched under the direction of Donald H. Keith, this site contained more than 1,000 examples of iron fasteners that were carefully analyzed and categorized (Keith 1987:105-115).

As a result of a burial environment that favored organic remains over iron, the majority of the fasteners in *La Belle* did not survive. With the exception of a few centerline fasteners in the bow, they were reduced to iron oxide and crumbled or disintegrated during the disassembly of the hull. The oxidation of the fasteners used for the exterior planking resulted in "rust-sickles" of iron, sand, silt. A few of these were rescued in an effort to examine head shape, but most did not survive disassembly.

Keith's analysis of the Molasses Reef Wreck fasteners remains the largest in-depth study to date. As a result, it has been the basis of other general discussions of this artifact class even when the fasteners did not survive (e.g., *San Juan*, Robert Grenier pers. comm. 1999) or only a handful of concretions did (e.g., *Emanuel Point Wreck*, Smith et. al. 1995). Although the majority of *La Belle*'s fasteners did not survive, because the preservation of the hull was excellent the impressions and holes of the fasteners did survive. In order to contribute to the discussions of fasteners in shipwreck sites, the holes and impressions were recorded as part of the extensive timber

documentation. This indirect information, while not the same as having fasteners in hand to study, is still a useful basis upon which to provide a discussion this artifact category.

Keith (1987:105) noted that the size and variety of fasteners in the Molasses Reef sample, “. . . makes it clear that the shipwrights who built the vessel recognized the need for at least a dozen different types of fasteners ranging from tacks less than a centimeter long to forelock bolts 0.40 m long with shanks 0.04 m in diameter.” In undertaking the Molasses Reef Wreck fastener study, Keith stated:

The best references to Iberian iron fastener types and nomenclature used in the early 16th century are Willis' (1984: 96-113) description and analysis of the fasteners found at Puerto Real and Barkham's (1981: 32-35) catalog of references to iron nails found in Basque ship construction contracts. Barkham's research of Basque records from the second half of the 16th century makes it clear that (1) most, if not all ships' fasteners in this period were iron; (2) iron fasteners were bought and sold by weight; (3) fasteners were differentiated then (as they are today) according to how many of them it took to make a pound; and (4) shipwrights employed a rule of thumb to estimate the total weight of fasteners required to build a ship of a specific tonnage, e.g., a ship of ca. 200 tons built in 1566 required between 40 and 50 *quintales* of iron fasteners (1987:107).

However, the most revealing document in Barkham's research was a contract for the purchase of ships' fasteners that specified 15 different types and alluded to the function of each (Appendix XII, 94-100). That contract revealed:

The 15 fastener types are divided into three groups, “bolts,” “spikes” and “dowels.” The exact meaning and configuration of “dowel” is unclear, but a diagram accompanying the contract on which the fasteners are traced shows that they must have had round shanks. Perhaps they differed from the other fasteners in that they had neither points nor pre-formed heads. Their function is not specified.

The other round-shanked fasteners are headed “bolts” ranging from 0.465 m in length and 0.017 m in shank diameter to 0.286 m long and 0.012 m in diameter. From the names of the bolts it is clear that the smallest ones were used in the construction of the half deck and the medium size ones were used on the sides of the ship, but the function of the largest ones is not specified.

The square shanked fasteners are headed “spikes” ranging from 0.44 m in length and 0.015 m in shank diameter to 0.12 m long and 0.008 m in diameter. Again, the function of the largest, longest spikes is not clear, but in order of decreasing size the others are used to attach the large and small wales, the “sides” (strakes?), the half deck, the decking and the “round-house” (Keith 1987:107).

A century later, the fasteners used in *La Belle* were little changed in either their manufacture or variety. A contract by Christopher Pett for a 3<sup>rd</sup> Rate to be built in the Woolwich yard in 1664 specified only the largest fasteners, smaller ones were left to the discretion of the builders. Of those specified, however, there were no less than six sizes, based upon their diameter (Lavery 1981:116-119).

An anonymous (1691:173-185) contemporary manuscript included not only specifications for wood, but for all of the ironwork to be included in the construction of a galley. The fasteners, called simply nails (*clous*) in the manuscript, were categorized either by weight, *clouds* [sic] *de poids*, or by count, *clouds* [sic] *de conte*. The largest nails were considered by their weight, for example a 15-inch nail that weighed 151 pounds to the hundred was a nail that individually weighed 1.51 pounds. The contract specified the number of nails required, their length, their individual weight, pounds, and the total weight of the order. The smaller fasteners, considered by count only, were listed by the total number required, for example 4000 *petits*. Rather than counted out, these were weighed out, with the understanding by all parties that certain number weighed a certain amount. Nine different types of nails by count and more than 30 different nails by weight were specified in the contract. This manuscript also included an illustration of 58 sizes and types of nails (Anonymous 1691:337). Unfortunately, there was no scale nor was the detail good enough to clearly differentiate shank shape (round or square). It

was possible, however, to differentiate those that had a forelock bolt, which number 10 of the 58. The remaining examples clearly had a pointed tip.

Forty-five years later Ollivier (1736:105-107) described nails in use by the French marine. Accordingly, nails 7 *pouces* (approximately 19 cm) and greater were classified by weight and those from 6 *pouces* (approximately 16 cm) and lesser were classified by count. Ollivier (1736:105) stated that, “one distinguishes four parts in a nail . . . the head, the collar, the stem and tip.” He described the nails by weight with their stem length and collar dimension. The position of the collar immediately below the head is inferred by the order in which he presented the four parts. What was not clear, though, was whether the collar dimension was a diameter or cross-section, an important difference from the standpoint of archaeological evidence. That the nails were tapered and had add-on heads is inferred by the following:

All these different nails are the same size or very near same size in the middle of the length of their stem as that to the collar; from there [the middle] to the tip, they lose a quarter or a fifth part of their size and about the five-sixth of this same size in the opposite direction, so that the tip of the nail is a lot longer than thick. The head of these nails has about 4 or 5 lines [1/12th of a French inch or .00225583 cm] more diameter than the size of the collar. One uses the nails to the weight of 20 to 26 *pouces* [inches] to bind the pieces that compose a mast and the others are used to attach the hull planks, the thick stuff under the clamps, wales and other pieces of this type. These last are filled with oakum to the collar when they are put to the hull planks of the decks and the freeboard (1736:106).

The longest fasteners, used to secure the keelson, frames and keel, often referred to as bolts, were custom made for each use in large ships (Boudriot 1986:140). The largest nails Ollivier described were 26 *pouces* with a collar size of 11 *lignes*, approximately 70 cm long with a 2.48 cm collar. Although purchased by contract with blacksmiths, these were produced in large numbers. Based upon their length, collar dimension, likely use,

and archaeological evidence, it is reasonable to assume that the majority of these were round shanked, requiring pre-drilling.

Of the nails by count, Ollivier described 17 different types that ranged in size from 1.3 cm to 16 cm long and were used for everything from nailing tarred canvas and leather to the pumps to nailing the hull planks for the forecastle and poop deck on frigates. He did not provide information on the size of the heads or their stem shape, but he did provide a collar size, which ranged from .4 to 1 cm. Based upon their length, collar dimension, described use, and archaeological evidence, the majority of these were likely square to slightly rectangular-shanked. However, the largest of these still required pre-drilling and many of the intermediate size required a pilot-hole.

In attempting to correlate the archaeological evidence left by the fasteners to general archival documents describing them, certain limitations must be considered. Keith described the four morphological features used to classify and catalog the fasteners from the Molasses Reef Wreck. They were: head shape and diameter, shank cross-section shape and diameter, shank length, and point configuration (Keith 1987:108). Without the fasteners and because none of the concretions collected from the site have as yet yielded useful examples<sup>1</sup>, in order to further the analysis it is necessary to examine the method by which fasteners were installed and the archaeological signatures left by this process.

Head Shape and Diameter: Typically, centerline fasteners were forelock bolts that were driven from the outside. In addition to pre-drilling the holes, their heads were

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<sup>1</sup> Subsequent to this writing a handful of concretions were cast by the conservation laboratory at Texas A & M University. Careful examination of photographs of the castings supports the descriptions and the results of the analysis presented here.

countersunk so they did not protrude. The countersunk diameter and depth had to accommodate a head that was also wrapped with oakum. Hull plank fasteners were also countersunk to create a smooth surface to the hull and these too were wrapped with oakum. Other countersunk fasteners might appear in those locations where a protrusion would create a hazard or impede movement of heavy equipment, such as cannons. Of necessity, the diameter was larger than the actual head size and so cannot be used as a reliable indicator of actual head diameter. Heads of countersunk fasteners might be round or flared with a slightly square shape, and flat to button-shaped. Unless the head is preserved, the only evidence is a round countersunk hole.

Shank Shape: Any medium to large fastener that required pre-drilling, whether round or roughly square-shanked, was inserted into a round hole. A moderately-sized square-shanked fastener that required pre-drilling still left a round hole, albeit with squared edges. Without the fastener, unless that hole is carefully examined for evidence of fastener edges or corners, an erroneous assumption about shank shape will be made. Small fasteners that required a pilot hole are less troublesome as generally a pilot hole is smaller in diameter than the cross-section of the fastener.

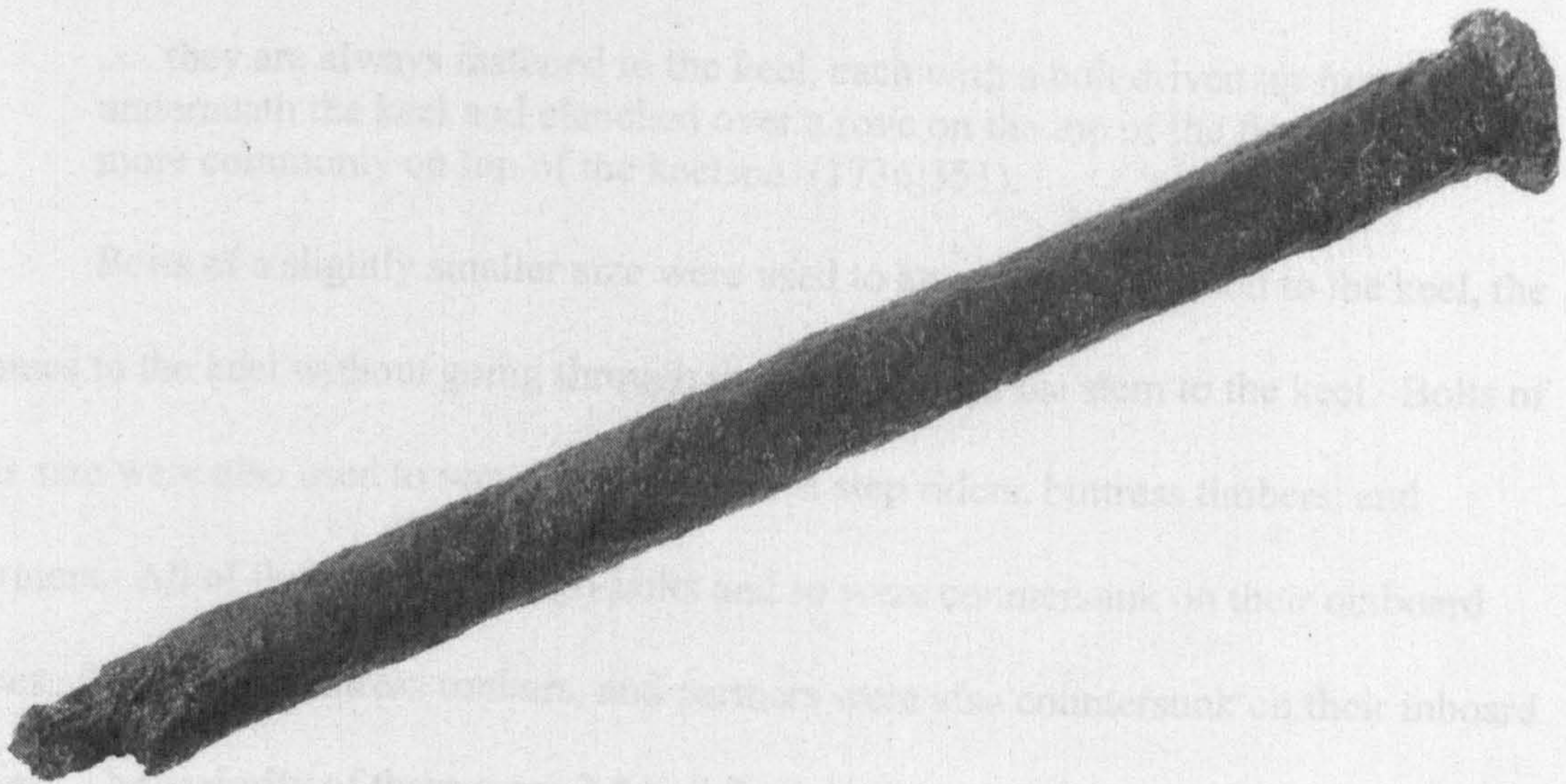
Shank Length: For those fasteners that pass completely through the wood and both ends are exposed, such as the fore and aft fasteners for the frames, it is possible to estimate their original length. However, for blind fasteners, which are generally those that are square-shanked, unless the depth of each hole is measured and the depth of the overlying timber is added, the length cannot be accurately determined. The time necessary to measure each hole and to make the necessary calculations would yield information that, while interesting, might not be worth the investment of personnel. Therefore, to determine fastener length a “rule-of-thumb” must suffice.

In modern general carpentry fasteners are typically 1.5 to 2 times longer than the thickness of the planks they are to secure (Willis 1984:105). In the late 18<sup>th</sup> century the length of nails used by the marine was determined by a ratio that specified it must penetrate the underlying timber by 5/9ths of its length (Boudriot 1986:140). Therefore, for a 10-cm plank the nail must be 22.5 cm long, which is slightly more than twice the thickness of the plank.

Point Configuration: Only the large pre-drilled through fasteners could have a rounded tip. These were driven into place using heavy mallets. All other fasteners, of necessity, required a pointed or chisel-shaped tip.

The fasteners in *La Belle* fall into two broad categories based upon their shank shape, either round or square to slightly rectangular in cross-section. Without illustrations that can be directly matched to Ollivier's detailed descriptions, the Molasses Reef topology was used in the analysis of *La Belle*'s fasteners. Based upon this topology, the fasteners can be further divided into bolts, drift pins, and nails. Bolts are defined as large, long, round-shanked fasteners with wide added-on heads (Keith 1987:108). Their function is to hold together the ship's largest timbers, and as such are through bolts.

In *La Belle* the largest bolts were used to bind the keel, frames, and keelson. Their diameter was 3 cm except at the locations of the keelson scarf where they were 3.3 cm (Figure 3-44). Their length varied from 50 cm to 85 cm based upon their location on the keel. These bolts are slightly larger than the largest described by Ollivier (1736:106). Using his rule-of-thumb, i.e., the bolts had heads 4 or 5 lines greater in diameter than the shank, the head diameter for the 3-cm bolt was approximately 4 cm. While the head diameter for the 3.3-cm bolt was 4.3 cm. These dimensions compare favorably with the



5176



3464

**Figure 3-44:** Two typical iron forelock bolts cast from concretions. Photographs by Stephanie Judjahn (top) and Amy Borgens (bottom).



surviving countersunk holes that are 4.1 and 4.5 cm in diameter. They were uniformly countersunk on the outboard face and were likely clenched over a rove, a practice

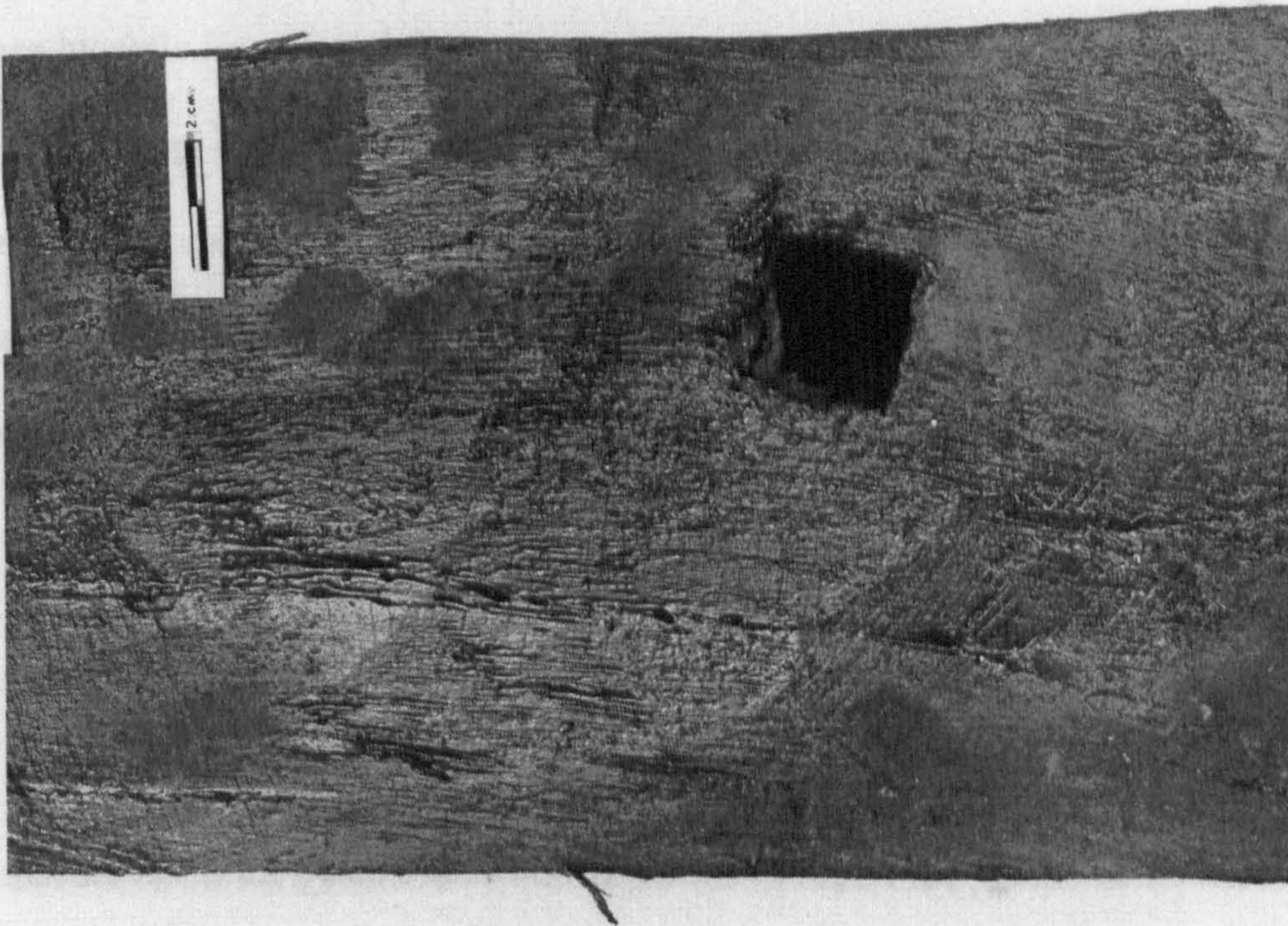
Ollivier described for the attachment of floor timbers:

. . . they are always fastened to the keel, each with a bolt driven up from underneath the keel and clenched over a rove on the top of the floor, or more commonly on top of the keelson. (1736:351).

Bolts of a slightly smaller size were used to attach the deadwood to the keel, the frames to the keel without going through the keelson, and the stem to the keel. Bolts of this size were also used to secure the main mast step riders, buttress timbers, and partners. All of these were through-bolts and so were countersunk on their outboard faces. The riders, buttress timbers, and partners were also countersunk on their inboard faces. The majority of these were 2.8 to 2.9 cm in diameter and their head diameter is hypothesized to be 3.8 to 3.9 cm.

Keith (1987:111) defined drift pins as long, square-shanked, peen-headed fasteners with beveled ends that were used to fasten large timbers and were driven into pre-drilled holes. The fore-and-aft fasteners used to assemble *La Belle's* frames are similar to this description. After the through-bolts, these are the largest fasteners for which there is surviving archaeological evidence. Basically square-shanked and tapering, they varied in size from 2.5 to 2.8 cm (Figure 3-45). The holes were pre-drilled and there is evidence that they were wrapped with oakum. Head shape is problematic, but is likely to have been slightly flared from the hammer blows used to drive it into the frames. Because the fasteners completely penetrated the frames, their length varied from 22 to 46 cm depending upon the frame set being assembled.

Nails are defined as slender, tapering, headed, square or slightly rectangular-shanked fasteners with fine drawn or flat points (after Keith 1987:111). These generally



**Figure 3-45:** This well-preserved hole from a forward/aft fastener is the best evidence of fastener size and shape. This example is typical, measuring 2.75 cm square. Extensive adz dubbing and remnant saw marks are also visible in this image. Photograph by George Vandervlugt.

did not pass completely through the timber and so were blind fasteners. Nails were used to secure hull, ceiling and deck planks, stringers, bulkheads and similar applications. The archaeological evidence suggests four sizes of nails: 1.6 to 1.8 cm, 1.4 to 1.5 cm, .9 to 1.3 cm, and .5 to .7 cm square. The largest, those from 1.6 to 1.8 cm, were used to hold the keelson on the frames while the large through-bolts were pre-drilled and used for the keelson scarf. Based upon the 5/9ths rule, these were minimally 25 cm long. The next group of fasteners, those from 1.4 to 1.5 cm, was used to secure the beams of the platform deck to the frames, the rider ends to the frames, fillers in the foremast assembly, the stringers, notched ceiling planks, and fillers in the main mast assembly. Their length is estimated to have been 18 to 22.5 cm, based upon the 5/9ths rule.

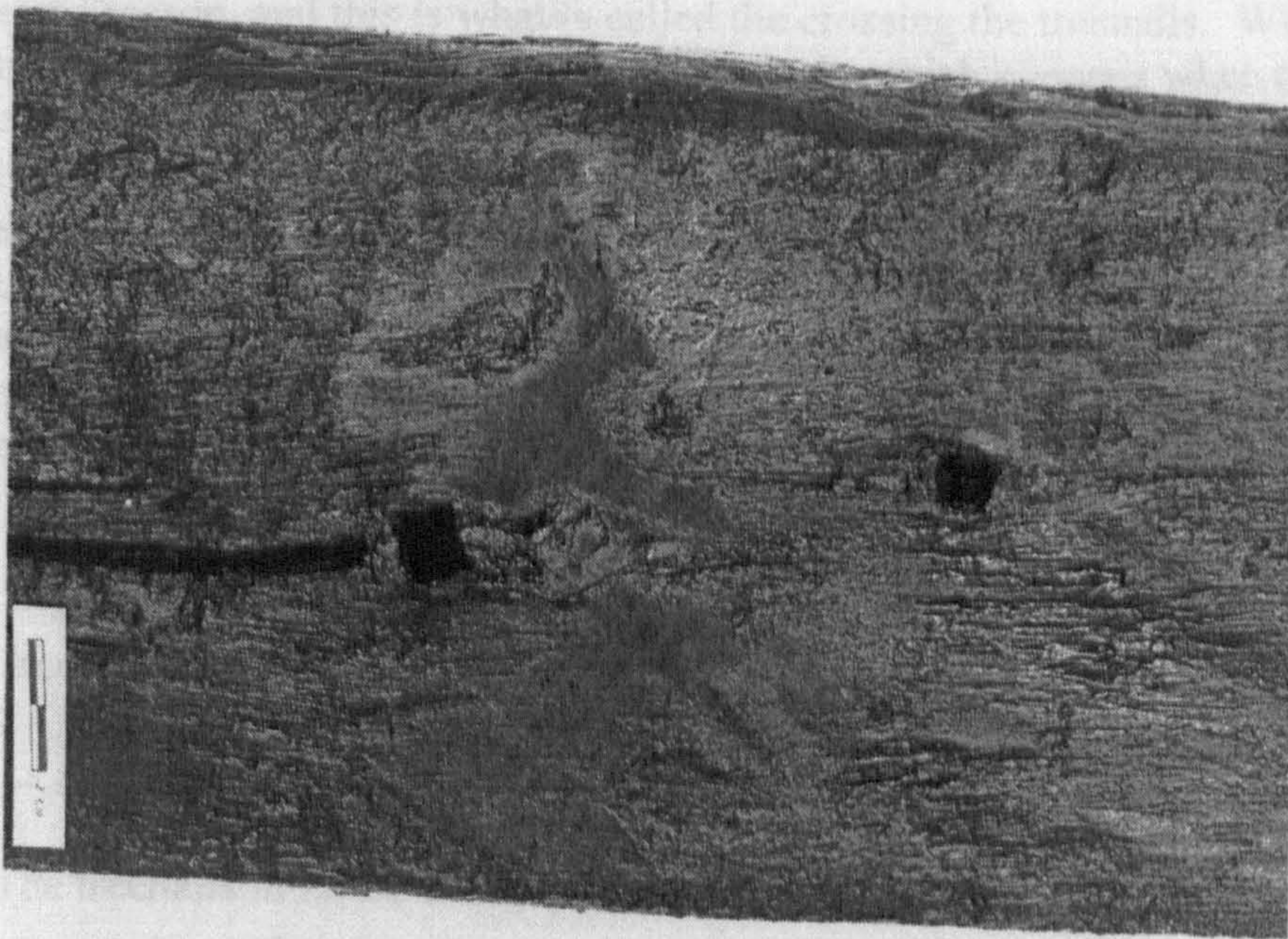
Hull and regular ceiling planks, buttress ends, and the ceiling fillers were held in place by nails from .9 to 1.3 cm square (Figure 3-46). These nails are estimated at 11.25 to 13 cm long, based upon the 5/9ths rule and the thickness of the hull and ceiling planks. The smallest nails, from .5 to .7 cm square, were used for the bulkheads, pump well planks and stanchion post bases, to toenail the foremast locking timber to the ceiling planks, and to attach the platform deck planks. These fasteners are estimated at 7 to 8.5 cm long (Figure 3-47).

### **Treenails**

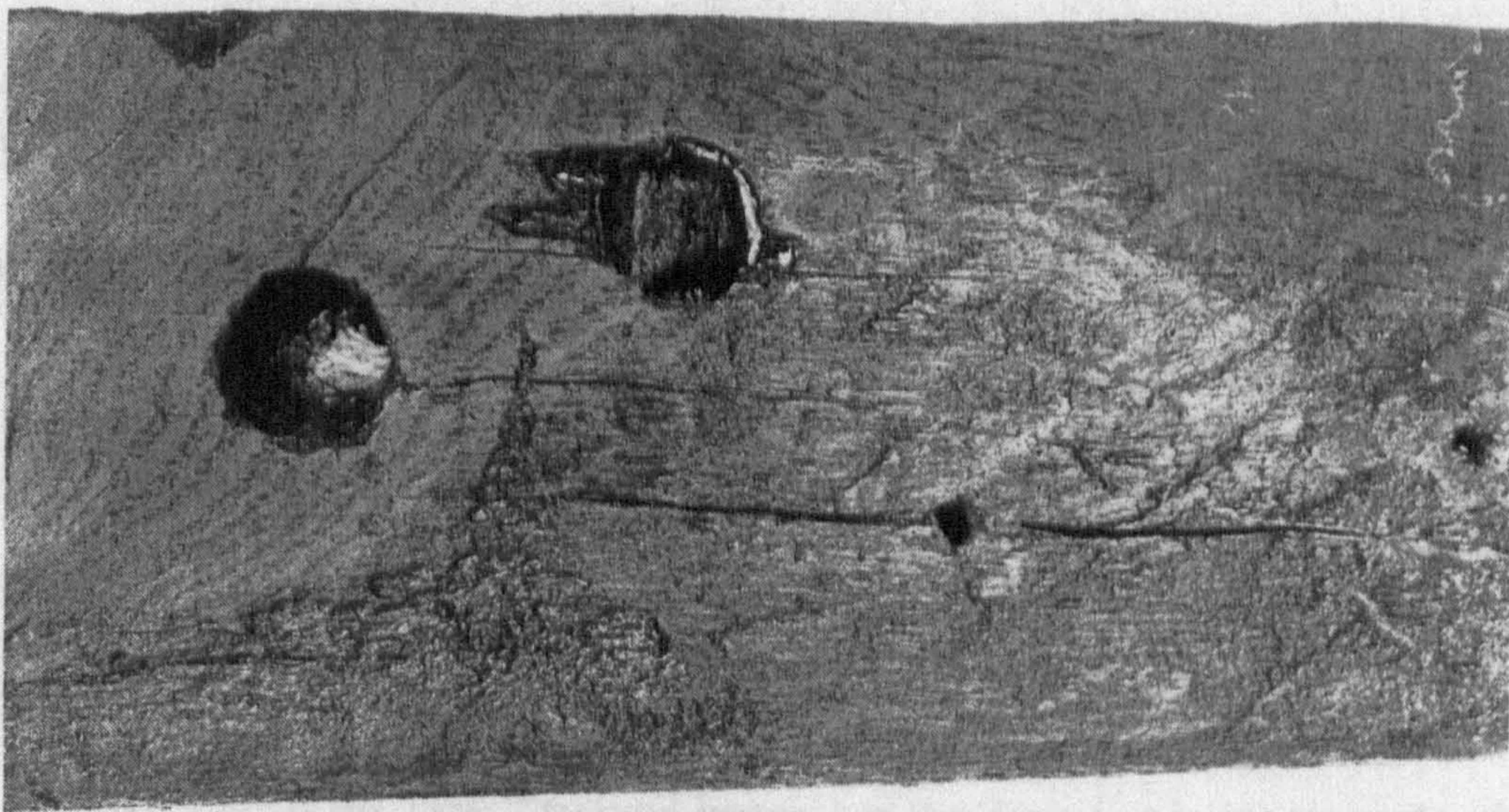
Ollivier (1736:206) defined a treenail as “. . . a bolt fashioned of oak, pine, or fir, which serves in the place of nails or iron bolts to fasten the planks to the frame timbers and to join together many other timbers.” Manufactured from split logs in the forest, they started out square-sided averaging 65 to 129 cm long [2 to 4 French *pieds*] and 4.2 to 5.4 cm thick [1-1/4 to 2 *pouces*] (Ollivier 1736:206). After preliminary shaping with a drawknife, rounding with a moot, or driving through a jig, their size was slightly reduced to approximately 2.9 and 2.25 cm for 4<sup>th</sup> rates and frigates (Ollivier 1736:206).

Used in a variety of locations, but primarily below the water line, Ollivier described how treenails were set in a ship:

For the treenail, a hole is bored that runs right through the bottom plank, the frame timber and the plank of the ceiling, and a treenail is chosen to fill this hole that is about one foot longer than the hole and of exactly the same diameter, save at the head where the diameter of the treenail exceeds that of the hole by a few lines. The treenail is greased with tallow or else tarred. It is driven in with a mallet, and when it reaches the point where its diameter is greater than the hole, so that the mallet must be wielded harder in order to drive it in, the head is wound round with a twist of spun yarn to prevent it splitting. Once the treenail has been driven in as far as it will go, it is cut off flush with the planking at either end and a small piece of wood called a treenail wedge or a spile is hammered into both ends to realign the treenail with the sides of the hole. A thread of oakum is also



**Figure 3-46:** Square-shanked iron nails from .9 to 1.3 cm square were used for hull and ceiling planks, buttress ends and the ceiling fillers. Photograph by George Vandervlugt.



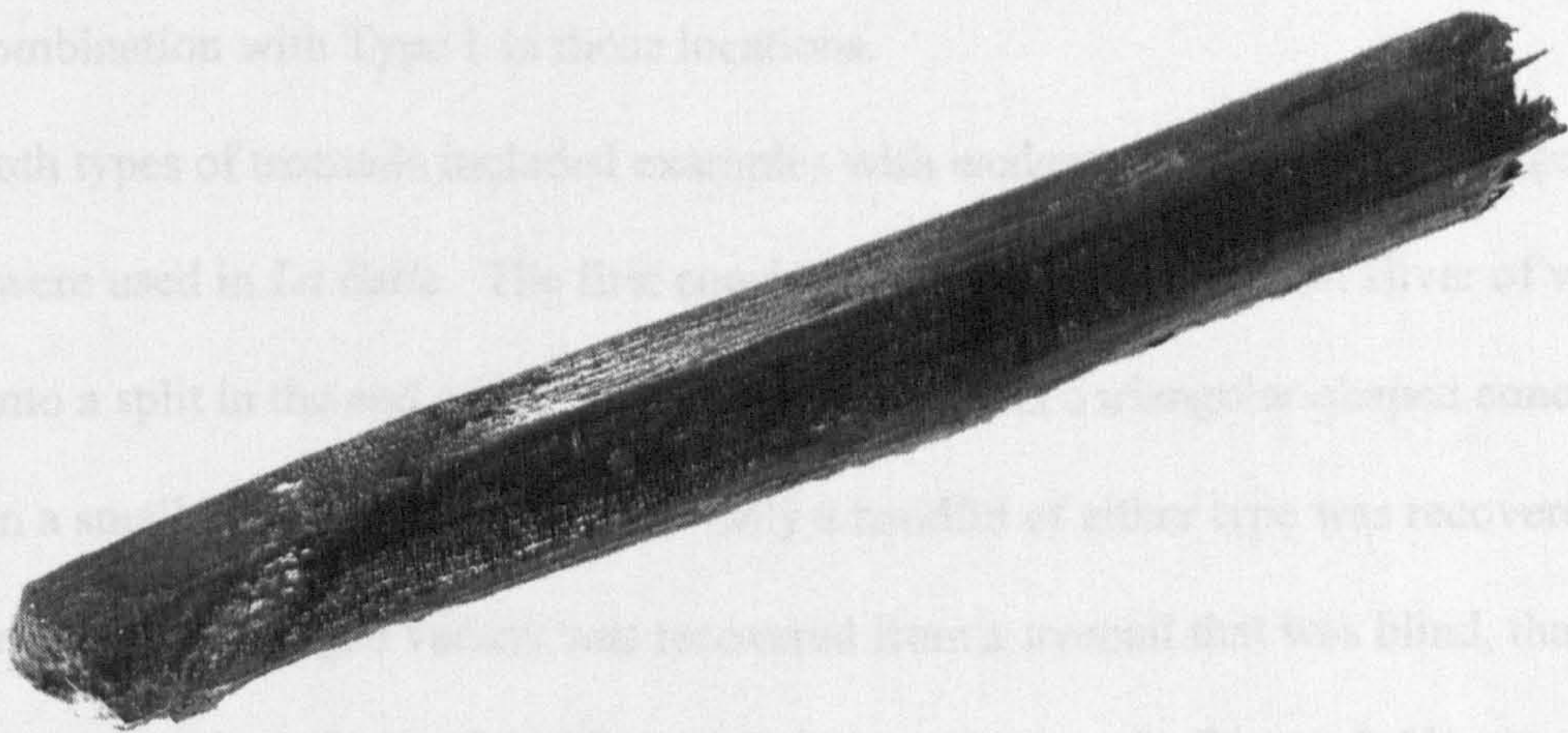
**Figure 3-47:** Square-shanked iron nails for bulkheads and similar applications. Also visible is the squared end of an outboard treenail (center) and the empty hole from a treenail (left) with faint striations visible on the inside. Photograph by George Vandervlugt.

inserted in a cross-shape or triangle in the head of each treenail for the same reason, and this is what is called the crossing the treenails. When a treenail cannot be driven all the way through, which happens when the auger-men meet iron when boring, which prevents them from continuing, the narrow end of the treenail is split, a wedge is inserted into the split, and the treenail is inserted ready armed into the faulty hole. Treenails are used to fill all the faulty holes in a ship that are bored for the bolts. They are also used to fasten together the timbers forming a double binding strake, to nog keel-blocks, and many other timbers. All the treenails which are used in building the King's ships are of oak (1736:206).

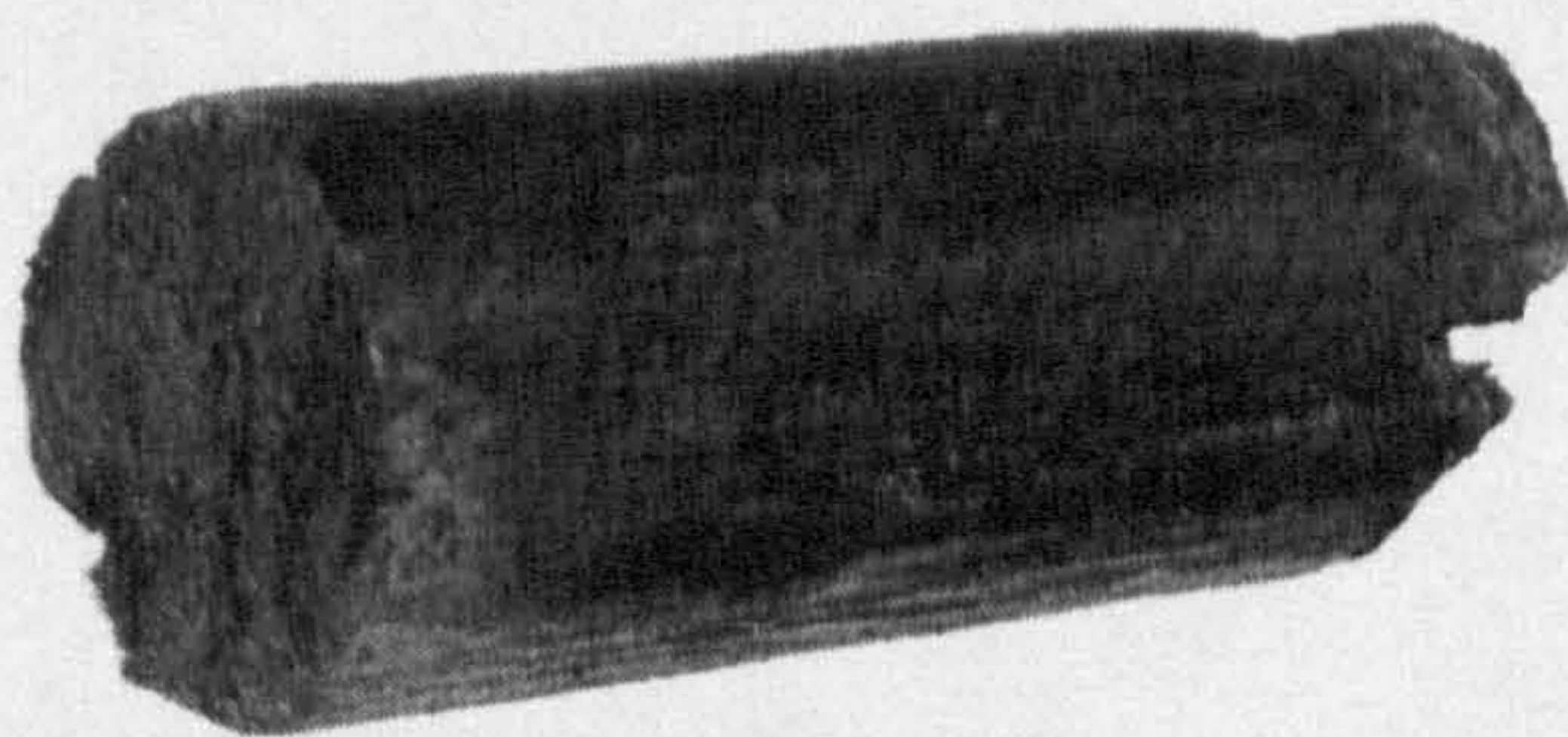
Ollivier (1737:52) also noted that treenails were set and driven only after the ship was planked and caulked. In this manner they hoped to prevent the treenails from splitting the planks and tighten the oakum in the seams.

The treenails in *La Belle* are oak (Mitchell 1998:13). Two distinct sizes survived, those from 2.3 to 2.7 cm in diameter, referred to here as Type 1, and those from 2.9 to 3.1 cm in diameter, referred to as Type 2. Morphologically they differ greatly. The Type 1 treenail is not only smaller in diameter, it tapers down its length to 1.9 to 2 cm. It is also clearly faceted, with either six or eight sides (Figure 3-48, refer also to Figure 3-47). Their taper, combined with visible faceting, suggests that these were either never modified after initial shaping with a drawknife, or modified after mooting or being driven through a jig. If they were not modified after initial shaping, this may account for their slightly larger than expected diameters, which should have been closer to 2.25 cm for a ship of this size according to Ollivier. The Type 1 treenail was the most common on the ship and was used to attach the hull and ceiling planking.

Not only is the Type 2 treenail larger than the Type 1, it is not tapered and is not faceted (Figure 3-49). These were likely shaped in the dockyard by mooting. Although parallel striations were not readily visible on the surviving samples, their uniform diameter suggests this method of manufacture. Far fewer in number, the Type 2 treenail



**Figure 3-48:** Type 1 faceted treenail. Photograph by George Vandervlugt.



**Figure 3-49:** Type 2 treenail. Photograph by George Vandervlugt.

was most frequently associated with the notched ceiling planks and stringers and was used in combination with Type 1 in those locations.

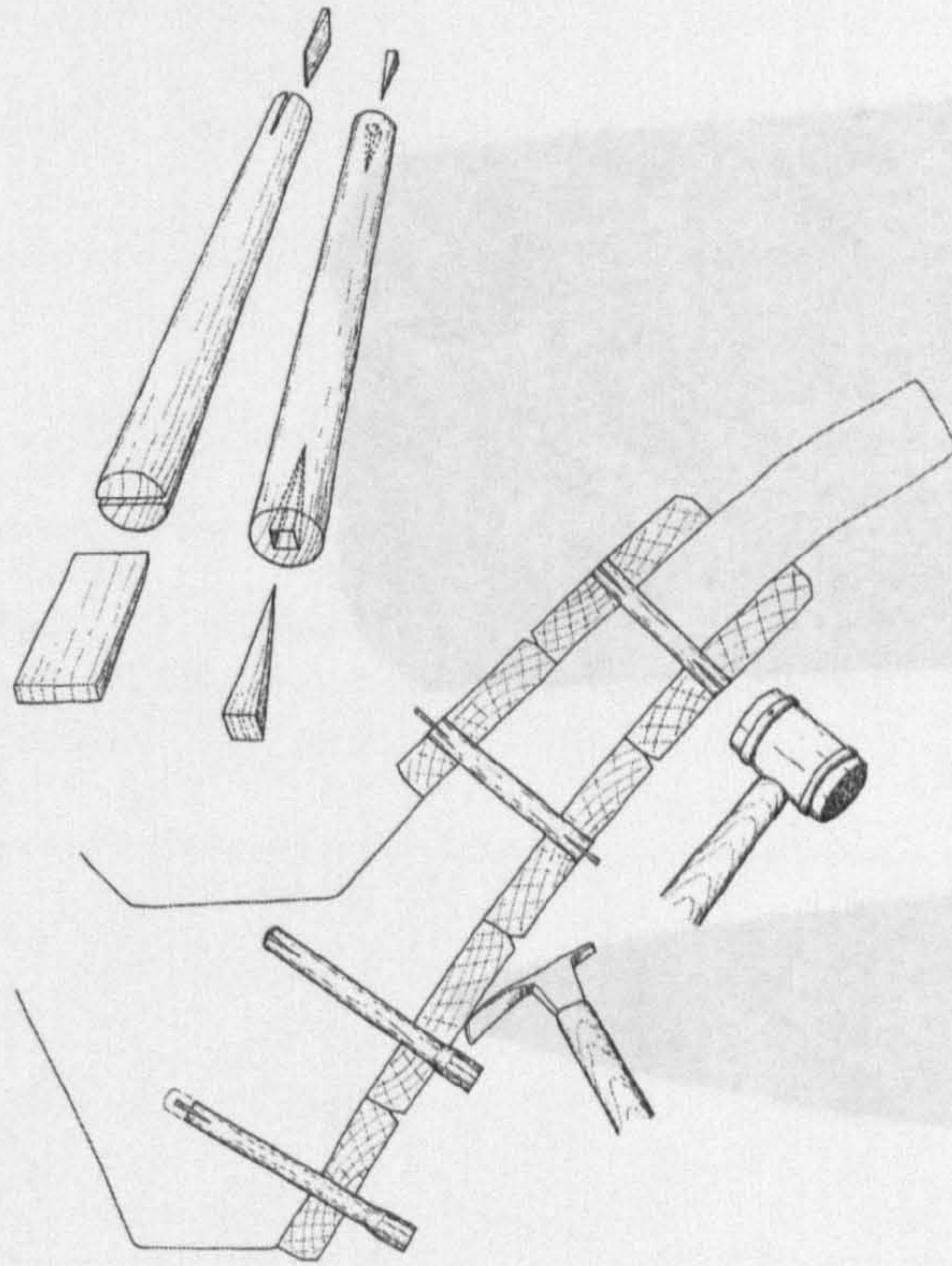
Both types of treenails included examples with wedges. Two styles of wedged treenails were used in *La Belle*. The first consists of a wedge that is a thin sliver of wood inserted into a split in the end of the treenail. The second is a triangular-shaped cone, inserted in a small hole (Figure 3-50 top). Only a handful of either type was recovered. One example of the wedged variety was recovered from a treenail that was blind, that is, it did not penetrate both faces of the timber. In a second example (Figure 3-51), the wedge was inserted in the end of the treenail and the wedged end placed in the pre-drilled hole (refer to Figure 3-50 bottom). As the treenail was hammered into place, the wedge was forced into the end of the treenail causing it to expand slightly making a very tight fit. The location from which it was recovered was not a faulty hole, as described by Ollivier above, but from a location that was inside a deep floor timber.

An example of a wedged treenail was also recovered from the outboard face of a frame timber. This is one of the cone-shaped variety and was associated with the hull planking (Figure 3-52). Cone-shaped wedges varied in size from 1 to 1.75 cm at the base and from 3 to 4.5 cm long (Figure 3-53).

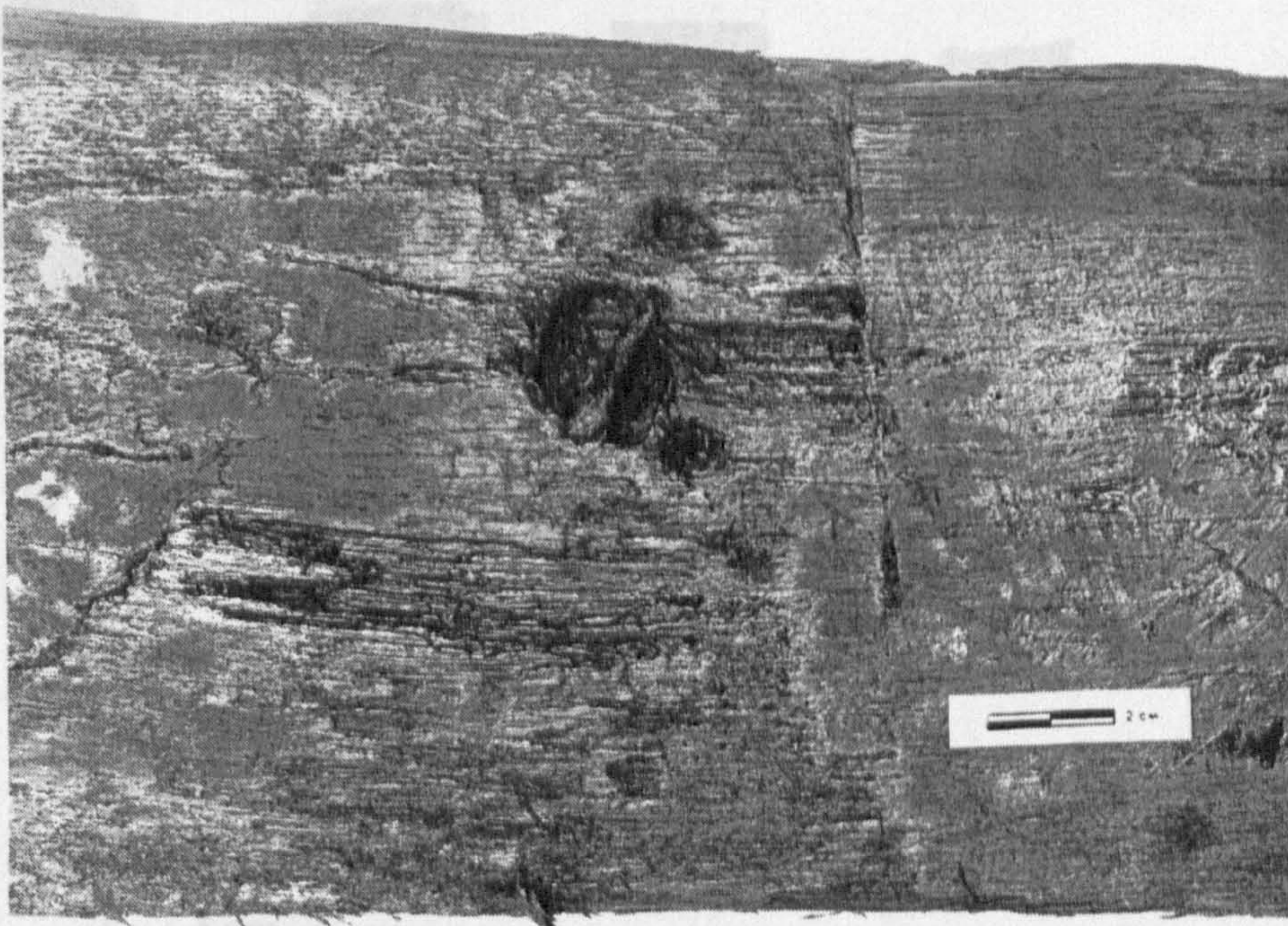
## **Fastening Patterns**

### **Frames**

When Ollivier (1737:65) described the English practice of framing, he noted that they fastened frames together using three treenails, “. . . in place of which we use three iron bolts.” All of the frames in *La Belle* were fastened together using iron fasteners. However, the vast majority of the forward frames were assembled using two iron

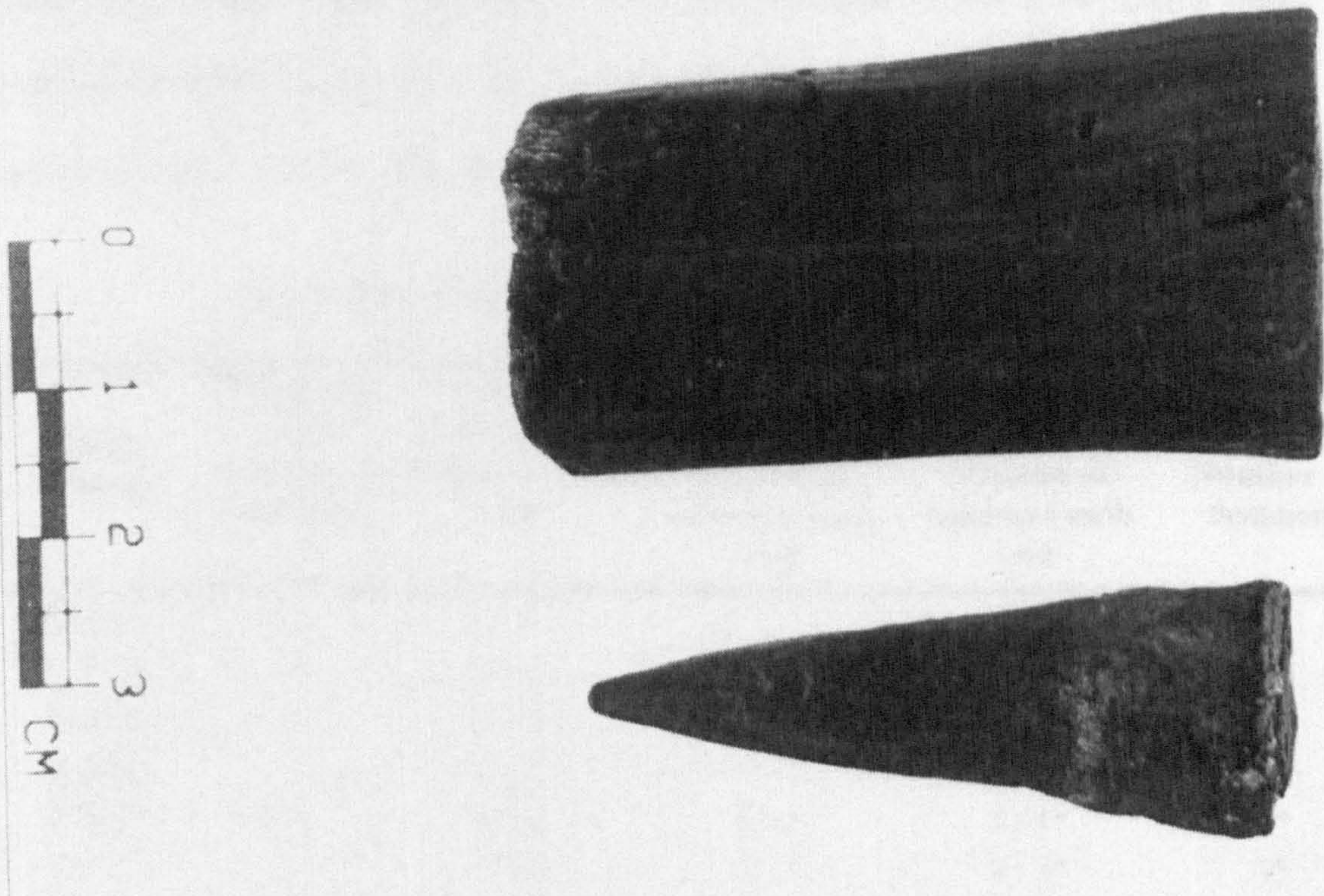


**Figure 3-50:** Two types of treenail wedges and their installation. Drawing by Marie-Andrée Marchand.

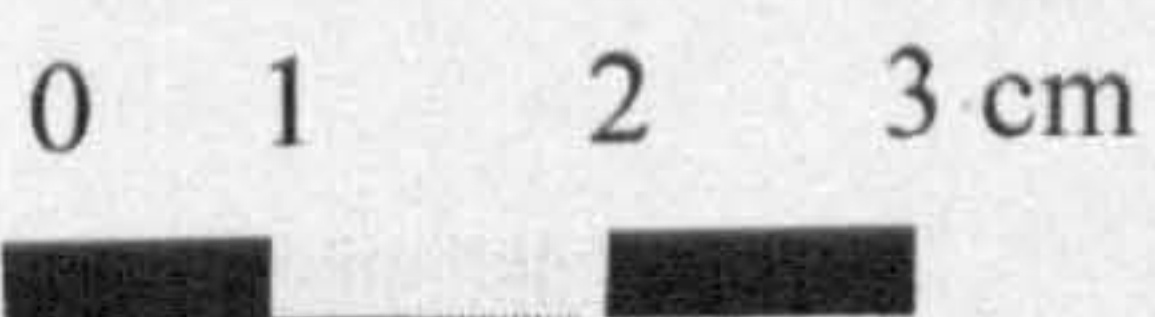
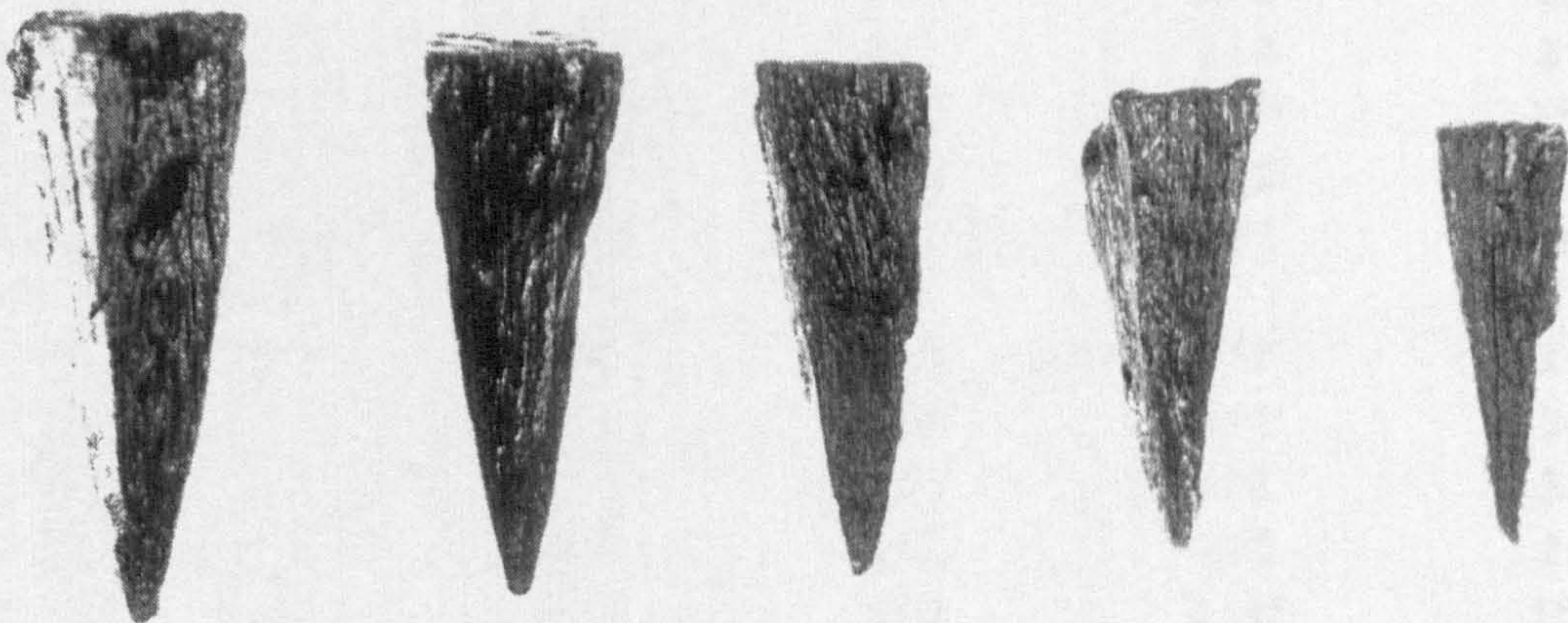


**Figure 3-51:** Flat sliver-shaped wedged treenail in situ. Photograph by George Vandervlugt.





**Figure 3-52:** Cone shaped treenail wedge. Photograph by Amy Borgens.



**Figure 3-53:** Various sizes of cone-shaped treenail wedges. Photograph by Amy Borgens.

fasteners per scarf. This is in contrast to the three-fastener pattern at the master frame and that prevails aft (Figure 3-54). The notable exceptions to both of these patterns appear at frame stations 3, 6, and 9 forward and at 3, 6, 9, and 12 aft.

**Figure 3-54: Number of Fore and Aft Fasteners by Frame**

<b>Frame Position</b>	<b>1<sup>st</sup> Futtock Port Number of fasteners</b>	<b>Floor Number of fasteners each end</b>	<b>1<sup>st</sup> Futtock Starboard Number of fasteners each end</b>	<b>2<sup>nd</sup> Futtock Starboard Number of fasteners each end</b>	<b>3<sup>rd</sup> Futtock Starboard Number of fasteners</b>
12 Fwd		n. a.			
11 Fwd	1*	1*/2	2 / n. a.		
10 Fwd	2	2 / 2	2 / 2	2 / n. a.	
9 Fwd	3	3 / 3	3 / 3	3 / 1*	1*
8 Fwd	2	2 / 2	2 / 2	2 / 1*	1*
7 Fwd	2	2 / 2	2 / 2	2 / 1*	1*
6 Fwd	2	2 / 2	2 / 3	3 / 2	2
5 Fwd	2	2 / 2	2 / 2	2 / 2	2
4 Fwd	2	2 / 2	2 / 2	2 / 2	2
3 Fwd	3	3 / 3	3 / 3	3 / 2	2
2 Fwd	2	2 / 2	2 / 2	2 / 1*	1*
1 Fwd	2	2 / 2	2 / 2	2 / 2	2
Master Frame	fwd 3 aft 1	3 / 3	fwd 3 / 3 aft 1 / 1	3 / 2	fwd 2 aft 1
1 Aft	3	3 / 3	3 / 2	2 / 2	2
2 Aft	3	3 / 3	3 / 3	3 / 2	2
3 Aft	3	3 / 3	3 / 3	3 / 2	2
4 Aft	3	3 / 2	2 / 2	2 / 2	2
5 Aft	1*	2 / 2	2 / 2	2 / 1*	1*
6 Aft	3	3 / 3	3 / 3	3 / 2	2
7 Aft	3	3 / 3	3 / 2	2 / 1*	1*
8 Aft	1*	1*/3	3 / 2	2 / 1*	1*
9 Aft	1*	1*/3	3 / 2	2 / 1*	1*
10 Aft	1*	2 / 2	2 / 2	2 / n. a.	
11 Aft	1*	1*/3	3 / 2	2 / n. a.	
12 Aft		n. a. / 3	3 / 2	2 / n. a.	
13 Aft	n.a.	n. a. / 2	2 / 1*	1*	
14 Aft	n.a.	1* / 1*	1*		
15 Aft		n. a.			

<b>Frame Position</b>	<b>1<sup>st</sup> Futtock Port Number of fasteners</b>	<b>Floor Number of fasteners each end</b>	<b>1<sup>st</sup> Futtock Starboard Number of fasteners each end</b>	<b>2<sup>nd</sup> Futtock Starboard Number of fasteners each end</b>	<b>3<sup>rd</sup> Futtock Starboard Number of fasteners</b>
16 Aft		n. a.			
17 Aft		n. a.			

\* Only one fastener survives due to limited timber preservation. This is not a confirmed pattern change. n.a.. = no surviving fasteners in this location

The master frame consists of paired first and third futtocks and an inline second futtock. The master frame was first assembled using the floor, the forward first futtock and the second futtocks. These timbers exhibit three fasteners from the floor to the first and the first to second futtock, and two fasteners from the second to the third futtock. This pattern is the basis to which all of the frames should be compared. The addition of the aft futtocks required an additional fore and aft fastener, resulting in a total of four fore and aft fasteners on each arm of the floor. The extra fastener was added to secure the aft first and third futtocks to the master frame after its basic assembly. Consequently, the aft futtocks exhibit only one fore-and-aft fastener at each scarf.

The fastener configuration forward of the master frame is internally consistent, but quite different from that of the master frame. From the floor to the first futtock the dominant pattern is two fasteners. The use of two fasteners continues from the first to the second and the second to the third futtock. The exceptions appear at stations 3 and 9, which employ three fasteners from the floor to the first futtock, three from the first to the second futtock, and two from the second to the third. These two frames repeat the basic pattern of the master frame. At frame 6 forward, only two fasteners are used from the floor to the first futtock, but three from the first to the second on the starboard side, and

two from the second to the third. The implications of these differences are discussed elsewhere.

The fastener configuration found on the master frame, with some modification, dominates aft. At frame positions 1, 2, 3, 6, 7, 8, 9, 11 and 12 aft, three fasteners are used from the floor to the first futtock. At frame 13 the pattern changes to only two fasteners on the floor, probably due to the short reach of each arm and their deep V shape. Notable exceptions appear at frames 4, 5, and 10 aft, and are discussed in greater detail elsewhere.

The use of three fasteners from the first to the second futtock appears at frame positions 2, 3, and 6 aft. This changes to a two-fastener pattern at frame 7 and continues through frame 12. This change is likely due the necessary rising and narrowing of the frames. The exceptions to this pattern appear at stations 1, 4, 5, and 10 aft and are discussed in greater detail elsewhere. Lastly, the number of fasteners used from the second to the third futtock is consistently two. At frames 14, 15, 16 and 17, the preservation was insufficient to determine a fastener pattern. However, based upon the apparent dominant pattern of two fasteners per scarf, two fasteners were likely.

As noted earlier, the angle of the fasteners on selected frame sets was found to run perpendicular to the fore and aft face of the timber. This pattern predominates at the master frame, stations 3, 6 and 9 forward and at stations 3, 6, 9, and 12 aft and results from their pre-assembly in the yard.

## **Planking**

According to Ollivier (1737:52), a common practice in the French marine was to install the ceiling planking followed by the hull planking, then the whole assembly was

caulked and drilled for treenails. By inference, the ceiling and hull planking were first attached using only nails. This practice is borne out by the archaeological evidence on *La Belle*, where the treenails clearly pass through all of the timbers. The resulting pattern on the hull planking shows that each plank was attached using one nail and one treenail per frame, as described by Ollivier (1737:52).

In a configuration typical of wooden hull construction, the position of the treenail and nail alternated from frame to frame. The exception to this was at the plank scarf, where both a treenail and nail were in the same quadrant and the fastener at the end of the scarf was a nail. The nails were countersunk on the outboard face, with obvious gouge marks present, and each was packed with caulking and oakum to prevent leakage. At the ceiling plank scarf the pattern also changes. An overlapping scarf that spans two frame sets was used for these planks, which necessitated the use of additional nails. Ollivier (1736:343) described the use of “. . . bolts driven through the outer planking of the hull and clenched over roves set against the planking on the inside” as one means to attach the “let down” ceiling. Examination of *La Belle* revealed the occasional large square-shanked fastener in the notched ceiling and stringers that was not associated with a structural feature. However, these do not have a regular pattern, nor do they favor one strake over another. Rather, it appears that they were placed as need required in combination with treenails and nails. Preservation was such that it is not possible to determine the presence or absence of a rove on these fasteners.

### **Evidence of Ribbands**

Although the likely location of the ribband at the floor is known, as are the likely locations of two of the intermediate ribbands below the breath ribband, there is no direct

evidence of these features, only indirect. Unlike the English practice of nailing ribbands directly to the frames, the French used a different method, which was recounted by Ollivier in the course of describing the construction practices at Deptford Yard:

[The ribbands] . . . are of the fir, with their butts made of oak as in our ships, and they are joined by long hooked-scarfs as we practice it at the dockyard in Toulon. I have seen none joined by a plain scarf and strengthened by an overlapping piece. [In England] they are fastened to the frames with nails and not chocks, so that in order to remove them when planking the hull they must perforce be broken . . . I approve . . . of the practice of nailing the ribbands to the frames without chocks; they hold up much better, and hold the frames better together in the interval before they are planked. We have no reason for nailing them to chocks save only to be able to shift them without breaking them so that they may then serve for some other purpose (1737:69-70).

The indirect evidence for the ribbands comes in the form of a series of blind treenails that align very closely with the outboard edge of the surmarks on the outboard face of a majority of the frames. Although the ribbands were attached to chocks, the chocks themselves had to be attached in some manner to the frames. A reasonable method of attachment is either with a clamp or with a treenail that could be sawn off flush with the frame when the ribband was no longer needed. The latter has the advantage of semi-permanence and security during the critical framing process. Furthermore, a treenail would not weaken the frame timber, nor would it preclude driving a nail in that location in the future. Because this treenail was not intended to attach hull and ceiling planking it was not through-drilled and, with other treenails that filled abandoned holes created for other purposes, appears as a blind treenail.

### **The Numbering System**

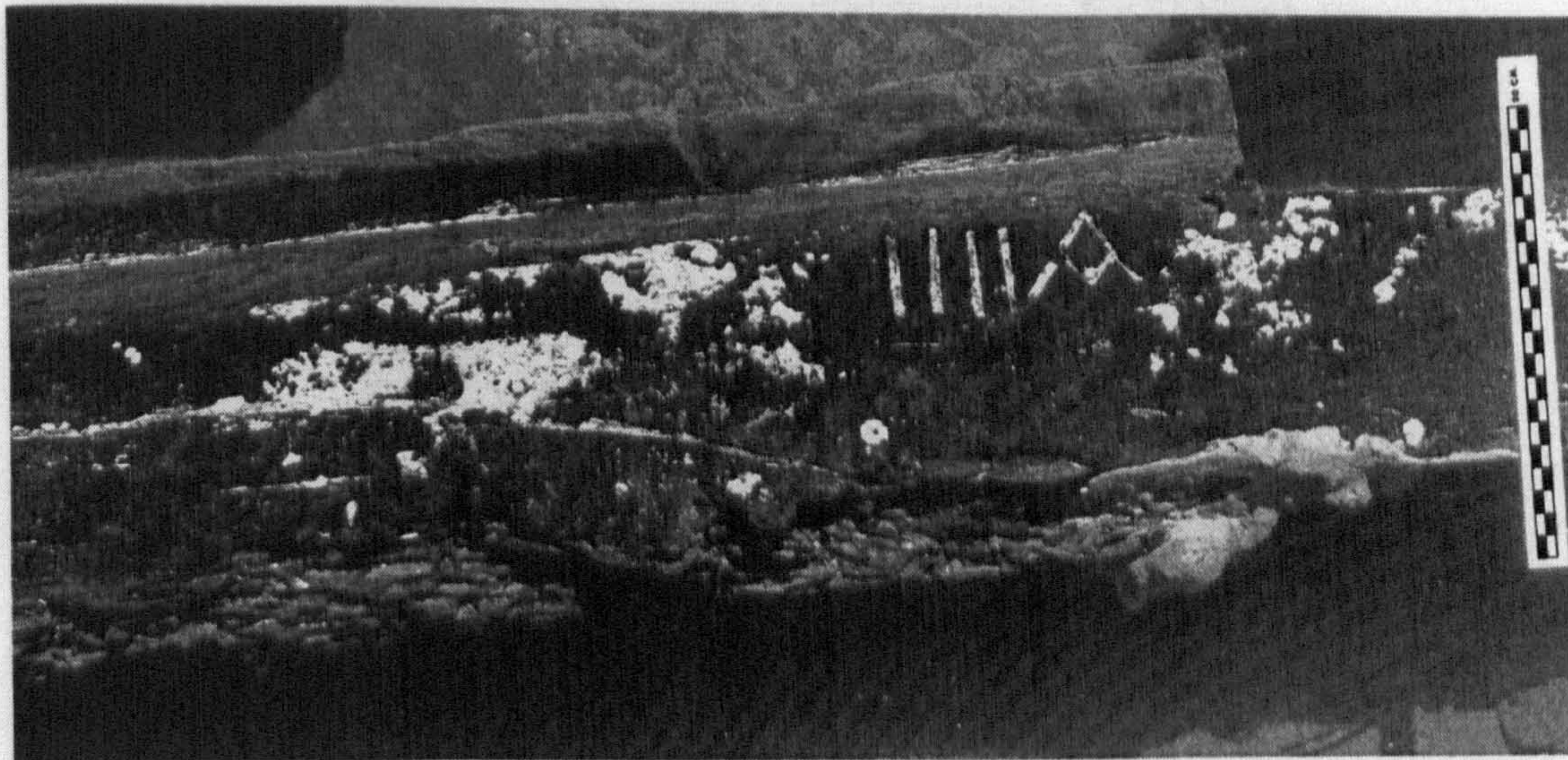
Among the most remarkable aspects of the keel, and all of the major timbers on *La Belle*, is its extensive marking by the shipwrights. The port side of the keel is deeply

carved with Roman numerals indicating the frame locations (refer to Figure 3-6). The frame numbers are followed by a stylized, but very typical and quite recognizable, letter A or the letter D. In the case of *La Belle*, the addition of the letter A, for the French word *avante* or forward, and the letter D for *derrière* or aft, is unique and not reported on any other shipwreck sites.

The use of Roman numerals rather than the Arabic numeral was common at this time. Unusual by today's standards is the numeral four on the keel, which was not written as IV but rather with four single I's as in IIIIA (Figure 3-55). This method was used again at the nine forward location, which is written as VIIIA, and at the four, nine, and fourteen locations aft (Figure 3-56). The master frame location on the keel is indicated with a star-like symbol that resembles an asterisk (Figure 3-57).

In addition to marks on the keel, each floor was inscribed at the centerline with a number and letter combination indicating its location on the ship. Marked in the same manner as the keel, the floors forward of the master frame bear the designation A for *avante* (Figure 3-58) and those aft bear the designation D for *derrière* (Figure 3-59). Those forward of the master frame are marked on the aft face; those aft of the master frame are marked on the forward face. In other words, standing at the master frame and looking toward the bow one can read the inscriptions on each of the forward floors and looking toward the stern one can read the inscriptions on each of the aft floors. The single exception is at the master frame, which is marked on the aft face with an asterisk similar to the mark on the keel (Figure 3-60).

In addition to the centerline engraving, the floors are marked on their port or starboard ends with the frame station and the designation B or T, *bâbord* or *tribord*, for

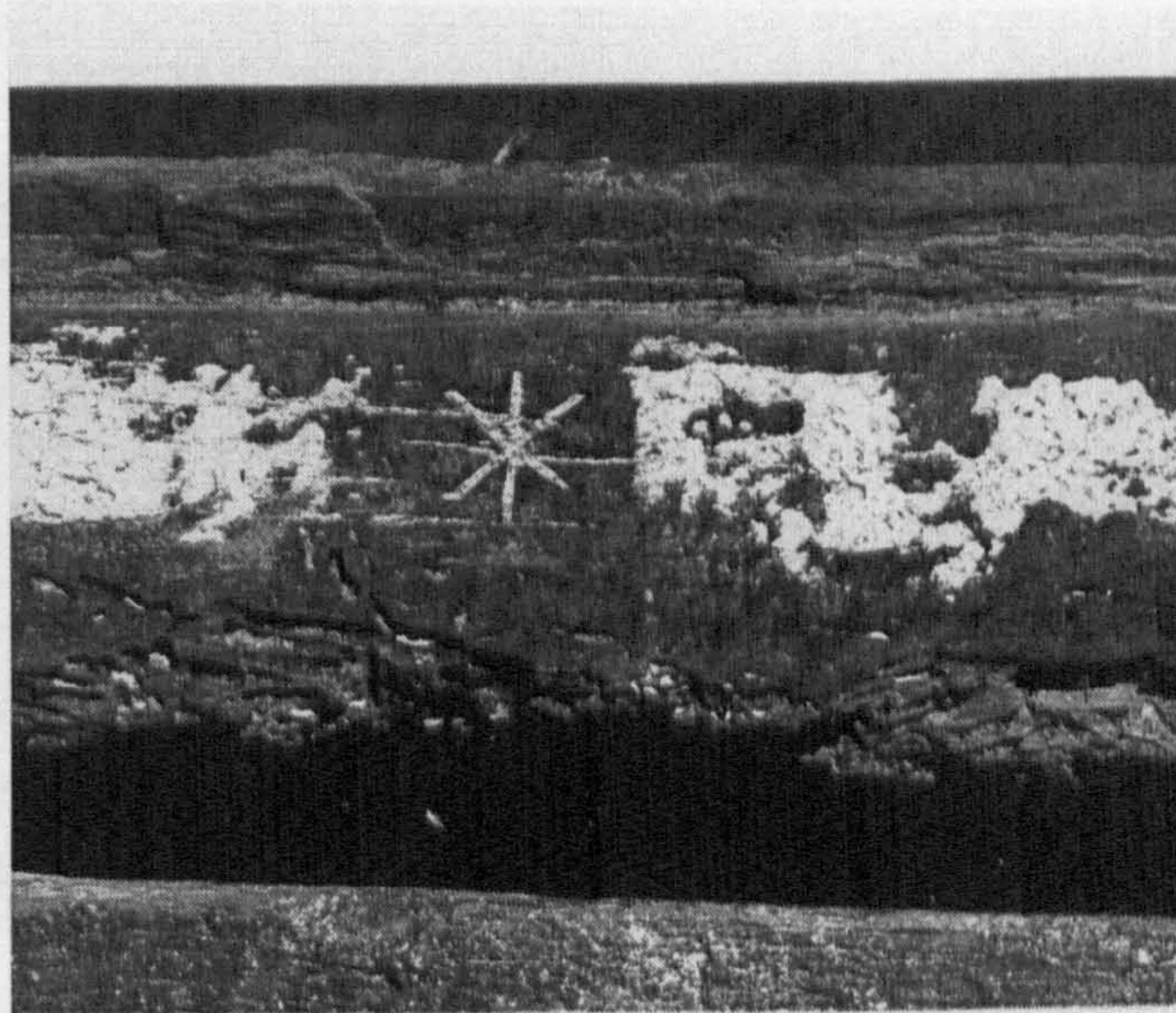


**Figure 3-55:** Roman numeral four forward on the keel. Photograph by George Vandervlugt.

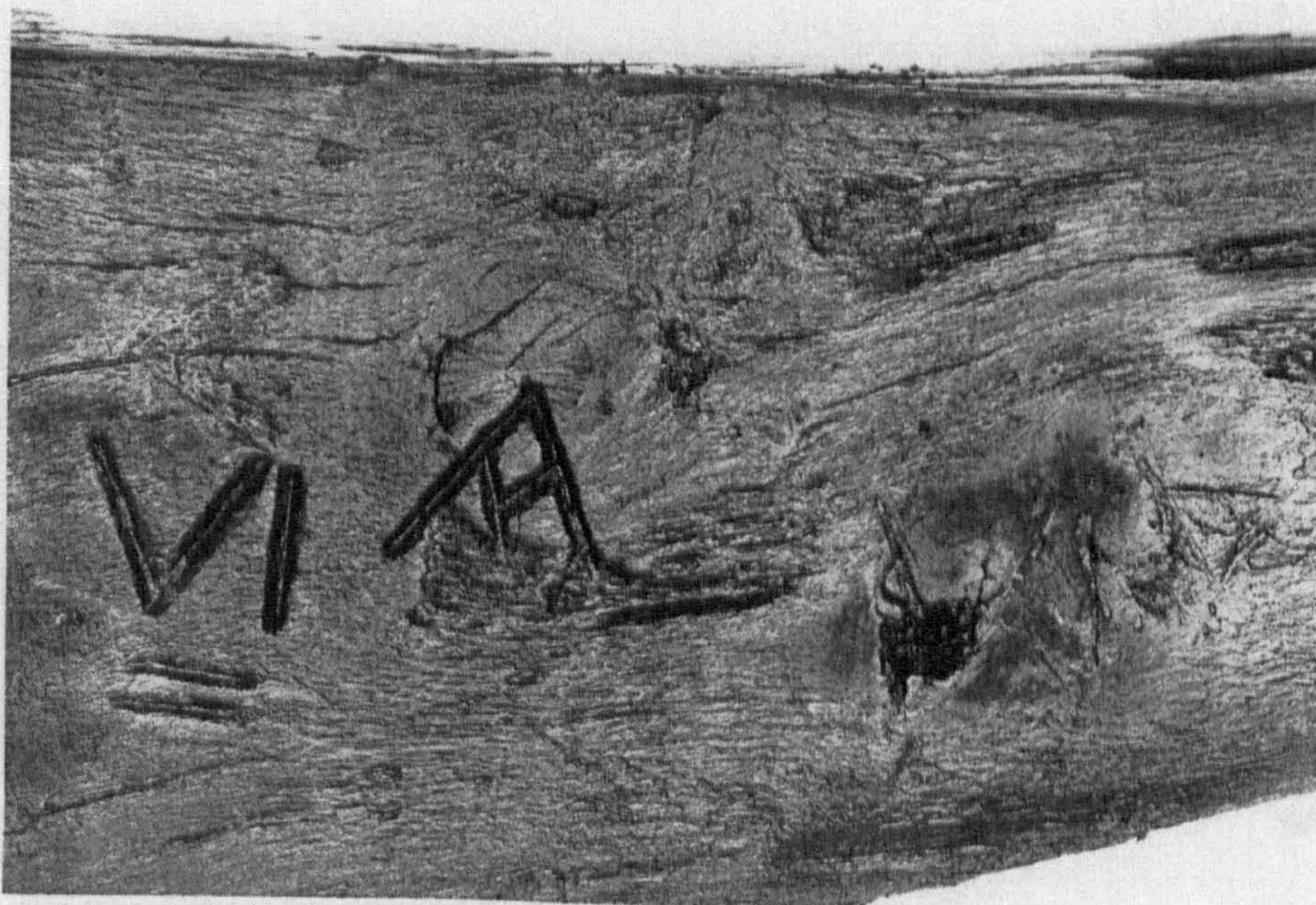


**Figure 3-56:** Roman numeral four aft on the keel. Photograph by George Vandervlugt.

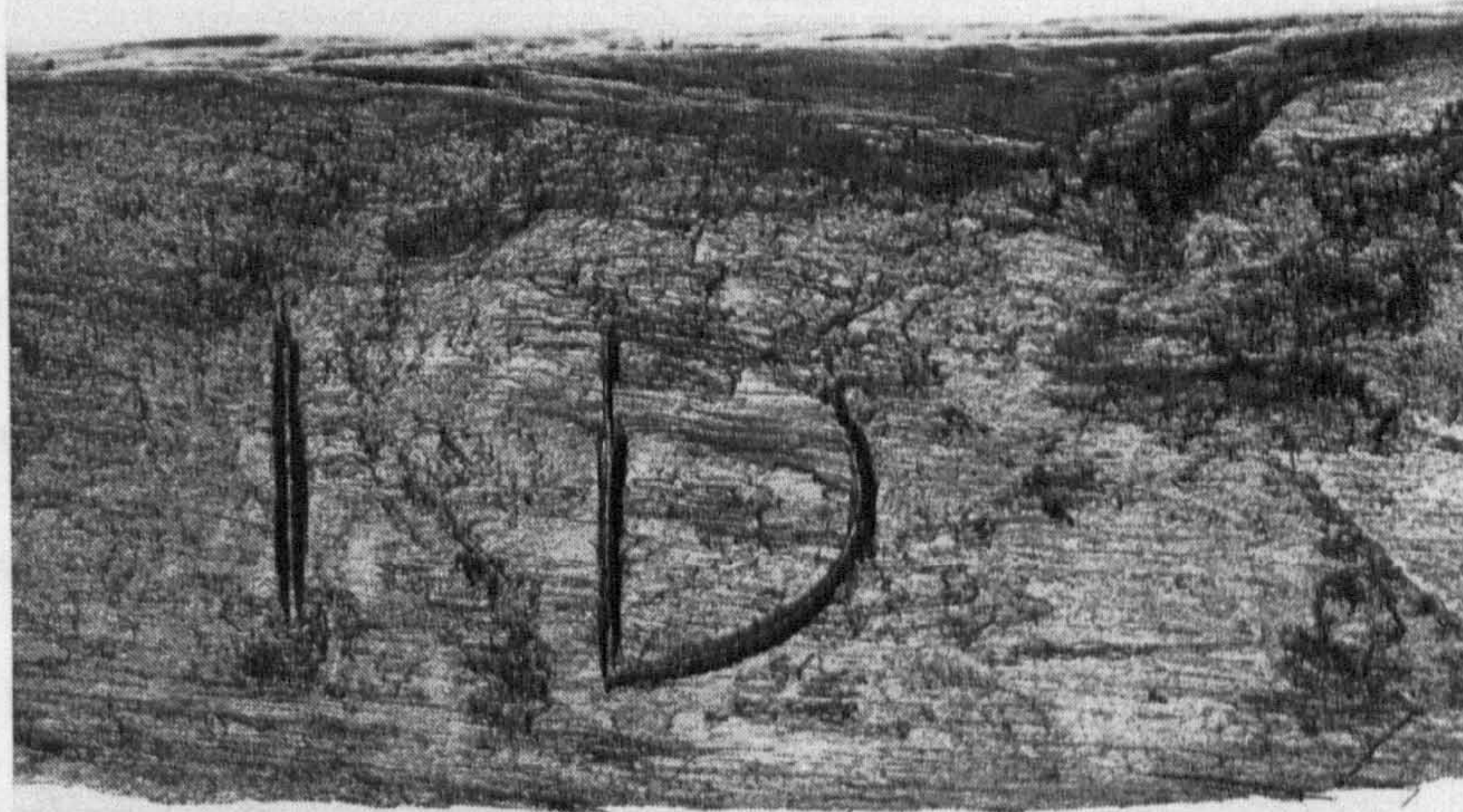




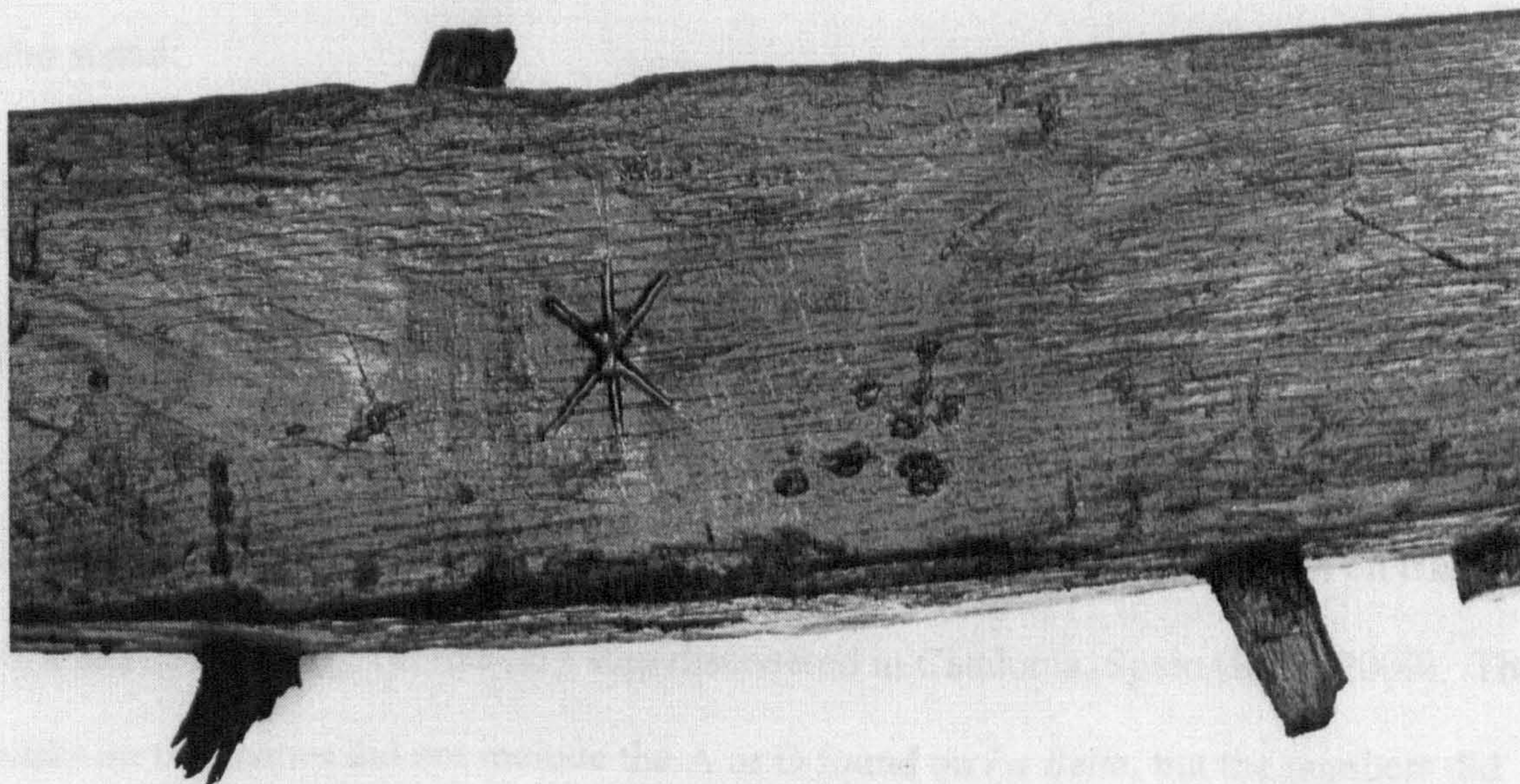
**Figure 3-57:** Location of the master frame marked on the keel. Photograph by George Vandervlugt.



**Figure 3-58:** Roman numeral at the centerline of a forward frame. Photograph by George Vandervlugt.



**Figure 3-59:** Roman numeral at the centerline on an aft frame. Photograph by George Vandervlugt.



**Figure 3-60:** Mark at the centerline on the master frame. Photograph by George Vandervlugt.

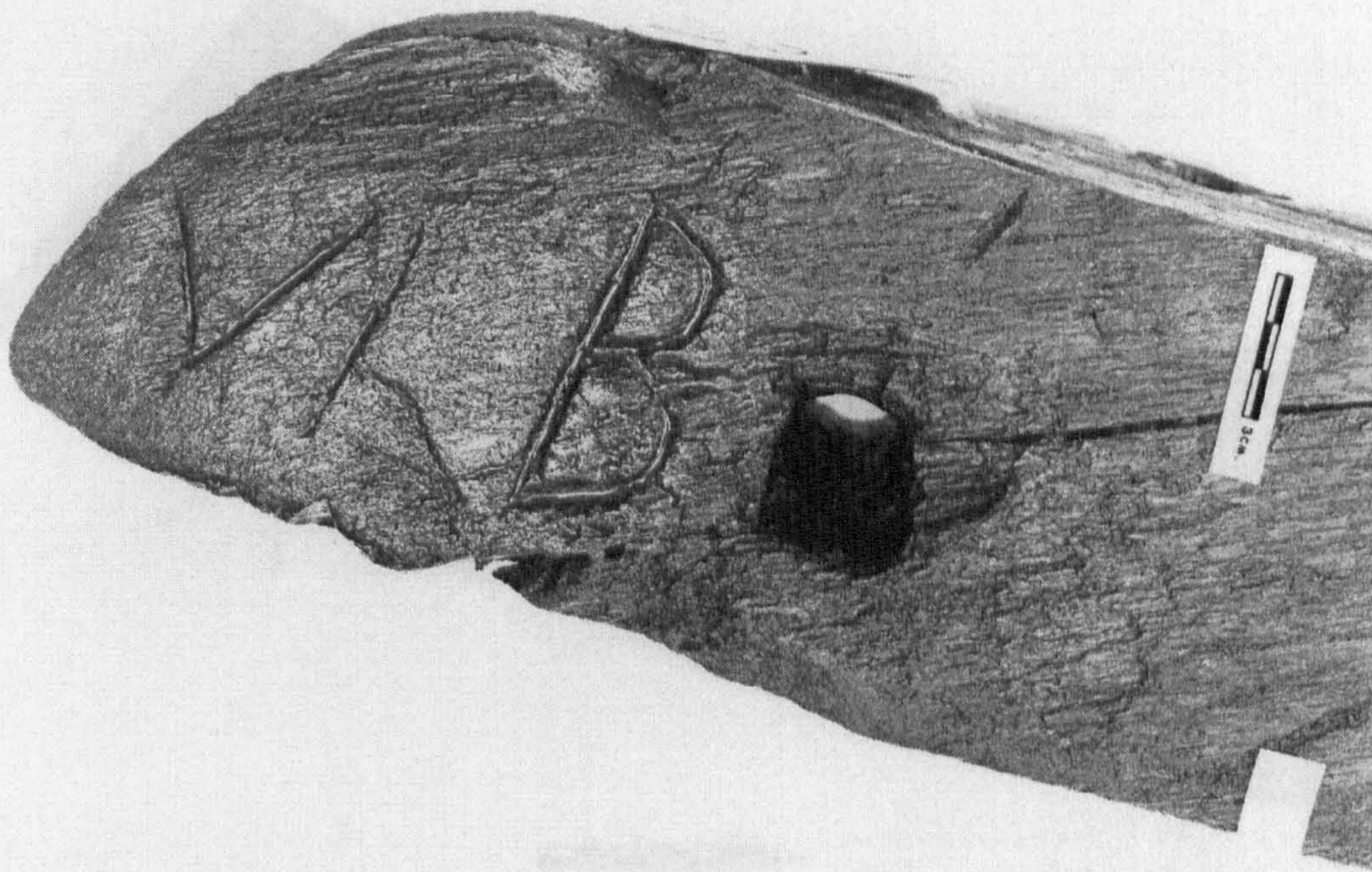
port and starboard, respectively (Figures 3-61 and 3-62). Similarly, the lower ends of the second futtocks, where they butt against the floor, are marked with a frame designation and a B or T depending upon their location on the port or starboard side of the ship. The Rochefort shipwrights made sure that even archaeologists would not be confused by the numbering system by carefully inscribing on the aft face the first floor forward of the master frame with the Roman numeral I and the letter T on the starboard side and the letter B on the port side. The first floor aft of the master is similarly marked on the forward face starboard side with a TI (Figure 3-63) and on the port side they used the mirror image of the BI, that is, they reversed the letter (Figure 3-64). Other stylized numbers include the X on the frame elements (Figure 3-65). These invariably are laying over on their sides and more resemble a plus symbol than an X.

Reference to numbering of frame elements appeared in two early treatises on shipbuilding first by Fernando Oliveira (1580:95) and later by Juan Baptista Lavanha who stated:

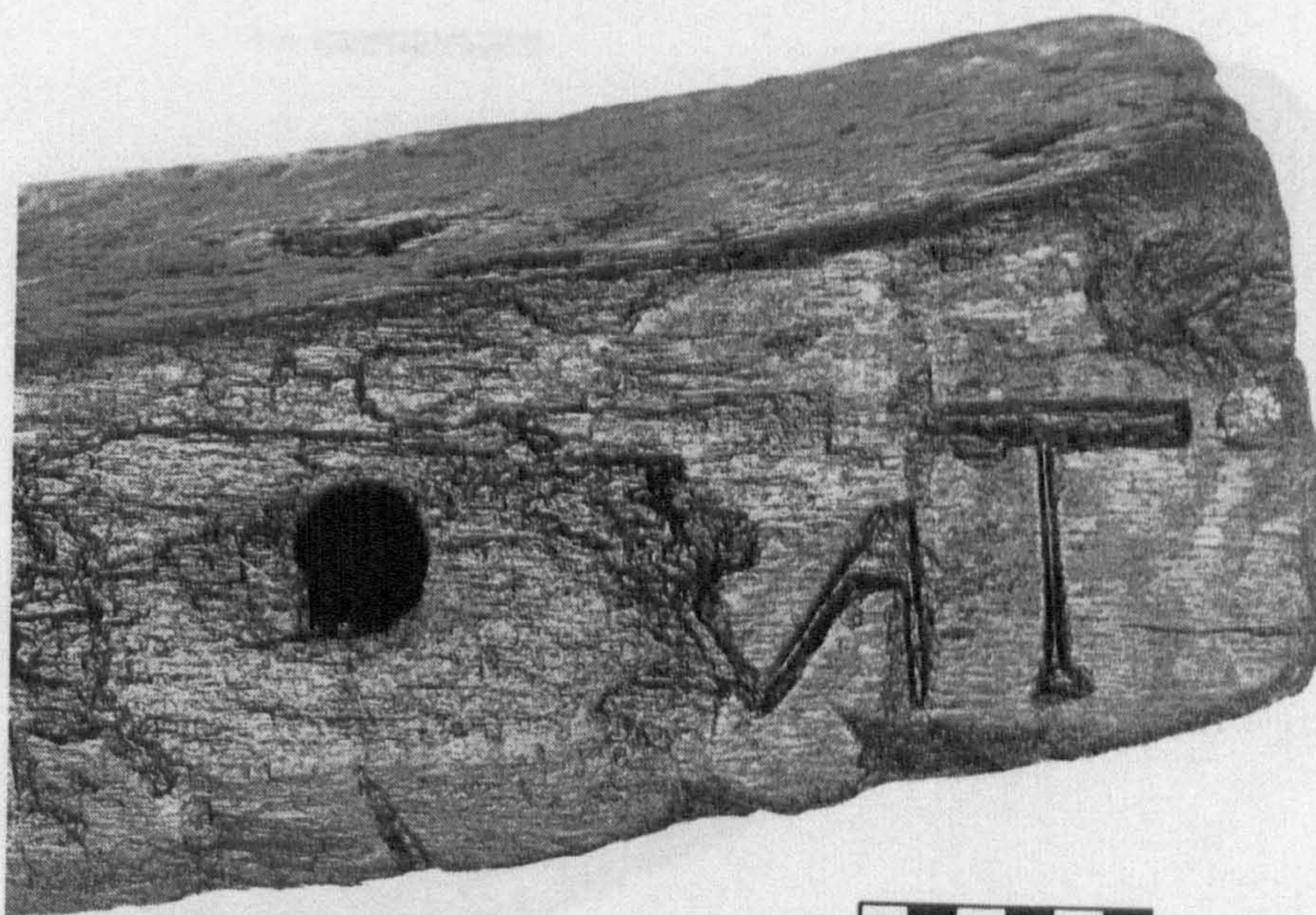
They also marked the places of the ends of the floor timbers OP; and if they mark its number with a chisel; first, second or third, etc., which is in order to know where it has to rest and what its place is . . . (1625:53).

This description seems to match the evidence found on *La Belle*.

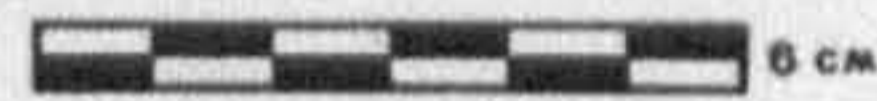
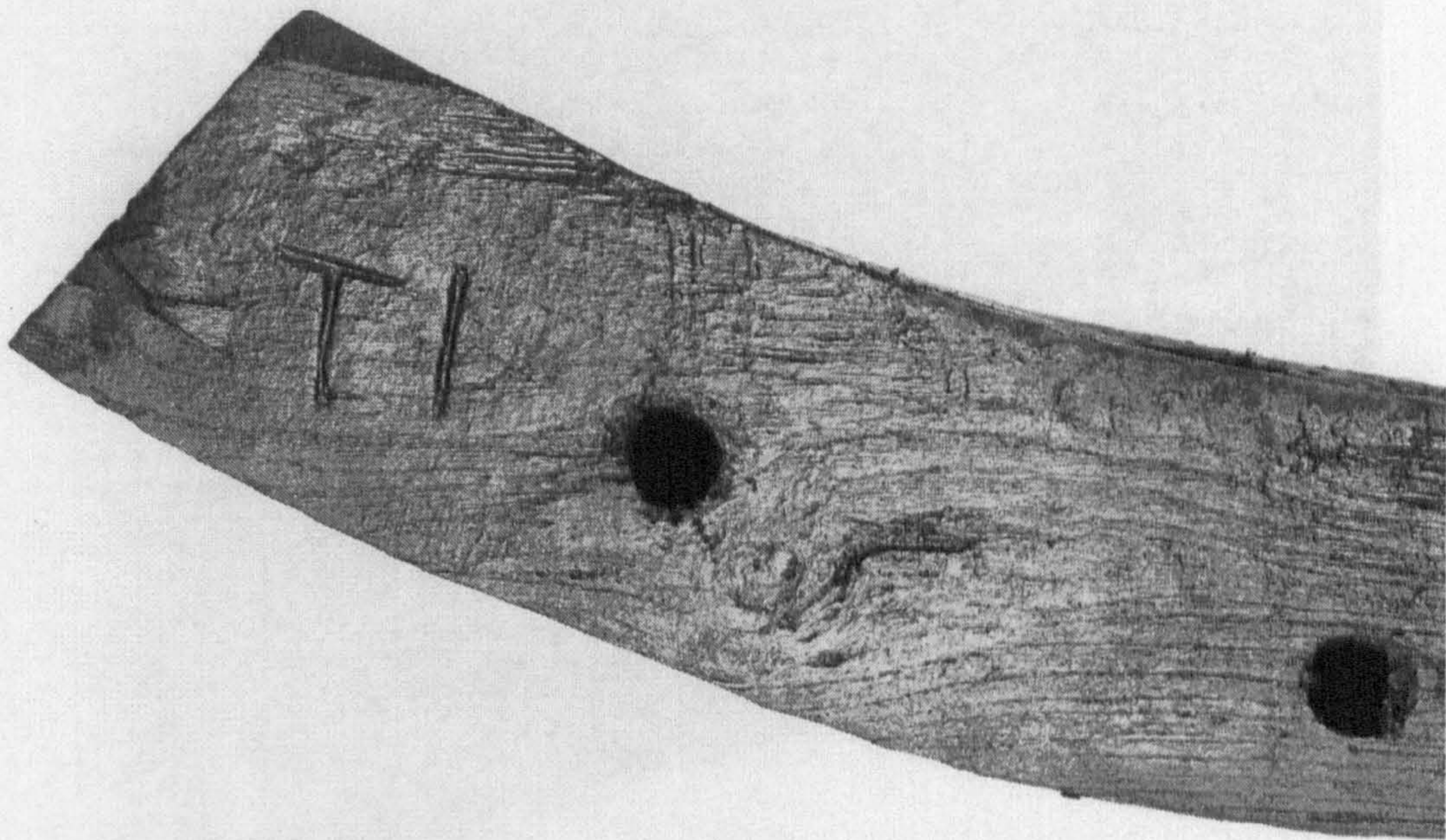
The archaeological record includes a handful of other shipwrecks whose frames are engraved with numbers. The oldest site to date where they are reported is on *Culip VI*, a late 13<sup>th</sup> or early 14<sup>th</sup>-century ship discovered in Catalonia, Spain (Rieth 2000). The marks on the frames did not include the A or D found on *La Belle*, but the numbers did include the use of four I's for the Roman numerals four and fourteen. Similar to *La Belle*, the floors were marked both at their centerline and on their ends and the master-



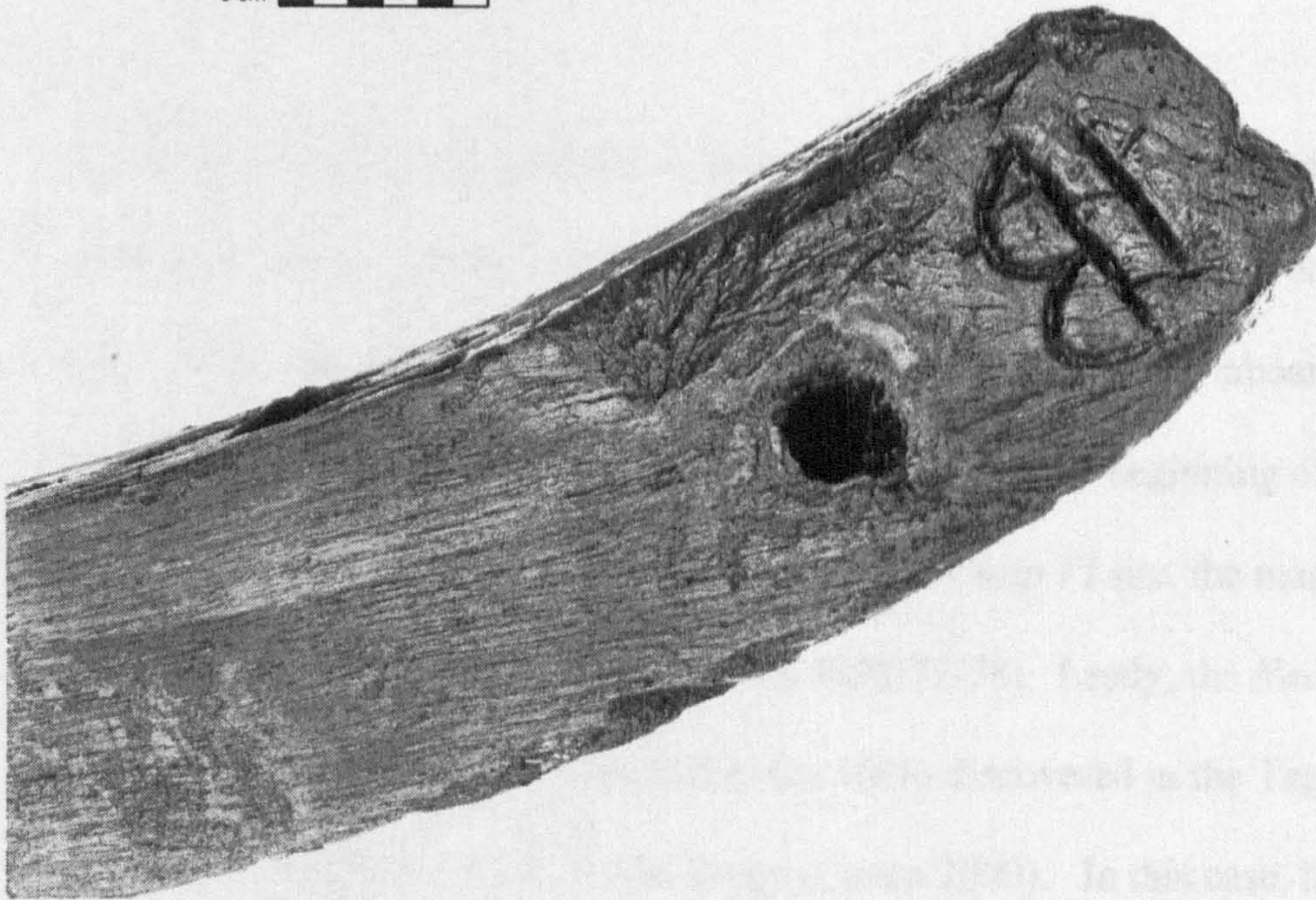
**Figure 3-61:** Marks at the starboard end of futtocks Photograph by George Vandervlugt.



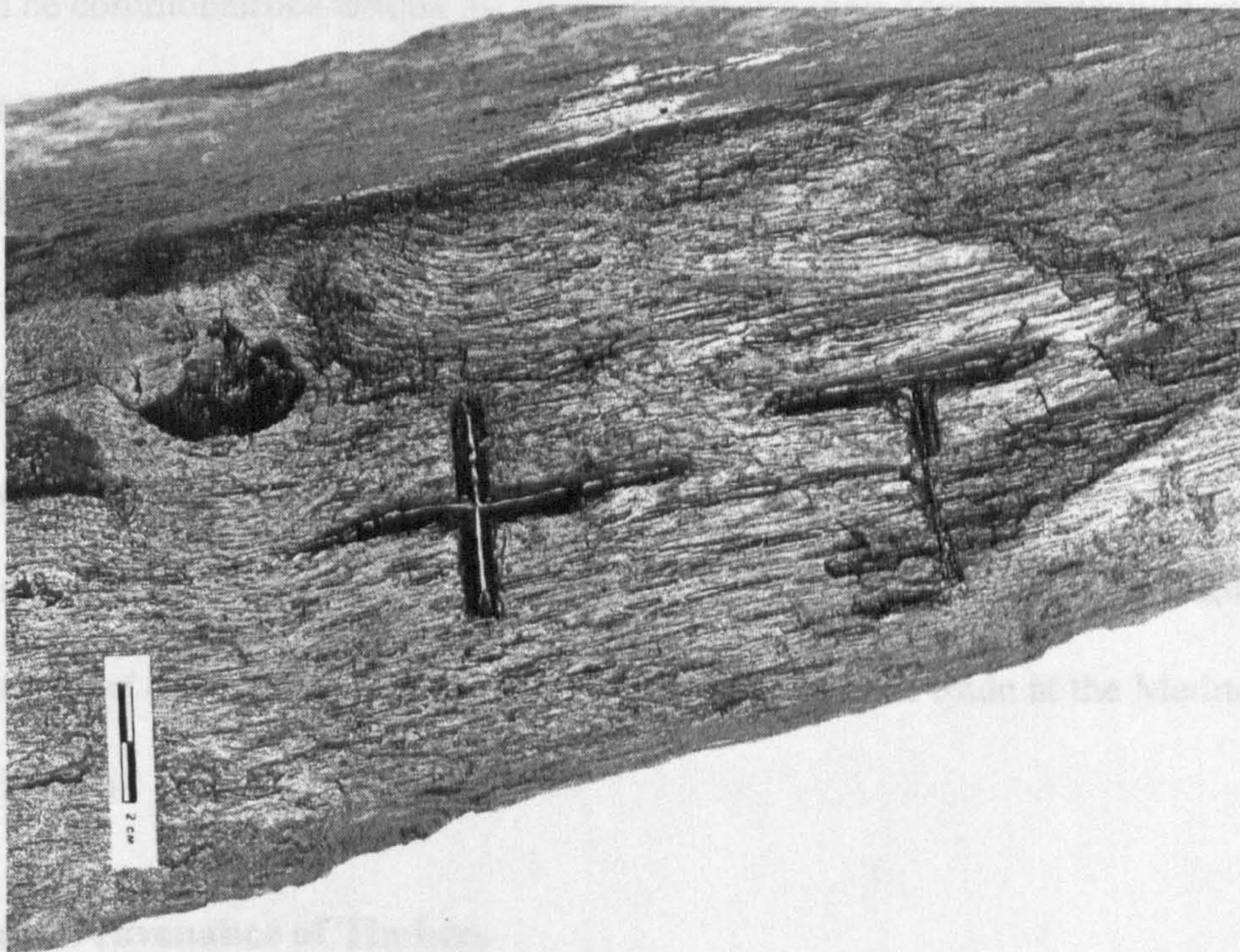
**Figure 3-62:** Marks at the port end of the futtocks. Photograph by George Vandervlugt.



**Figure 3-63:** Marks at the port end of forward floors. Photograph by George Vandervlugt.



**Figure 3-64:** Marks at the port end of aft floors. Photograph by George Vandervlugt.



**Figure 3-65:** Stylized numbering on frames. Photograph by George Vandervlugt.

floor was also marked, but with the Roman numeral I rather than with an asterisk (Rieth 1996:153-154).

The *Ria de Aveiro A* wreck, dating to the mid-15th century, also had frames that were engraved (Alves et. al., 2001:21-22). In this case the markings appeared only on three frames; the forward face of frame 12, the aft face of frame 5 and the inboard face of frame 15. The *Cais do Sodré* wreck, dating to the end of the 15<sup>th</sup> or beginning of the 16<sup>th</sup> centuries, also exhibited marked frames and, similar to the *Culip VI* site, the master-floor was marked with the Roman numeral I (Rodrigues 1998:72-78). Lastly, the *Nau Nossa Senhora dos Mártires*, an early 17<sup>th</sup>-century ship (ca 1605) discovered in the Tagus River, Portugal, exhibited Roman numerals on the floors (Castro 2000). In this case, however, the numerals were inverted and all appeared only on the surface that faced the bow (Alves et. al.1998:205).

The commonalities among all of these sites are their Mediterranean/Iberian ship building roots. Because both Oliveira and Lavanha, with their intellectual roots in these areas, mentioned this custom, it is further support that this was a regional-specific practice. The clearly Mediterranean origins of *Culip IV*, with its early date, and the Iberian construction of *Nau Nossa Senhora dos Mártires* (ca. 1605) argue strongly for the transference of this practice to the Atlantic and to the shipwrights of France. The appearance of numbers on *La Belle*'s frames, therefore, comes as no surprise considering the elder Mallet and many of his contemporaries learned their trade at the Mediterranean port of Toulon.

### **Reuse and Provenance of Timbers**

Examination of the timbers from *La Belle* for unambiguous evidence of reuse did not produce the expected evidence in the form of tool marks. Many of the timbers exhibit a very smooth finish on their forward and aft faces. This finish is so smooth that virtually no tool marks are visible. However, the presence of this finish is hardly conclusive evidence of reuse. The dendrochronological results, discussed elsewhere, suggest that timbers from other sources were used in the ship's construction. Given these two apparent contradictions in the evidence, it is prudent to consider two other avenues to evaluate the possibility of reuse: the physical characteristics of the timbers and the presence of unused or aberrant fastenings or fastening patterns.

### **Physical Characteristics**

It is generally assumed that most timbers on a ship, particularly those comprising the floors and futtocks, are as similar as hand crafting will allow, considering the

necessary changes in length and molded dimension. A pronounced disparity in their physical characteristics might, therefore, shed light on reuse. Because of the necessary change in the floors on the molded face, only the sided dimensions were examined. Each frame component was measured on its outboard face in the recognition that it was the least damaged through wear and tear. Also considered were the effects of iron oxidation, impregnation, and exfoliation of the wood on the inboard face and the potential impacts of excavation and dismantling. Floors were measured at their centerline, while futtocks were measured in at least two places where no erosion or waney wood was present. The results of this examination appear in Figure 3-66 in which shaded areas represent timbers selected for dating.

**Figure 3-66: Sided Dimensions of Floors and Futtocks**

<b>Frame Position</b>	<b>1<sup>st</sup> Futtock Port</b>	<b>Floor</b>	<b>1<sup>st</sup> Futtock Starboard</b>	<b>2<sup>nd</sup> Futtock Starboard</b>	<b>3<sup>rd</sup> Futtock Starboard</b>
12 Fwd		20cm			
11 Fwd	17cm	17cm	13cm	n/a	
10 Fwd	12cm	17cm (1624)	12cm	14cm	
9 Fwd	14cm (1616)	13cm	14cm	13cm	14cm
8 Fwd	15cm	15cm	15cm	13cm	12cm
7 Fwd	14cm	15cm	15cm	14cm	14cm (no date)
6 Fwd	14cm	17cm	14cm	15cm	14cm
5 Fwd	11cm (1663)	13cm	12cm	13cm	12cm
4 Fwd	13cm	17cm (1676)	13cm	13cm	13cm
3 Fwd	13cm	17cm	14cm	13cm	13cm
2 Fwd	12cm	16cm	13cm	15cm	13cm
1 Fwd	12cm	16cm	14cm	12cm	13cm
Master Frame	fwd 14cm		fwd 14cm (1623)		fwd 15cm (1474)
	aft 13cm	16.5cm	aft 13cm	14cm	aft 13cm (1481)
1 Aft	13cm	16cm	13cm	14cm	12cm



Frame Position	1 <sup>st</sup> Futtock Port	Floor	1 <sup>st</sup> Futtock Starboard	2 <sup>nd</sup> Futtock Starboard	3 <sup>rd</sup> Futtock Starboard
2 Aft	12cm	15cm (1632)	12cm	12cm (1641)	13cm
3 Aft	14cm	16cm	14cm	13cm	13cm
4 Aft	13cm	16cm	13cm	12cm	13cm
5 Aft	12cm	16cm	13cm	13cm	13cm
6 Aft	14cm	16cm	13cm	13cm	15.5cm
7 Aft	13cm	16cm	14cm	13cm	13cm
8 Aft	13cm	15cm	15cm	13cm	12.5cm
9 Aft	13cm	16cm	14cm	15cm	14cm
10 Aft	13cm	15cm	14.5cm	15cm (1618)	
11 Aft	13.5cm	17cm	14cm	12cm (1560)	
12 Aft		17cm	13.5cm	13.5cm	
13 Aft	14cm	17cm	12cm	12cm	
14 Aft	13cm	17cm	12.5cm		
15 Aft		17cm			
16 Aft		16cm (1531)			
17 Aft		n/a			

n/a = timber too eroded to obtain measurement; shaded area = sampled for dendrochronological dating; ( ) = dating result

Two details emerge from a perusal of Figure 3-66: the most prevalent sided dimension of the futtocks is 13 cm and the most prevalent sided dimension of the floors is 16 cm. The only exceptions to the latter are the deep floors aft at frame positions 12-16 (position 17 is the fashion frame) and 10-11 forward, which are all 17 cm (position 12 forward is an exception). With regard to the futtocks, timbers having a sided dimension of 14 cm are nearly as numerous as those with a 13-cm dimension. It appears that the shipwrights intended the futtocks to be either 13 or 14 cm sided and the floors 16 cm sided, with the exception of the deep floors, which they intended to be 17 cm. The regularity of these dimensions makes those that are greater or less all the more obvious.

Four floors were sampled for dendrochronological analysis, they are at 2 aft, 16 aft, 4 forward, and 10 forward. The floor at 2 aft has a sided dimension of 15 cm. This timber (sample BDD2812) has a latest estimated felling date of 1632. The next sampled timber is a floor at frame position 16 aft, which has a sided dimension of 16 cm. This timber (sample BDD2817) has a latest estimated felling date of 1531. The sampled floor at frame position 4 forward has a sided dimension of 17 cm. This timber (BDD2805) has a latest estimated felling date of 1676. The last sampled floor is at 10 forward; this timber has a sided dimension of 17 cm. This timber (sample BDD2802) has a latest estimated felling date of 1624.

Of the 29 floor timbers, only 8 have a sided dimension different from 16 or 17 cm. Of that number, 5 floors have a sided dimension of 15 cm: frame positions 7 and 8 forward, and 2, 8, and 10 aft. That one of them dates to 1632, well prior to the construction of the ship, is at least notable. Two floors, both forward at frames 5 and 9, have sided dimensions of only 13 cm. If the deep V-shaped floors were the only ones that were intended to have a sided dimension of 17 cm, as is suggested by the measurements in Figure 3-66, then the appearance of floors of that size at frames 3, 4 and 6 forward are clearly anomalous. This also suggests that a 16-cm dimension for the floor at 16 aft may also be atypical, particularly when its 1531 felling date is considered. Similarly atypical is the floor at 12 forward with a 20-cm sided dimension.

Three first futtocks were sampled that are located at 5 and 9 forward on the port side, and the forward futtock on the starboard side of the master frame. The timber at 5 forward is sample BDD2796 and was felled about 1663. The timber at 9 forward is sample BDD2800 felled around 1616. Lastly the timber at the master frame is sample BDD2799 and has an estimated felling date of 1623.

**PAGE**

**NUMBERING**

**AS ORIGINAL**

Frame Position	1 <sup>st</sup> Futtock Port	Floor	1 <sup>st</sup> Futtock Starboard	2 <sup>nd</sup> Futtock Starboard	3 <sup>rd</sup> Futtock Starboard
Master Frame	fwd 14cm 3	16.5cm 3 / 3	fwd 14cm 3 / 3 (1623)	14cm 3 / 2	fwd 15cm 2 (1474)
	aft 13cm 1		aft 13cm 1 / 1		aft 13cm 1 / 1 (1481)
1 Aft	13cm 3	16cm 3 / 3	13cm 3 / 2	14cm 2 / 2	12cm 2
2 Aft	12cm 3	15cm (1632) 3 / 3	12cm 3 / 3	12cm (1641) 3 / 2	13cm 2
3 Aft	14cm 3	16cm 3 / 3	14cm 3 / 3	13cm 3 / 2	13cm 2
4 Aft	13cm 3	16cm 3 / 2	13cm 2 / 2	12cm 2 / 2	13cm 2
5 Aft	12cm 2*	16cm 2 / 2	13cm 2 / 2	13cm 2 / 2*	13cm 2*
6 Aft	14cm 3	16cm 3 / 3	13cm 3 / 3	13cm 3 / 2	15.5cm 2
7 Aft	13cm 3	16cm 3 / 3	14cm 3 / 2	13cm 2 / 2*	13cm 2*
8 Aft	13cm 3*	15cm 3* / 3	15cm 3 / 2	13cm 2 / 2*	12.5cm 2*
9 Aft	13cm 3*	16cm 3* / 3	14cm 3 / 2	15cm 2 / 2*	14cm 2*
10 Aft	13cm 2*	15cm 2 / 2	14.5cm 2 / 2	15cm (1618) 2 / 2*	
11 Aft	13.5cm 3*	17cm 3* / 3	14cm 3 / 2	12cm (1560) 2 / 2*	
12 Aft	3*	17cm 3* / 3	13.5cm 3 / 2	13.5cm 2 / 2*	
13 Aft	14cm 2*	17cm 2* / 2	12cm 2 / 2*	12cm 2*	
14 Aft	13cm 2*	17cm 2* / 2*	12.5cm 2*	2*	
15 Aft		17cm 2* / 2*			
16 Aft		16cm (1531) 2* / 2*			
17 Aft		2* / 2*			

\* = presumed original number of fasteners; shaded area = dendrochronological analysis and dating; ( ) = dating result

As previously noted, the model for the fastener configuration is found at the master frame, three fasteners up to the level of the second to third futtock scarf where it changes to two fasteners. Aft of the master frame, those frames that deviate from this pattern appear at stations 1, 2, 4, 5, and 10.

At each station where there is a deviation in either fastener pattern or dimension, the question must be: What prompted the change? One plausible answer is to incorporate used timbers and the second is to avoid drilling new holes. This latter eliminated extra work on already seasoned timbers, which are notoriously hard to work with, and prevent its possible weakening. At station 1 aft both of these hypotheses work if the second and third futtocks on the starboard side were used timbers already drilled with only two holes. If the floor and first futtock were new timbers, then it would be an easy matter to drill the standard three holes for that scarf, then drill two holes in the upper end of the first futtock to match the existing holes in the second futtock. The fact that the sided dimension of the third futtock is only 12 cm, which is narrower than average, and that only one other second futtock aft is 14 cm, is also highly suggestive of timbers with a different provenance.

The frame at station two is an anomaly not because of its fastener pattern, but because of the smaller than average sided dimensions of the floor and futtocks. By chance, two timbers from this frame set were sampled for dendrochronological analysis and dating. The resulting dates of 1632 and 1641 are so close that they can be assumed to be statistically identical. In combination with the physical deviation, this argues strongly for reuse of this frame set at least up to the level of the third futtock.

The floor at station four aft is an anomaly for two reasons: its fastener pattern and its smaller than average sided dimensions of a second futtock. The floor of this frame is

the only example that has an unequal number of fore and aft fasteners on each arm and the second futtock is only 12 cm sided. This combination raises the question of mixed reuse of these timbers, similar to that postulated for the frame at one aft. If the used timbers are the starboard side first and second futtocks, based upon the two fastener pattern and a smaller sided dimension of the second futtock then, in order to complete the frame, a new floor and port side futtock was necessary. If the three-fastener pattern described by Ollivier was the emergent standard at the time of *La Belle's* construction, which seems the case, then drilling the starboard arm for only two fasteners and the port arm for three fasteners makes perfect sense.

The frames at 5 and 10 aft are atypical because of the two-fastener pattern used throughout and for the larger and/or smaller sided dimensions of several of their timbers. The strong possibility of reuse of these frames is further supported by the 1618 date of the second futtock at frame 10.

The reuse of the second futtock at 11 aft and the floor at 16 aft is also a probability, but only because of their anomalous sided dimension and dating, not their fastener pattern. Reuse is a possibility for three of the timbers in the frame at 8 aft and the third futtock at 6 aft because of their sided dimension.

Forward of the master frame, the completely different dominant fastening pattern raises several questions regarding reuse of timbers. Because many of the timbers have a two-fastener pattern, the appearance of a three/two pattern leaps out as an anomaly. Further, because the pattern appears on the frames at three and nine forward and not on six, it is even more puzzling. It seems that the intention of the builders was to use the three/two fastener pattern at frames three, six and nine forward just as they had aft. The

execution, however, required some adjustment both in the number of fasteners and the sizes of the timbers used.

The fastener pattern at frame three is the same as the master frame. What is unusual about this frame is the 17-cm sided dimension of the floor. This is unlike the aft frames where the floors are clearly intended to be 17 cm from frame 11 aft and the forward frames where they are 17 cm beginning at station 10. In fact, 5 of the 12 floors forward are 17 cm, but only two of these appear in the deep V-shaped floors. Is the appearance of 17 cm an indication that this floor, or indeed this frame, is a replacement?

The frame at six forward is anomalous because it does not follow the three/two pattern and because it has heavier than normal sided dimensions for its floor (17 cm) and second futtock (15 cm). This frame also includes the only first futtock with a two/three fastener pattern for the floor to first futtock and the first to second futtock on the starboard side. If the second futtock was a replacement and the desire to maintain three fasteners at the first to second futtock scarf was deemed critical, then drilling an extra hole at that location clears up the mystery. This hypothesis is supported by the distance between the holes in this timber and the distance between the holes on other timbers forward. The distance between the two fasteners at frames 7, 8, and 10 forward is 70 cm. The distance between the two outer fasteners on frame 6 is 70 cm. Directly in the middle, at 37 cm, the hole for the third fastener was drilled.

The frame at nine forward returns to the fastener configuration present on the master frame and at station three forward. This reinforces the special role that the frames at every third station, both forward and aft played in the construction of *La Belle*. What makes this frame unusual, however, is the sided dimension of its floor at only 13 cm.

This is the narrowest floor in the entire ship, furthermore, the first futtock on the port side dates to 1616.

The regularity of the fastening pattern forward, other than noted above, makes the irregularity of the sided dimensions of the timbers even more puzzling. In combination with statistically sound dendrochronology dates ranging from 1616 to 1676, it raises the potential for many used and/or replacement timbers. Given the high state of activity at Rochefort with many different types and sizes of ships being built, it is reasonable to assume that the heavier-than-average floors in *La Belle* were only that, heavier-than-average for this application, but a stock size for ship construction in general. This would also apply to the heavier-than-average futtocks, a good example of which appears in frame 8 forward and on the port side at 11 forward. The same reasoning applies to the narrower-than-average dimensions. The use of stock-sized timbers is further supported because the larger or smaller sided dimension does not follow a time curve, i.e., the dating result is not earlier for the narrowest timbers. The builders simply used timbers, and indeed whole frames, of the right general shape and molded dimension in combination with judicious reuse of existing timbers.

### **Rebuilt Versus New Ship**

The differences in the fastening patterns, the results of the dendrochronological dating, and the varying sided dimensions of the timbers, all point to a ship that was not a built-from-scratch or “new” ship made to order for the expedition. Rather, it may have been a ship so extensively rebuilt that it was considered a new ship in the French system. Fortunately, Ollivier (1737:171) elaborated on the differences between the French and English practices for the repair (*radoub*) and rebuild (*refonte*) of ships.



In France, there were two kinds of repair: those carried out while the ship was still afloat and those undertaken in dry dock, the latter of which Ollivier (1736:287) found to be the better, more efficient method when extensive repairs were required. Repairs undertaken while afloat even included the replacement of frame pieces. By contrast, repairs in England were of three categories, small, medium, or great, depending on the cost. Ollivier noted that the English carried out their repairs in dry dock often without removing the ballast or masts and

. . . are content to shift all the planking below the water line that the caulkers find at fault, to eke the forward and aft riders with lower and upper futtocks, and to increase the number of standards on the gundeck . . . to bring the ship to a condition in which she will last a few more years, and indeed nearly as long as our own ships last after a rebuild, which costs more than building a new ship (1737:171).

However, when the English found that the removal of frames was necessary, they broke up the ship “. . . because the cost of such a repair exceeds that of building anew . . .”, that is, a rebuild (Ollivier 1737:171).

A rebuild in France meant “. . . to change all the pieces or most of the pieces of which an old vessel is composed and that are spoiled . . .” and this work was only carried out in dry dock (Ollivier 1736:289). In comparing the practice of rebuilding in England, Ollivier noted that the English definition of a rebuild was so loose that it included ships broken in one port and built several years later in another and may not even include original timbers. According to Roberts, this was a surprise to Ollivier because this sort of practice was considered building a new ship in France (Roberts, in Ollivier 1737:35).

Ollivier (1737:171) further stated that the English “. . . preserve here with great care all their old ship-timbers and find a useful purpose for each timber, whether to build the dockyard buildings, or to line the sides and building platforms of their docks . . . ”

This latter remark suggests that he was not surprised at the reuse of ship timbers, and quite possibly implies that this is a different use than by the French, although he does not state so specifically. Perhaps what is implied by Ollivier's remarks is that when a French ship was broken up everything still of use was recycled into another ship rather than used in general construction.

From a technical standpoint, the French practice of assembling frames with bolts meant that when breaking a ship apart the frames held their shape. In a rebuild, no matter how extensive even to the point of shifting frames into a completely different ship, their shape was not altered, nor would they require disassembly and reassembly, only some dubbing and slight adjusting to fit. That would account for the differences in the sided dimension of the forward timbers.

The reason the dating results from *La Belle*'s timbers span such a long period may have as much to do with the life span of ships as the French practice of recycling timbers. Pierre Le Conte compiled a list of French naval ships between 1648 and 1700 in which he provided a date of construction and a date of loss, capture, and decommissioning. The average life span of the ships noted as decommissioned from the largest battleships of 1000 tons to the smallest sloops and galleys of 25 tons, was 22 years (Le Conte 1935). The list included nearly 1000 ships in this period and so is a reasonable indicator of their useful life.

Another factor that must be taken into account when evaluating whether *La Belle* was a new or rebuilt ship is the delay between tree felling and construction, that is, the period of drying or storage. At the Rochefort yard timbers were stored in covered sheds until needed. Szepertyski (1999:4) pointed out a commonly held but a mistaken notion that "the son uses wood from his grandfather." In fact, in furniture construction, carving

of statuary or works of art, painted panels, and other similar endeavors, “. . . from a technological standpoint it is well known that fresh wood is more workable than dry” (Szepertyski 1999:4). Some notable exceptions to this rule exist. In the manufacture of casks, the accepted period of drying in the 20<sup>th</sup> century can be up to two years before construction (Brad Loewen, pers. comm. 2000).

By inference from Ollivier’s remarks, however, timbers of more recent harvest were preferable for ship construction. Yet Ollivier (1737:54) also noted at the Deptford yard in England that, “The plank is stacked with great care under cover and seems to be timber of old felling, sawn already long since and very dry.” His comment on the Woolwich yard mirrors that from Deptford, “Plank is stacked under cover with great care . . .”(Ollivier 1737:54, 74). However if the stacking were aimed at drying or seasoning before use, then Ollivier’s comment about the Chatham yard suggests another possibility; “I saw in Chatham a large pond . . . in which are immersed several timbers which have already been worked for frames” (Ollivier 1737:102). Presumably the practice was aimed at keeping the timbers from drying and therefore making them easier to modify.

It seems highly unlikely that trees felled well prior to their first use were left about and then sawn to shape. Rather, they would be worked when reasonably fresh because doing so was easier. By inference, drying time would be limited to that period from the time of felling to arrival in the shipyard, which could be up to one year, followed by an interval before use. Drying the timbers for the sake of doing so should not be a factor when considering a date of construction because it is likely to be within a year to 18 months of felling. For timbers from *La Belle*, if the dating of the samples is accurate, then reuse of already shaped timbers rather than first use of old trees or old timbers that were only roughly shaped makes more sense.

One last piece of evidence that further supports the hypothesis that *La Belle* was an extensively rebuilt ship is the statistically strong dating results from timbers other than its frames. The lower stringer on the starboard side dates to 1565, the main mast partner on the starboard side dates to 1664, and the main mast buttress on that same side dates to 1649. One of the two ceiling planks sampled dates to 1613, one of the two hull planks sampled dates to 1647, and the central section of the keelson dates, however tentatively, to 1516. The mixing of old and new timbers is amply demonstrated by the aft section of the keel, a second ceiling plank, a hull plank, and the main mast filler, all of which date to 1683. If *La Belle* were a completely new ship, rather than an extensively rebuilt one, then more of the timbers should have dated to the few years just prior to its construction.

### **Implications of Reused Timbers**

Accepting the notion that *La Belle* was an extensively rebuilt ship has other implications. The first is that because rebuilding meant “. . . to change *all the pieces or most of the pieces of which an old vessel is composed* [emphasis added] . . .”(Ollivier 1736:289) a rebuild was probably faster than starting a new ship from scratch. As discussed extensively elsewhere, there was a great deal of pressure brought to bear by Seignelay and the King to get La Salle’s expedition underway quickly. At Rochefort, both Arnoul and Du Mont were actively seeking a swift solution to the problem they faced in complying with this demand. Completion of a ship already undergoing extensive rebuilding was the answer.

Second, a ship with an existing older method of hull design, discussed in detail elsewhere, is more likely to be easily blended with new timbers in a ship that is being extensively rebuilt. Bear in mind that *La Belle* was originally projected for Rochefort’s

Intendant (refer to Chapter II). To build a new ship for this purpose might be frowned upon, but rebuilding an old ship might be accomplished with few objections and less capital outlays. The English used this tactic when they had limited budgets for the building of new ships (Lavery 1983:64 et seq.). That a rebuild resulted in what was considered a new ship was so much the better.

Lastly, from a purely practical standpoint, the numbering of frames and each of their component elements can aid in the rapid assembly or rebuilding of ships. This is particularly true in a large busy yard with craftsmen that are predominantly illiterate. Unfortunately, there is no way to determine when the keel and frames were numbered, although several frame elements did exhibit damage to their numbers other than through deterioration. If, however, the new timbers were marked together with their component pieces as the ship was being rebuilt and replacement frames selected, they could be moved from the pre-assembly area to the “new” ship with minimal confusion and delay.

## Chapter IV. Species Identification and Dendrochronological Analysis

### Introduction

By the time *La Belle* was built in 1684, France's naval service was well on its way to being transformed into an important arm of the French empire. However, its shipbuilding industry still suffered from nearly three centuries of haphazard administration (Bamford 1955, 1956). Further, unsuitable French forestry management practices forced the import of foreign timber to improve the quantity and quality of the ships being built. In a calculated move by Jean-Baptiste Colbert to quickly create a large Navy, shipwrights from Copenhagen, Glückstadt, and Göteborg worked with French shipwrights, trained in the newest techniques, incorporating imported timbers into French ships in both French and foreign yards (Acerra 1993 III; Rieth 1998). The import of timbers, the import of craftsmen, and the training of French master shipwrights would eventually have profound effects on French shipbuilding. It was into this period of tremendous expansion, shipbuilding creativity, and want for suitable timbers that *La Belle* was conceived and built.

Because there was widespread importation of timber for the French marine in the late 17<sup>th</sup> century, two of the goals of this research were to obtain species identification and to identify the origin of the timbers used in *La Belle*. Dendrochronology, widely used for dating purposes, focused on determining origin in this study because the date of the site is

not in question. Wood origin is an important avenue of research because the location of the forests from which wood was logged for shipbuilding at Rochefort is unknown.

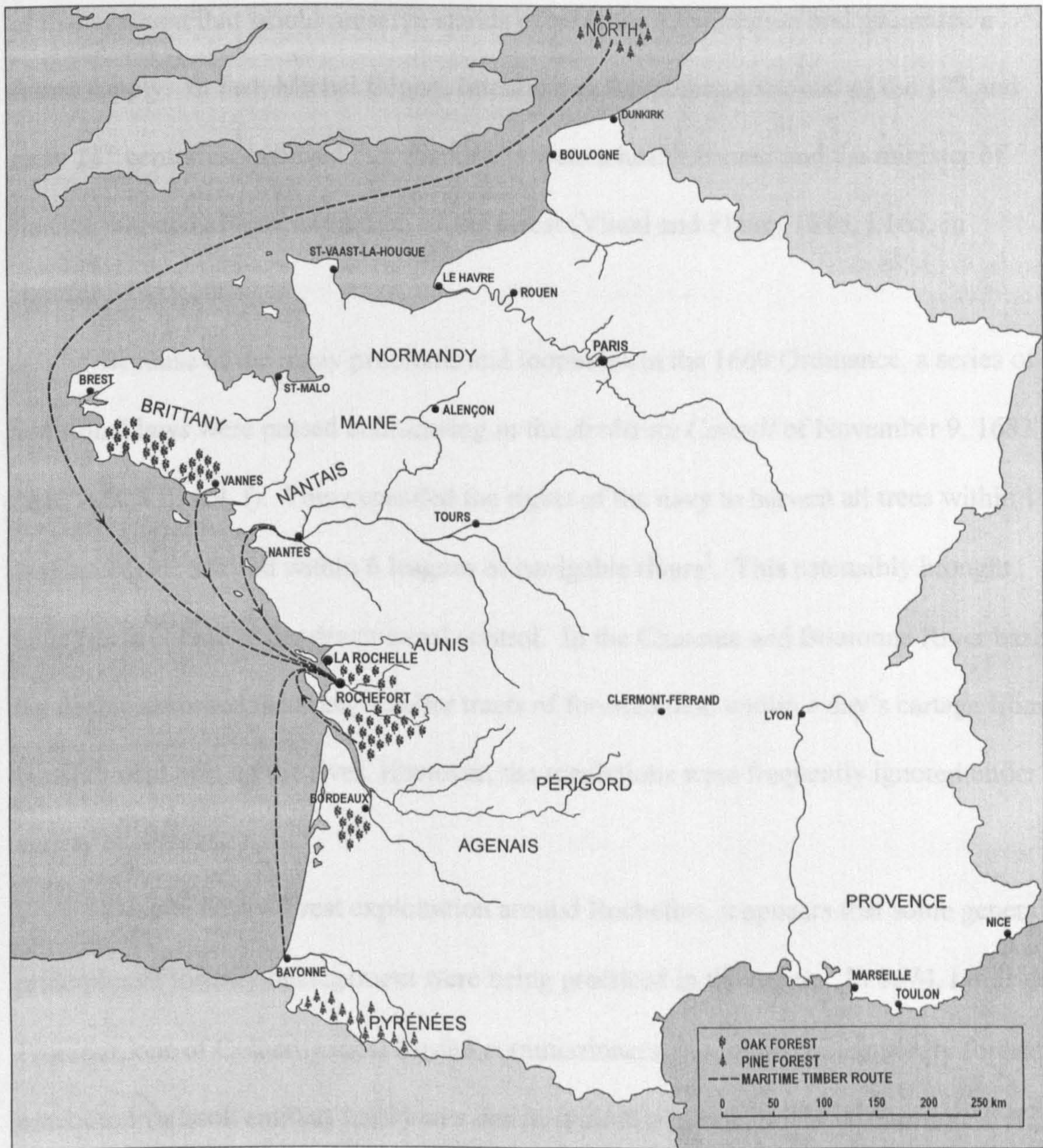
When combined with the information from species identification, dendrochronology can provide a more detailed picture of forest exploitation both locally and regionally.

Furthermore, because there are no other investigated late 17<sup>th</sup>-century shipwreck sites from the Rochefort region that have undergone these analyses, the data from *La Belle* can contribute greatly to shipbuilding research.

### **Rochefort Arsenal Timber Supply**

It is known that the naval yard at Rochefort received timbers imported from Norway, Russia, and Germany, while the domestic forests of Bretagne, Bordeaux, and the Pyrenees also provided some of its needs (Acerra 1993 III; Bamford 1956 ) (Figure 4-1). In addition, timber stockpiling at three of the royal shipyards was seen as desirable to ensure a steady supply for shipbuilding. Colbert ordered the build-up of supplies sufficient for the construction of four, then ten ships-of-the-line, but the expansion of the fleet and timber shortages acted to limit accumulation of large reserves (Colbert III:236, in Bamford 1956:33).

Of the three major shipyards (Toulon, Brest and Rochefort), the naval shipyard at Rochefort was in a particularly advantageous position because it was located at the end of a tributary that could directly supply timber from its inland provinces. The Charente River, and its smaller tributary the Boutonne River, both supplied Rochefort and were heavily exploited in the years following establishment of the arsenal. Although the 1669 *Ordonnance des eaux et forêts* (AN, Series Archives Diplomatique (AD), VII, vol. I) was



**Figure 4-1:** Domestic and imported timber into Rochefort 1660-1714 (after Acerra 1993, III:527). Drawing by Marie-Andrée Marchand.

to be applied nationwide, in fact it was resisted vigorously in some regions and not applied at all in others. The forests of Rochefort were entirely excluded from the Ordinance scheme until 1702 (Viaud and Flourey 1845, I:165, in Bamford 1955:100).

Thus, for more than 35 years naval officials raided the forests without regard to a system



of management that would preserve stands of trees for reforestation and guarantee a future supply. In fact, Michel Bégon, Intendant at Rochefort at the end of the 17<sup>th</sup> and early 18<sup>th</sup> centuries, believed that the forests were a health hazard and the minister of finance authorized total extinction of the forest (Viaud and Flourey 1845, I:165, in Bamford 1955:100).

Because of the many problems and loopholes in the 1669 Ordinance, a series of additional laws were passed culminating in the *Arrêts du Conseil* of November 9, 1683 (AN, AD, VII, vol. I). This expanded the rights of the navy to harvest all trees within 15 leagues of the sea and within 6 leagues of navigable rivers<sup>1</sup>. This ostensibly brought huge tracts of land under direct naval control. In the Charente and Boutonne River basins the decree absorbed the many smaller tracts of forested land within a day's cartage from a transshipment port on the river. However, the regulations were frequently ignored under a variety of pretexts.

Despite heavy forest exploitation around Rochefort, it appears that some general principles of forestry management were being practiced in the region. In 1674, Louis de Froidour, one of Colbert's most trusted commissioners, described contemporary forestry practices in a book entitled *Les Ventes des Bois du Roy* (Reed 1954:43). Froidour recommended that forests be planned and managed with an understanding of the problems of transport and the nature and proximity of the most suitable market. Coppice, that is trees that were cut according to a regular system of felling and allowed to sprout again from the old stumps, should be located on the periphery of the forest and cut

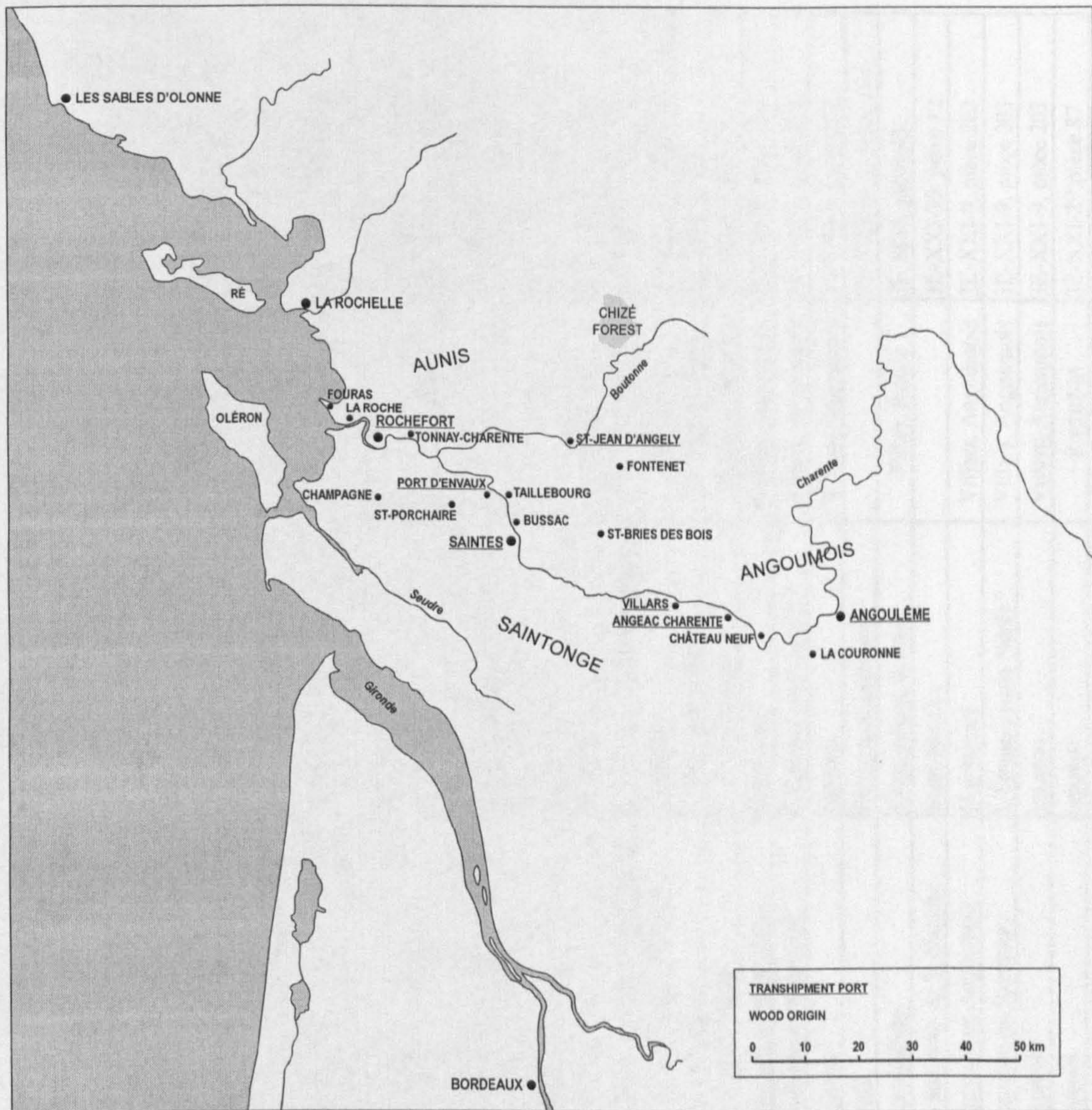
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<sup>1</sup> The common league at the time of Colbert was 4.8 km (roughly 3 miles). The protected zone under this ordinance was 72 km from the sea and 28 km from navigable rivers.

according to a 15 to 30-year cycle. Areas of natural regeneration should be located well away from the forest margins and chosen for the quality of the soil. High forest should contain trees between 50 and 150 years of age with a minimum of 8 to 10 standards per acre left untouched. Standards were healthy trees that would, through natural processes, drop seeds and thus regenerate and maintain the forest (Reed 1954:37, 43-44). Later that number was increased to 20 trees per acre. This program of rotational cutting was important in order to ensure that trees of sufficient age and suitable size for shipbuilding were available.

The practice of developing forests in small valleys near rivers described by Froidour is depicted in several maps of the period. These maps clearly illustrate small land holdings most less than  $\frac{1}{2}$  league long and  $\frac{1}{4}$  league wide (2.4 km by 1.2 km wide) scattered throughout the river valleys of France (Service Historique de la Marine 1997:39-41, 43-46). A survey of the notarial archives at La Rochelle and Rochefort for the years 1670-1700 mirrors this pattern of small land holdings in the Charente and Boutonne River basins, which directly served the arsenal at Rochefort. These tracts, very localized and smaller than a square mile (1.6 km<sup>2</sup>), appear as place names in the numerous timber contracts (Figure 4-2). The town and hamlets identified in this process represent both small land holdings and river transshipment points. Because some of these place names were difficult to identify, even with the most detailed regional maps, it further supports their small size and extremely localized nature.

The timber contracts also provide information about the nature and use of wood brought to Rochefort during the 30-year period from 1670-1700, when exploitation of the local forests was unhindered by ordinances for its protection (Figure 4-3). Of the 101



**Figure 4-2:** Place Names of Transshipment Points in the Charente and Boutonne River Basins 1670-1700. Drawing by Marie-Andrée Marchand.

contracts identified, 63 were unequivocally for marine use. Of the 63 that were for marine use, 14 were for masting timber. Six of the contracts were for masts from the Baltic, six were for masts from the Pyrenees, and two did not specify a location. This reflects the emphasis on using fir from the Pyrenees during this period. Of the 46 remaining marine timber contracts, only 7 were for timber from outside the immediate Rochefort region, again indicating the emphasis on the use of local oak for shipbuilding.

**Figure 4-3: Timber Contracts and Wood Sources 1670-1700, Rochefort**  
(After Allaire 1998:E1-E4)

Dénomination	Variété	Usage	Mention du lieu d'origine	Localisation actuelle	Vendeur ou transporteur	Références (ADCM et autres)
baux	non préciser	charpenterie navale	Fressiere en Angoumois	[à préciser]	Villars, Angoumois	3E-XXI-9:pièce 203
baux	non préciser	charpenterie navale	Lepinau en Saintonge	L'Épinaux (près Néré) ?	Villars, Angoumois	3E-XXI-9, pièce 203
baux	non préciser	charpenterie navale	Monbergere paroisse de Villars	[plusieurs possibilités]	Villars, Angoumois	3E-XXI-9, pièce 203
bois	peuplier	"pour la Marine"	inconnu	inconnu		3E-XXI-26: pièce 19
bois	non préciser	pour vaisseaux du roi	inconnu	inconnu		3E-XXI-27: pièce 218
bois	chêne	construction-radoub	forêt de Vuzain(?)	[à préciser]	Rochefort	3E-XXI-25, pièce 79
bois	non préciser	charpenterie navale	Bordeaux	Bordeaux		3E-XXI-28: pièce 155
bois	non préciser	charpenterie navale	La Briandière près Fontenay	Richardière près Fontenet ?		3E-XXI-28: pièce 155
bois	non préciser	charpenterie navale	La Chapelle-Bertrand	La Chapelle-Bertrand		3E-XXI-28: pièce 155
bois	non préciser	charpenterie navale	Casagnets proche de Blaye	Blaye, Gironde		3E-XXI-28: pièce 155
bois d'équarrissage	chêne	charpenterie navale	inconnu	inconnu	Rochefort	3E-XXI-29:pièce 87
bois haute futaie	non préciser	pour vaisseaux du roi	Château et paroisse de Bignay	Bignay près St-Jean-d'Angely	Tonnay-Charente	3E-XXI-25, pièce 60
bois haute futaie	non préciser	pour vaisseaux du roi	Champagne en Saintonge	Champagne	Rochefort	3E-XXI-25, pièce 76
bois torts	non préciser	charpenterie navale	forêt de Chizé	Chizé, Deux-Sèvres	St-Jean-d'Angely	3E 1835, f. 202
bois torts	non préciser	charpenterie navale	St-Jean-d'Angely	St-Jean-d'Angely	St-Jean-d'Angely	3E 1835, f. 202
bordage	non préciser	charpenterie navale	Fressiere en Angoumois	[à préciser]	Villars, Angoumois	3E-XXI-9, pièce 203
bordages	non préciser	charpenterie navale	Lepinau en Saintonge	L'Épinaux (près Néré) ?	Villars, Angoumois	3E-XXI-9, pièce 203
bordages	non préciser	charpenterie navale	inconnu	inconnu	Villars, Angoumois	3E-XXI-9, pièce 203
bordage	non préciser	charpenterie navale	Nord	Baltique-Scandinavie		3E-XXXIV-1, pièce 154
bordages	non préciser	charpenterie navale	Koenigsberg	Koenigsberg, Russie	Pillau, Russie	3E 1835, pièce 43
bordages	non préciser	pour la réfection des fosses aux mâts de St-Nazaire	pour la réfection des fosses aux mâts de St-Nazaire	Saint-Nazaire		3E-XXI-25: pièce 12
courbes	non préciser	charpenterie navale	Fressiere en Angoumois	[à préciser]	Villars, Angoumois	3E-XXI-9, pièce 203
courses	non préciser	charpenterie navale	Lepinau en Saintonge	L'Épinaux (près Néré) ?	Villars, Angoumois	3E-XXI-9, pièce 203
courbes	non préciser	charpenterie navale	inconnu	inconnu	Villars, Angoumois	3E-XXI-9, pièce 203
estambray	chêne	charpenterie navale	inconnu	inconnu	Rochefort	3E-XXI-29:pièce 87
genoux	non préciser	charpenterie navale	Fressiere en Angoumois	[à préciser]	Villars, Angoumois	3E-XXI-9, pièce 203

Dénomination	Variété	Usage	Mention du lieu d'origine	Localisation actuelle	Vendeur ou transporteur	Références (ADCM et autres)
genoux	non préciser	charpenterie navale	Lespinau en Saintonge	L'Épinaux (près Néré) ?	Villars, Angoumois	3E-XXI-9, pièce 203
genoux	non préciser	charpenterie navale	inconnu	inconnu	Villars, Angoumois	3E-XXI-9, pièce 203
hiloires	chêne	charpenterie navale	inconnu	inconnu	Rochefort	3E-XXI-29:pièce 87
mâts	non préciser	livrées au Havre	Haguesund, Norvège	Haguesund (près Bergen)	navire de Lübeck	ADSM 2E70-256 (1654)
mâts	pin	dans fosse aux mâts	Nord	Baltique-Scandinavie		SHMR 1L3-19 [1682]
mâts	non préciser	pour la Marine	Pyrénées	Pyrénées	livrés à Bayonne	ADPA 3E-4401:5 juillet 1666
mâts	non préciser	pour navire	Nord	Baltique-Scandinavie		3E-XXI-6:(14e doc, à saisir)
mâts	non préciser	pour navire	Suède	à préciser		fonds Marine et Colonies
mâts	non préciser	pour navire	Prusse	à préciser		fonds Marine et Colonies
mâts	non préciser	pour navire	Danemark	à préciser		fonds Marine et Colonies
mâts	non préciser	pour navire	Pyrénées	à préciser		fonds Marine et Colonies
mâts	non préciser	pour navire	Auvergne	à préciser		fonds Marine et Colonies
mâts	pin?	pour navires	des Pyrénées	à préciser	par Bordeaux	SHMR 1L3-19 [1682]
mâts	pin?	pour navires	des Pyrénées	à préciser	par Bayonne	SHMR 1L3-19 [1682]
mâts	pin?	pour navires	des Pyrénées	à préciser	par Bayonne	SHMR 1L3-19 [1683]
mâts	non préciser	pour navires	à la fosse aux mâts St-Nazaire	Saint-Nazaire		3E-XXI-24: pièce 13
mâts	"suiffes ou femelles des sapins"		à préciser	à préciser		ordonnance de 1689
membres	non préciser	vente-achat	La Roche	(plusieurs possibilités)		3E-XXXIV-2, pièce 13
pièces de bois	non préciser	"pour navire"	inconnu	inconnu		3E-XXI-6 (9e doc, à saisir)
planches	sapin	charpenterie navale	Nord	Baltique-Scandinavie		3E-XXI-6: (15e doc, à saisir)
planches	chêne	charpenterie navale	inconnu	inconnu		3E-XXI-6 (18e doc, à saisir)
planches	sapin	charpenterie navale	inconnu	inconnu		3E-XXI-6 (19e doc, à saisir)
planches	sapin	charpenterie navale	Nord	Baltique-Scandinavie		3E-XXI-6 (50e doc, à saisir)
planches	non préciser	charpenterie navale	inconnu	inconnu		3E-XXI-6 (57e doc, à saisir)
planches	sapin	charpenterie navale	Nord	Baltique-Scandinavie		3E-XXI-6 (29e doc, à saisir)
planches	non préciser	charpenterie navale	Nord	Baltique-Scandinavie		3E-XXXIV-1, pièce 154
planches	non préciser	livrées au Havre	Haguesund, Norvège	Haguesund (près Bergen)	navire de Lübeck	ADSM 2E70-256 (1654)
préceintes	non préciser	charpenterie navale	Fressiere en Angoumois	[à préciser]	Villars, Angoumois	3E-XXI-9, pièce 203
préceintes	non préciser	charpenterie navale	Lespinau en Saintonge	L'Épinaux (près Néré) ?	Villars, Angoumois	3E-XXI-9, pièce 203

Dénomination	Variété	Usage	Mention du lieu d'origine	Localisation actuelle	Vendeur ou transporteur	Références (ADCM et autres)
préceintes	non préciser	charpenterie navale	inconnu	inconnu	Villars, Angoumois	3E-XXI-9, pièce 203
revers	non préciser	charpenterie navale	Fressiere en Angoumois	[à préciser]	Villars, Angoumois	3E-XXI-9, pièce 203
revers	non préciser	charpenterie navale	Lespinau en Saintonge	L'Épinaux (près Néré) ?	Villars, Angoumois	3E-XXI-9, pièce 203
revers	non préciser	charpenterie navale	inconnu	inconnu	Villars, Angoumois	3E-XXI-9, pièce 203
serregoutières	chêne	charpenterie navale	inconnu	inconnu	Rochefort	3E-XXI-29:pièce 87
stock de bois	non préciser	"pour la Marine"	inconnu	inconnu	Rochefort	3E-XXI-27: pièce 5
traversins	sapin	pour la réfection des fosses aux mâts de St-Nazaire	inconnu	Saint-Nazaire		3E-XXI-25: pièce 12
varangues	non préciser	pour la réfection des fosses aux mâts de St-Nazaire	inconnu	Saint-Nazaire		3E-XXI-25: pièce 12
bois	chêne	à couper	village de Chapeau et Bignay	Bignay		3E-XXI-9, pièce 174
bois	ormeau	à couper	village de Chapeau et Bignay	Bignay		3E-XXI-9, pièce 174
bois	frêne	à couper	village de Chapeau et Bignay	Bignay		3E-XXI-9, pièce 174
bois	chêne vert	arbres à couper	bois de Fouras	Fouras		3E-XXI-25: pièce 96
bois	noyer	menuiserie	Aginois	Aginois	Marmande	3E-1451
bois	noyer	menuiserie-ébénisterie	Bassac	Bassac		3E-XXXIV-1, pièce 46
bois	noyer	menuiserie-ébénisterie	Bassac	Bassac		3E-XXXIV-1, pièce 97
bois	non préciser	non mentionné	Sud-Ouest	à préciser	Bayonne	3E-XXXIV-1, pièce 70
bois	peuplier	non mentionné	St-Porcher	Saint-Porchaire (Saintes)?		3E-XXI-26: pièce 158
bois	peuplier	non mentionné	Angoumois	Angoumois		3E-XXI-26: pièce 158
bois	chêne	non mentionné	Chastelart	[à préciser]	Angeac-Charente	3E-XXI-28: pièce 103
bois	chêne	non mentionné	Châteauneuf	Châteauneuf-sur-Charente ?	Angeac-Charente	3E-XXI-28: pièce 103
bois	ormeau	pour bâtir un quai	Champagne	Champagne (Charente-Mar)	Champagne	3E-XXI-25: pièce 76
bois	frêne	pour bâtir un quai	Champagne	Champagne (Charente-Mar)	Champagne	3E-XXI-25: pièce 76
bois	non préciser	vente-achat	à préciser	à préciser		3E-XXI-6 (1er doc, à saisir)
bois	non préciser	vente-achat	à préciser	à préciser		3E-XXI-6 (40e doc, à saisir)
bois haute futaie	non préciser	arbres à couper	forêt de Taillebourg	Taillebourg		3E-XXI-25:pièce 60
bûches	non préciser	à brûler ?	inconnu	inconnu		3E-XXI-29:Pièce 45
charbon de bois	non préciser	combustible ?	Roumette, par. St-Brie-des-Bois	St-Brie-des-Bois		3E-XXXIV-1, pièce 121
chevrons	chêne	menuiserie	St-Sorlin des Chaux, Saintonge	St-Sorlin (près Saintes)	port d'Envaux	3E-XXXIV-1: Pièce 30

Dénomination		Variété	Usage	Mention du lieu d'origine	Localisation actuelle	Vendeur ou transporteur	Références (ADCM et autres)
colonnes	noyer	menuiserie-ébénisterie	Angoumois	Angoumois	Angoumois	La Couronne	3E-XXXIV-3, pièce 247
fagots de bois	non préciser	à brûler ?	port de Taillebourg	Taillebourg	Port d'Envaux		3E-XXI-27: pièce 39
fagots de bois	non préciser	à brûler ?	inconnu	inconnu			3E-XXI-29: Pièce 45
guéridons tournés	noyer	menuiserie	inconnu	inconnu			3E-XXI-29, pièce 92
madriers	chêne	menuiserie	St-Sorlin des Chaux, Saintonge	St-Sorlin (près Saintes)	port d'Envaux		3E-XXXIV-1: Pièce 30
madriers	noyer	menuiserie-ébénisterie	Angoumois	Angoumois	Bassac		3E-XXXIV-2: pièce 112
madriers	noyer	menuiserie-ébénisterie	Angoumois	Angoumois	La Couronne		3E-XXXIV-3, pièce 247
madriers	non préciser	vente-achat	La Roche	(plusieurs possibilités)			3E-XXXIV-2, pièce 13
membrures	noyer	menuiserie-ébénisterie	Angoumois	Angoumois	La Couronne		3E-XXXIV-3, pièce 247
planches	non préciser	à faire scier	inconnu	inconnu			3E-XXI-6 (55e doc, à saisir)
planches	noyer	charpenterie	inconnu	inconnu			3E-XXI-27, pièce 53
planches	sapin	inconnu	inconnu	inconnu			3E-XXI-6 (61e doc, à saisir)
planches	sapin	pour coffre de 8 pieds	inconnu	inconnu			3E-XXI-29, pièce 92
popellons	noyer	menuiserie-ébénisterie	Angoumois	Angoumois	Bassac		3E-XXXIV-2: pièce 112
quenouilles	noyer	menuiserie-ébénisterie	inconnu	inconnu	Bassac		3E-XXXIV-2: pièce 112
solives	chêne	menuiserie	St-Sorlin des Chaux, Saintonge	St-Sorlin (près Saintes)	port d'Envaux		3E-XXXIV-1, Pièce 30
tables	noyer	menuiserie	inconnu	inconnu			3E-XXI-29, pièce 92
tablettes	sapin	menuiserie	inconnu	inconnu			3E-XXI-29, pièce 92
Abbreviations Used: ADCM Archives Départementales de la Charent-Maritime (La Rochelle)							
ADSM Archives Départementales de Seine Maritime (Rouen)							
SHMR Service Historique de la Marine (Rochefort)							
ADPA Archives Départementales des Pyrénées Atlantiques (Pau)							

Of the 38 remaining contracts that did not specifically mention marine use, some indicated wood of a general nature (*bois*), mature trees (*haute futaie*), and squared timbers (*madriers*), that could be put to use in the construction of a ship. These general types, when used for finishing work on a ship in the construction and fitting out of cabins, may include wood used for joinery (*menuiserie*) or cabinet making (*ébénisterie*). These usages appear in 15 of the remaining 38 contracts. Only 7 of the 100 total contracts listed could in no way be involved with ship construction as they were for wood to make charcoal (*charbon*), for the construction of a quay (*quai*), for burning (*à brûler*), or for the construction of a trunk (*pour coffre*). Several others suggested construction for housing with a request for joists (*solives*), rafters (*chevrons*), or columns (*colonnes*).

The species of woods purchased included walnut (*noyer*), ash (*frêne*), elm (*ormeau*), fir (*sapin*), spruce (*sapin* or *épicéa*), pine (*pin*), poplar (*peuplier*), and the very important oak (*chêne*). With the exception of fir and pine, neither of which could be obtained within the general Rochefort region, all of the other species were locally available. The extensive use of locally and regionally available wood not only suggests a well-organized network of timber exploitation, but reflects the emphasis of Colbert to avoid importing timber as much as possible. “It is both undesirable and unnecessary to buy from foreigners to supply our navy, especially when we have the same things as abundantly as they” (Colbert 1861-1862 III:256). He went as far as to order that in even cases where domestic timber was even a bit more costly, it be used instead of imports (Colbert 1861-1862, III:256).

The extensive use of oak, even in those contracts that are indicated as *non précise* (not specified), is inferred by its use for naval carpentry and region of harvest. Oak was



the principal wood found in the Rochefort, Tonnay-Charente, and greater Angoumois. Contracts examined in the Bordeaux notarial archives exhibit a similar pattern, where closer examination of unspecified woods were oak (B. Loewen, pers. comm. 2000).

While the search of the archives in La Rochelle that produced the timber contracts discussed was not comprehensive, it was thorough. At Rochefort, however, the examination of notaries and marine records was exhaustive. Together, they represent a reasonably thorough investigation of the notarial documents at both locations. These timber contracts thus provide a credible indication of the extent of the shipbuilding activity at Rochefort, the species of wood being purchased, the usage for which they were intended, and the locations from which the trees were harvested. The overall picture is of a well-developed system of forest exploitation and transport to serve the royal yard at Rochefort. Figuring out the numbers of ships built at Rochefort using regionally-supplied wood was not possible based on these contracts.

### **Species Analysis**

It was clear during the excavation and later disassembly that *La Belle* was constructed using several species of wood, which is customary in shipbuilding. The most common types used are well known and easily recognized so the decision to undertake this analysis was prompted by a desire not only to confirm wood species, but to determine if any New World species were incorporated into the obvious repairs to the ship, and to investigate both the range and origin of European trees used, if possible.

## **Rationale and Research Approach**

The research was designed to accommodate a comprehensive sampling of the structural elements. Therefore, the samples were selected based upon location in the ship (forward, aft, port starboard, hold), function (bulkhead, hull or ceiling plank, pumpwell, stanchion, etc.), and scarcity (a single example of a particular element). Using these criteria, 134 timbers were selected for sampling, representing approximately 35% of the total surviving elements on the ship.

The individual sample results are presented in full in Appendix B and will not be discussed here. The species identification was undertaken by Amy Mitchell, a member of the project crew, under a separate agreement with the Texas Historical Commission (Mitchell 1998). Mitchell's familiarity with the ship contributed substantially to the quality of the result.

## **Results and Analysis**

All of *La Belle*'s major timbers, the keel and keelson, the frames, deck beams, stem and stern post, forward and aft deadwoods, and longitudinal stringers are of white oak (*Quercus* spp.). Other elements including deck beams, ceiling and hull planking, treenails, filler planks finishing off the ceiling planking, the two extant mast steps, and numerous repair pieces are also oak. Oak thus accounts for 73% of the timbers sampled. Given the characteristics of oak and the preference among shipwrights to use it, this comes as no surprise.

When these findings are compared with the timber contracts, the results are surprisingly similar. Although only a few of the 101 contracts specifically stated oak

(*chêne*) as the variety of wood to be provided, the locations from which these trees were logged were predominantly the oak forests of the Rochefort region and so can be presumed to be oak. Further, of the 48 contracts for ship construction (excluding masts) 34 were for wood from Rochefort. This latter represents 71% of the ship construction timber contracts surveyed for the years 1670 to 1700, a very close correlation to the percentage of sampled timbers.

The second most used species in the construction was pine (*Pinus sylvestris*<sup>2</sup>). Pine was used for all of the bulkheads, forward hold platform deck, bulkhead nailers, and for the main mast. Pine was also used variously for small filler pieces below the forward mast, stanchion posts in the middle bulkhead and the pump well, nailers at the base of the stanchion posts in the pump well, and as wedges between the ceiling planks and frames. The use of pine for planks, beams, and masting timber is generally consistent with the widely accepted use of this species in ship construction. This use in *La Belle* is characteristic with its qualities as a hard, tough, and elastic wood. Pines account for 21% of the timbers sampled and it was clearly selected for use in the bulkheads and the forward hold platform deck.

Historically, the terms pine and fir were often confused, which presents some problems for analysis of the timber contracts *vis a vis* the species identification. The words for pine and fir are quite different in French appearing as *pin* and *sapin*, respectively, and so are clearly differentiated in the language. However, even modern

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<sup>2</sup> Mitchell (1998:3) points out that the two species of *P. resinosa* and *P. sylvestris* cannot be microscopically differentiated. *P. sylvestris* grows in the Baltic and the mountains of the Pyrenees and France's central plateau, while *P. resinosa* is a North American species.

dictionaries translate *sapin* as both fir and pine. An example of this mixing of usage appeared with the entry “*suiffes ou femelles des sapins*,” or female of the firs, describing the species of wood for a masting contract that apparently refers to pine (refer to Figure 4-3). The problem, therefore, is the scribe exactly recording the species. Notwithstanding this potential limitation, a closer look at the timber contracts does provide some interesting results. The 63 contracts for ship construction include 14 specifically for pine (*pin*) or what can be presumed to be pine based upon use and source. Of these, six are for pine from the Baltic, six are for pine from the Pyrenees, two are not specified, and all are for masting timber, for which pine was the preferred tree. The 14 contracts for pine masts represent 22% of the total number of ship construction contracts surveyed.

Although Baltic pine was preferred to domestic species for masting, both were used at the various shipyards. The main difference between Northern and French pine was not species, but quality. Both Colbert and Signelay noted the lower quality of domestic pine masting timber that “. . . infallibly rot[s] at the heart in less than a year” (AN Marine G., f. 184, Signelay to Colbert, 9 May 1680). Because it is impossible to differentiate microscopically northern from French pine, the condition of *La Belle*'s mast in situ may provide the best clue to its origin. Immediately upon excavation the mast clearly exhibited differential preservation with a solid outer layer and a softer, more eroded core (Figure 4-4). Further support for this comes from documents found in the archives in Rochefort. On May 21, 1683, a load of masts from the port of Bayonne was delivered to Rochefort by the flute *La Suzanne* (SHMR 1L<sup>3</sup> 19, f. 30-31). Bayonne was the embarkation port for timbers from the Pyrenees (refer to Figure 4-1) and a May delivery coincides with the construction period for *La Belle*. While not conclusive, these



**Figure 4-4:** The core of the main mast is deeply eroded. Photograph by Toni L. Carrell.

two pieces of evidence suggest that the mast may be from a tree harvested in the Pyrenees, which was the principal source of domestic masting timber in the 1680s.

Beyond the masts are ten additional contracts specifically for *sapin*, or what can be presumed to be *sapin*, based upon their source. Given the historic confusion between pine and fir, these additional contracts for planks, boards, and cross-pieces to repair a mast, may be either species. However, seven of these additional contracts list the timbers as imported from the Baltic. If the timbers used in *La Belle* are generally representative of the types used in ship construction, then the extensive use of pine for small interior planking strongly suggests the possibility that at least some species in the contracts are also pine. If 10 of the 48 contracts specifically for ship construction (excluding masts) can be assumed to be pine, this represents 20.8% of the ship construction contracts, very

closely corresponding to the 21% pine used in *La Belle*.

The fir was the third most-used species. Four smaller pieces were identified as true firs (*Abies* spp): a stanchion post in the middle bulkhead, a stanchion post in the pumpwell, the main maststep chock, and a small chock forward that supported a small shelf or platform. Historical sources often used the term fir incorrectly, referring instead to Scots or Norway pines. The true firs have the same basic characteristics as the pines and were used interchangeably with pine in the second bulkhead and the pumpwell. Its light weight made it suitable for sashes and trim and may have been used to finish out cabins in ships. Because nothing of the decks and cabins survives, this handful of examples represents only 3% of the wood species from the sampled timbers, likely under representing the extent of its use. Its low percentage in the species identification results and the confusion over terminology between pine and fir in the contracts, makes any correlation between the two as an indicator of its general use in ship construction inconclusive. It should be noted, however, that the true firs do grow in the higher altitudes in the northern, central, and eastern sections of France and two contracts for *sapin* that do not give a location could easily be for domestic harvest. Coincidentally, those two represent 4% of the construction contracts.

The investigation revealed one example each of spruce<sup>3</sup> (*épicéa*) and elm (*orme* or *ormeau*), both of which were for special timbers requiring unique qualities. The tailpiece fastened to the top of the keelson the stern is spruce, *Picea* spp. It is generally considered

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<sup>3</sup> To add to the confusion over terminology, *sapin* is variously translated in French as both fir and spruce, with spruce also having the alternative translation of *épicéa*.

lighter and weaker than pine, but with the same broad characteristics. Its location in the stern to fill in the space left where the port and starboard ceiling planks met covering the aft-most floor and resulting in a slight depression or V, suggests the need for a timber suitable for light decking. The variety of spruce that grows in the higher mountains of the French Jura, Vosges, and Alps is *P. excelsa* of which this may be a sample; unfortunately, differentiating the subspecies is microscopically impossible. Spruce accounts for only 3% of the forest species in France (Reed 1956:75) so was not widely used in ship construction.

The pump tube is identified as elm. Because the tree grows very straight and does exceedingly well when either kept wet or dry, it is perfectly suited for a pump tube. Elm is also a common wood for ship construction, primarily used for keels and other purposes that require a straight, durable wood. The archaeological recovery of the elm pump tube from the Basque whaling ship *San Juan*, wrecked in 1565, is just one example of the long history of this wood for pumps (Waddell 1985:243-259). Only one contract for elm appears and its designated use was in the construction of a quay. Here the elm was to be harvested in the nearby area of Champagne, suggesting that the elm used for *La Bell's* pump tubes could easily have come from that region.

One surprising result from the study was the discovery of a live oak example. The single sample of live oak is from a notched filler or covering board that seals off the top ceiling plank preventing debris from entering the space between the ceiling and outer hull. Mitchell (1998:2-3) noted that there are only a few species of live oak, the two principal examples are American live oak (*Quercus virginiana*) and a Mediterranean Holly oak (*Quercus ilex*). *Q. ilex* and its related species are also commonly called "Holm

oak” and were routinely used in Mediterranean shipbuilding. When Atlantic builders received the rare shipment of this species, they used it in the same manner as local oaks. The filler piece in *La Belle* is clearly not a replacement, so it must be assumed that it is the Mediterranean variety. The Mediterranean Holly oak grows from the southern European coasts to North Africa and so could easily have been transported to Rochefort for use during intermittent periods of extreme need and limited supplies.

None of the repair pieces sampled could be identified as New World species, so the repairs noted in the hull planking and a few other locations were clearly undertaken either before the ship’s departure from France or in the New World with a supply of Old World woods carried for that purpose.

In summary, the species represented in *La Belle* are typical of those expected in ship construction. Because there is a strong correlation between the percentage of species used and the timber contracts during the 30 years from 1670 to 1700, this is simply another indicator that this ship was built in a well-organized shipyard geared toward rapid production of ships of all sizes. In this regard it is a good example of ship manufacture from the late 17<sup>th</sup>-century. The range of species identified also reflects both a comprehensive use of domestic trees and an extensive timber supply network serving Rochefort as well as nearby yards. Presumably this was not an isolated organizational milieu, but rather reflects the larger over-arching organization of the shipbuilding industry in late 17<sup>th</sup>-century France.



## **Dendrochronological Analysis**

As the species analysis amply demonstrates, shipwrights coveted strong, durable oak for ship construction. For the archaeologist this is a double benefit, not only contributing to the ship's excellent preservation, but the extensive use of oak made dendrochronological analysis possible.

## **Rationale and Research Approach**

Dendrochronological analysis was undertaken to address questions other than dating, the first of which is wood origin. This type of analysis is possible because of the pronounced regional growth patterns of European oak. In regions of the south Atlantic coast provenance can sometimes be determined within a radius of 9 km. Further north, where the growth patterns are less pronounced, origin can still be determined within a radius of 190 km or less. The use of dendrochronology in this manner is common in Europe to establish the origin of a variety of wood material remains and building components (Schweingruber 1989:149-162). Identification of the origins of the wood used in *La Belle* might, therefore, provide an insight into the exploitation of the forests in the Rochefort region and presumably reflect larger, national, patterns of import, transport, and use.

The second reason for undertaking dendrochronological analysis is that it can address the relationship between the felling date and use of the wood. In the closing 20 years of the 17<sup>th</sup> century, the forests around Rochefort were even more heavily exploited for ship timbers (Viaud and Fleury, 1845 (I):165, in Bamford 1955:100). Wood shortages, whether in the yard or in the forest, suggests that wood scarcity might have

been a consideration during *La Belle*'s construction. Scarcity implies that there would be a very short time lag between felling and use and may further indicate that the timbers were cut expressly for the construction of this ship. This information may in turn provide an insight into the workings of the Rochefort shipyard and the relationship between the shipyard and timber merchants a mere 20 years after its establishment.

Dendrochronology can also provide information on the reuse of old timber. Until the advent of modern large forested tracts providing a constant supply of timber, wood was generally regarded as a material to be conserved and reused. Contracts for the sale and dismantling of ships were common throughout Europe as ships grew both in size and numbers and pressure for the build-up of national navies increased. It was also a method to keep the harbor clear of derelicts and was a source of income for the dismantling specialists. The benefit of reusing timbers from dismantled buildings or ships is self-evident if timber supplies are erratic, but reuse might also save money and reduce the wait for suitable materials. It is an accepted fact of manufacturing that supply shortages can increase the cost of construction, suppliers charge more for a scarce or limited resource. Delays in supply influences not only cost, but in an era of internecine wars and external aggression, can affect national security.

Lastly, it was hoped that dendrochronology might provide some insights into the selection process for trees in the forest. Were trees of a certain age, for example, routinely selected for floors or second futtocks? What were the minimum or maximum ages of the trees harvested? At what point does the age range peak? The first of these questions addresses shipbuilding practices, while the latter more directly address forestry management.

The sampling strategy was designed to test a cross-section of *La Belle*'s structural elements. Only timbers manufactured of oak (*Quercus* sp.) were selected for study. This was due in part to the expertise of the laboratory, but also because of the very long dating sequences for central European oak. The dating chronology for *Quercus* sp. in Europe extends back 6000 years and is among the longest of any species (Schweingruber 1989:26).

Prior to the selection of samples, macroscopic tree ring counts were undertaken on 57 timbers; these were limited to floors, first, second and third futtocks. This sample represents 43% of the timbers in those categories. While not precisely accurate, it was felt that the visual counts would provide enough rings for preliminary sorting. The results were then plotted in a scatter graph to determine their range. Based upon these preliminary results, the timbers fell into three groups: timbers with counts between 45 and 60, timbers with counts between 70 and 80, and timbers with counts greater than 90. Within each of the groups an effort was made to select floors, first, second, and third futtocks for sampling. Specific timber selection within each group, however, was made at the time of sample collection.

The dendrochronology sample collection and analysis was done by the Laboratoire d'Analyses et d'Expertises en Archéologie et Oeuvres d'Art located in Bordeaux, France, under the direction of Beatrice Szepertyski (1999). This laboratory was selected because it specializes in the analysis of woods south of the Loire Valley. No other laboratory in France has focused on this area to the same degree and, under Szepertyski's direction, a master sequence for the region has been developed. It was against this sequence that the timbers from *La Belle* were checked.

## **Sample Collection and Documentation**

Twenty-six samples were collected that included three first futtocks, three second futtocks, three third futtocks, two deep floors, and two floors from the calculated frames. Beyond these, one section of the keelson, one section of the keel, one deck beam, one main mast partner, one main mast buttress, one main mast filler piece, one longitudinal stringer, two ceiling planks (one port side, one starboard side), and four hull planks (three from the starboard side and one without provenance) were sampled. All samples were collected in a manner to limit visual impact, recognizing the need for eventual museum display, and possible weakening of the timber.

Samples were obtained by sawing rather than coring because the waterlogged condition of the timbers resulted in extremely poor, distorted, results that readily crumbled. The inability to core meant that some timbers could not be sampled easily and others not sampled at all. This also limited sample location to maximize the presence of certain tree characteristics to increase dating accuracy. Although some of the large structural elements, such as the deadwood, stem and stern posts were on the short list for analysis, they were deemed not suitable for sampling.

Following final selection, each timber was photographed before and after sample collection, the area of the sample was noted on individual timber drawings, the location of the timber marked on appropriate base maps, and an internal sample number assigned. The laboratory later assigned separate inventory numbers for their in-house purposes. Figure 4-5 provides a cross reference between the laboratory sample number, the field sample number, timber tag number, and timber identification.

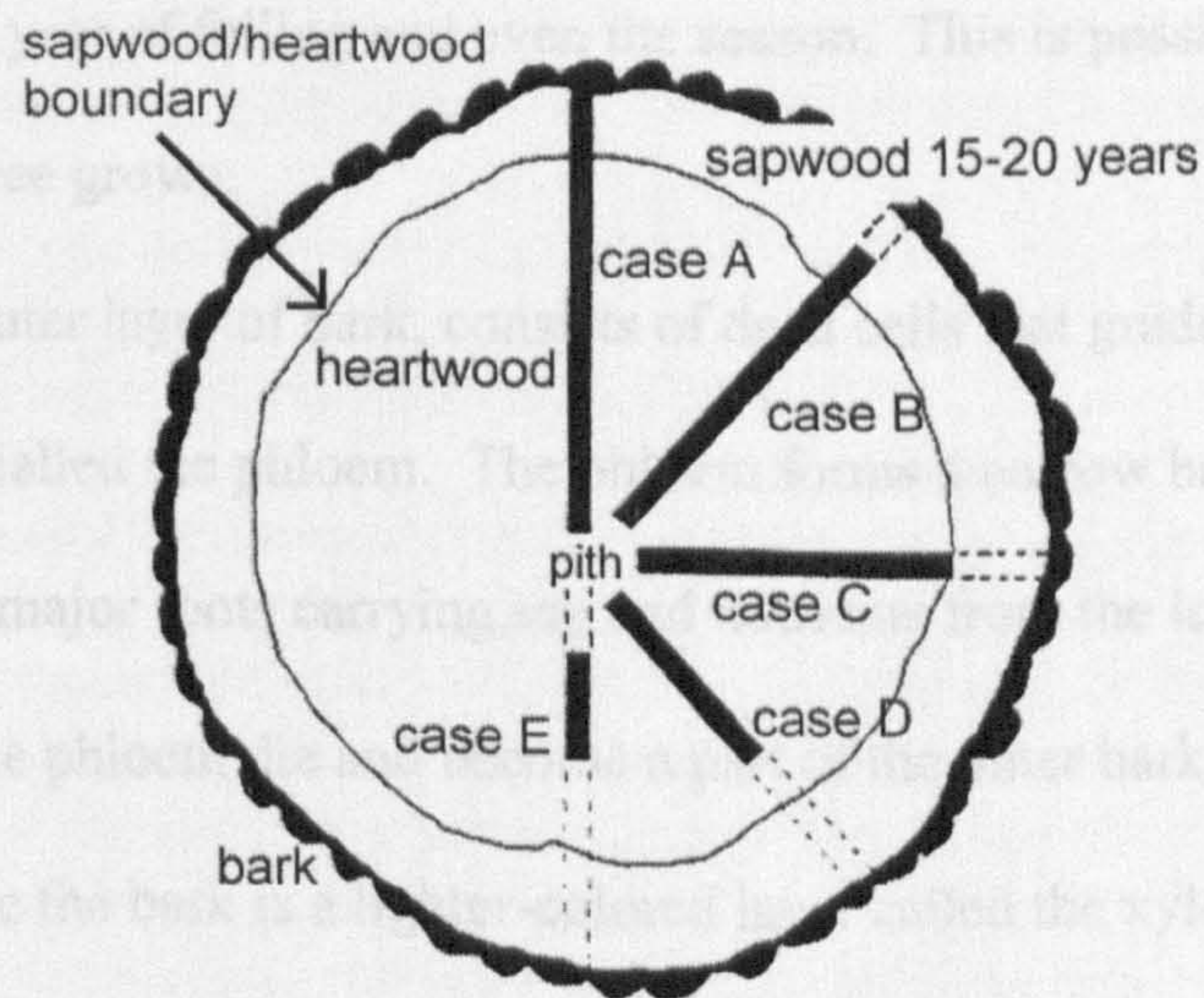
**Figure 4-5: *La Belle* Dendrochronology Sample Identification**

Laboratory Number	La Belle Sample Number	Timber Tag Number	Timber Identification
BDD:2793	40	169	3 <sup>rd</sup> futtock, fwd, master frame
BDD:2794	41	153	3 <sup>rd</sup> futtock, stbd, 7 forward
BDD:2795	42	171	3 <sup>rd</sup> futtock, aft, master frame
BDD:2796	43	256	1 <sup>st</sup> futtock, port, 5 forward
BDD:2797	44	206	2 <sup>nd</sup> futtock, stbd, 10 aft
BDD:2798	45	187	2 <sup>nd</sup> futtock, stbd, 2 aft
BDD:2799	46	228	1 <sup>st</sup> futtock, stbd, master frame
BDD:2800	47	247	1 <sup>st</sup> futtock, port, 9 forward
BDD:2801	48	27	beam, forward platform deck
BDD:2802	49	246	floor, 10 forward
BDD:2803	50	67	main mast filler, aft
BDD:2804	51	66	main mast partner, stbd
BDD:2805	52	259	floor, 4 fwd
BDD:2806	53	208	2 <sup>nd</sup> futtock, stbd, 11 aft
BDD:2807	54	385	hull plank, stbd
BDD:2808	55	354	keel, aft section
BDD:2809	56	119	keelson, central section
BDD:2810	57	381	hull plank, stbd
BDD:2811	58	no number	hull plank, no provenance
BDD:2812	59	271	floor, 2 aft
BDD:2813	60	127	ceiling plank, port
BDD:2814	61	99	ceiling plank, stbd
BDD:2815	62	365	hull plank, stb
BDD:2816	63	91	stringer, lower run, stbd
BDD:2817	64	218	floor, 16 aft
BDD:2818	65	178	main mast buttress, stbd

## Tree Morphology and Dating

The selection of suitable samples is both a science and an art. When a tree is cut the outermost cells die and wood production stops. Frequently the bark and outermost, or terminal, ring is absent because insects attack there, fungus or other problems appear, and the outer layer is removed while shaping a timber for use. This is of particular concern in the dating of ship timbers because the condition of the timber and its post-felling modification can limit its value for dating.

Problems that may be encountered in obtaining suitable samples for the dating works of art also apply to dating ships (Figure 4-6).



**Figure 4-6:** The limitations of dendrochronology analysis based upon the presence or absence of tree structures (after Klein 1980, in Schwengruber 1989:163).

Where the bark still exists (see case A) the year in which the tree was felled can be determined exactly. Where the bark is missing but the sapwood can be seen (as in case B), it is possible to ascertain in which year the tree was felled by allowing for missing sapwood rings . . . depending on the age of the tree, [which] will be added on. [In this case] where samples . . . consist entirely of heartwood . . . the earliest possible felling date of the wood can be given, provided at least fifteen sapwood rings are still in existence. Pieces of wood which display only a few

annual [heartwood] rings could have come from any one of most areas within the trunk. In such cases (D, E) there may well be disparities [in] the earliest date provided by the dendrochronologist . . . (Klein 1980:113-123).

In case C where the wood partly comprises heartwood, but the end of the annual rings can be seen at the sapwood/heartwood boundary, it is possible to ascertain, within specific limits, the year the tree was felled by allowing for missing sapwood.

Klein clearly pointed out how the accuracy of dating is dependant upon the presence or absence of certain tree structures. What he did not elaborate on is the very fine scale of these structures and how they improve the possibility for obtaining useful results. In A, where the bark and sapwood are present, this can allow for an accurate determination of the year of felling and even the season. This is possible because of the manner in which a tree grows.

The corky, outer layer of bark, consists of dead cells that grades into an inner, living layer of bark called the phloem. The phloem forms a narrow band around the trunk, branches and major roots carrying sap and nutrients from the leaves. Over time the outermost cells of the phloem die and become a part of the outer bark, eventually sloughing off. Inside the bark is a lighter-colored layer called the xylem, commonly called sapwood, that grades into the darker heartwood or pith. The sapwood/heartwood boundary is easily visible in some species of trees, such as pine and spruce, because of the clear color differences between the two. It is the xylem that carries water and minerals up through the trunk and is a living layer responsible in part for the vitality of the tree. Over time the inner most layer of xylem dies and is transformed into the darker heartwood. Young trees consist mostly of living sapwood, while older trees have a thinner band of

sapwood with substantial heartwood cores that are dead. Both the xylem and heartwood exhibit annual growth rings (Page 1983:71-82).

The outer bark, phloem (inner bark), xylem (sapwood), and heartwood are all easily seen by the naked eye. What is not visible is a microscopically thin layer known as the cambium or cambial zone. The cambial zone is positioned between the phloem and xylem; the cells outside the cambium eventually become part of the phloem, those on the inside become part of the xylem. It is this layer that is responsible for a tree's circulation and growth. During the growing season the cells of the cambium divide at a rapid pace creating new tissue for both the phloem and xylem. The rapid growth toward the inside creates the annual rings in the xylem. The cambial zone is so sensitive to the changes in daylight hours, temperature, and precipitation that accompany the seasons it is reflected in the cambium as ring boundaries (Schweingruber 1989:109). The presence of the cambium permits a determination of the season of felling.

Because the cambium is rarely present in worked timbers, the sapwood/heartwood boundary is a useful tool in the dating process. The relationship between the age and diameter of a tree and the number of sapwood rings was analyzed by Hollstein (1980:33-44). Recognizing that the number of sapwood rings varied regionally, Hollstein looked at 493 oak samples from the past 27 centuries and found that in 98% of all the trees analyzed the number of sapwood rings fell between 10 and 38, the average being 20. Further, Baillie noted that there appeared to be a correlation between the age of oaks and the number of sapwood rings. He found that in trees less than 160 years of age the majority of sapwood rings fell between 20 and 45 years (1982 in Schweingruber 1989:146). Szepertyski (1999:3) stated that in 95% of the oak trees studied in France the



sapwood contained between 10 and 40 growth rings ( $25 \pm 15$  years). Thus, if the sapwood/heartwood boundary is present, one can estimate the maximum and minimum number of rings that are missing. Clearly, the more growth rings present, the greater the accuracy of the estimate and the dating result. When the assemblage is homogeneous, then a comparison between samples can further refine the results.

When both the cambium and sapwood are missing, Szepertyski (1999:3) suggested that providing an estimated date of felling for a tree less than 150 years old is still possible. She called this the “hypothesis of minimal removal” and stated that in the era before mechanized processing of trees, the craftsman looked for a tree close to the dimensions of the piece to be fashioned to reduce production time and loss of material. This assumption is based upon the observed high proportion of construction elements that generally have sapwood or traces of trimming the sapwood on the edges of finished timbers. Finished timbers are identified as those where the surface evidences tool marks.

The hypothesis of minimal removal is supported by the early 18<sup>th</sup> century ship building treatise by Ollivier (1737). He described the minimal removal of the sapwood in the forests and later in yards during his visits to England’s major shipyards.

The compass timber which I saw used at Deptford arrives in the Dockyard rough-hewn or only worked on two faces, so that scarce the bark is removed and the upper branches cut off. The timber is from the English forests; it is of middling good quality and extremely dry, yet it is used with but little care; much of the sapwood is left on, and I saw many frames, timbers of the stem and transoms where there were two or three inches of sapwood . . . (Ollivier 1737 [Roberts 1992:54]).

Similar observations were made at both the Woolwich and Chatham yards, and in Holland he reported that oak was only roughly hewn in the forest leaving 8 to 11 cm on each face. He noted, though, that overall their planks were cleaner of sapwood than those

supplied to the French Royal dockyards but only a limited amount of the sapwood was removed (Ollivier 1737 [Roberts 1992:74, 102, 228]).

Because craftsmen chose to remove as little of the surrounding wood as practicable, an estimate of the missing sapwood is possible even if the sapwood is not present. Szepertyski (1999:3) stated:

This can be explained in the following manner: on the edges from a transverse cut on a beam, when all the xylem [sapwood] is missing (which is between 10 and 40 rings), [generally] a minimum of heartwood is [also] missing, that is a maximum of 10 rings. This establishes that the last ring found is situated between 10 and 50 years . . . before the date of felling . . . thus providing an estimate of maximum missing rings.

There is another situation that can present itself when both the cambium and sapwood are missing. Here the only date that can be provided is a date after which the tree was felled. If the assemblage of samples is large and homogeneous and the chronological sequence is narrow, with the final group of growth rings falling between two and five years, there is a probability that the last growth ring is close to the sapwood/heartwood boundary and a reasonably accurate felling date can be inferred. However, if the final group of growth rings goes beyond a 15-year interval, the probability that the last observed ring in any sample is close to the boundary decreases and the only date than can be provided is *post quem*, which would be based on the overall regional chronology (Szepertyski 1999:4).

### **Synchronization**

All of the samples were referenced against the master reference for the Grand-Sud-Ouest of France, the chronology developed by the Szepertyski laboratory for oak. It was against the average ring width that each year was assigned a value above or below the

average. A signature year for a specific region is important because a statistically significant number of trees always show that value for that year. These years are critical in deciding whether the dates and geographic provenance are correct.

The sequence that included *La Belle's* samples ran from 1376 to 1675 and is identified as the *séquence moyenne*, the mean sequence. The table presented in Figure 4-7 is a composite, including both hull timbers and casks, presenting the annual ring index values by year based on the samples from *La Belle*. As such, it is a site chronology and does not contain any links to the master chronology. Each row represents a 10-year time span, with the starting year in the left column.

**Figure 4-7: Annual Ring Index Values By Year**  
(After Szepertyski 1999:7)

Start Year	Ring Index Values									
1376	,	,	,	37	-86	31	-64	-60	65	65
1386	-67	-43	39	44	0	-51	-12	12	-13	36
1396	9	-4	15	-28	66	-12	-28	-55	-113	69
1406	113	21	-27	-66	-80	6	125	23	32	-71
1416	-44	11	45	-39	-31	86	-36	-15	-69	37
1426	<b>15/</b>	-34	46	-19	18	-4	6	69	-12	-29
1436	-20	-35	57	39	-21	-36	-43	14	-24	5
1446	3	52	4	-10	-8	43	22	9	-46	-33
1456	-13	-2	36	-7	<b>25/</b>	6	<b>2/</b>	<b>-53*</b>	-15	10
1466	<b>10/</b>	4	<b>7/</b>	-7	22	8	<b>11*</b>	30	-12	-17
1476	-11	<b>-12*</b>	<b>-58*</b>	-1	<b>46/</b>	2	-20	10	<b>-1/</b>	-18
1486	16	14	-15	7	<b>17/</b>	-16	<b>-40*</b>	24	-15	13
1496	<b>-29/</b>	<b>42/</b>	-8	-1	-18	-4	12	28	-15	13
1506	<b>-55/</b>	4	20	29	9	5	<b>5/</b>	<b>-49/</b>	-4	26
1516	-19	-3	7	<b>19/</b>	-1	-15	<b>-18/</b>	7	14	-11
1526	<b>23/</b>	10	<b>13/</b>	-43	-24	<b>-13/</b>	<b>33/</b>	<b>8/</b>	-19	-14
1536	11	33	25	1	-30	-35	<b>-25/</b>	12	<b>-15/</b>	24

Start Year	Ring Index Values									
1546	-2	-16	-5	6	-11	20	22	3	-10	-23
1556	<b>23/</b>	-6	-6	15	-12	6	-15	<b>16/</b>	-14	8
1566	-2	12	<b>-19/</b>	19	-8	0	0	-20	-11	20
1576	6	8	-12	<b>14/</b>	<b>-37/</b>	<b>15/</b>	-16	12	1	13
1586	-11	-6	2	<b>-15/</b>	29	-8	9	-7	-1	8
1596	-5	-30	-4	-4	25	5	-5	20	-10	4
1606	-10	19	-13	9	-6	-16	-3	-13	13	-5
1616	<b>23/</b>	8	-27	-1	-20	8	3	-15	14	-4
1626	19	-7	5	<b>-17/</b>	25	-6	<b>9*</b>	<b>-32/</b>	7	14
1636	10	<b>-24/</b>	<b>17/</b>	<b>-15/</b>	1	-17	-8	14	0	7
1646	13	-6	-7	0	-2	-9	8	7	<b>-31*</b>	46
1656	<b>-19/</b>	2	-24	-2	<b>0/</b>	<b>-30*</b>	18	<b>5*</b>	<b>32/</b>	-12
1666	<b>6*</b>	-37	50	2	-4	-16	,	,	,	,

/ = signature year 75% have this value      \* = signature year 90% have this value  
 minus (-) = value below the average

Examination of the index values reveals a total of 48 signature years that group into six distinct clusters, indicated in bold in Figure 4-7: 1460 to 1497, 1506 to 1544, 1556 to 1568, 1579 to 1589, 1629 to 1639, and 1654 to 1666. There are two signature years that are isolated from these groups, 1426 and 1616. The former is separated by a total of 83 years, the latter by a total of 38 years. These isolated signature years, unless part of a long overlapping ring sequence appearing in several samples, are problematic insofar as their usefulness in temporally anchoring a sample.

### Results and Analysis

The analysis combined information about: 1) the physical characteristics of each sample; 2) the presence or absence of cambium, sapwood, the sapwood/heartwood boundary; and 3) the number and width of the indexed ring values. This permitted

placement of each sample in the chronology and a determination of the earliest and latest felling date. The 26 samples from *La Belle's* hull included samples both with and without sapwood; none, however, retained their cambium.

The laboratory placed each sample in the chronology and assigned earliest and latest felling dates taking into consideration the year the ship was constructed. While all 26 samples were characterized, only 22 were able to be placed. The four samples that could not be placed are presumed to have come from outside this region. In addition to the number of growth rings present in each sample, Figure 4-8 includes the date of the first sapwood ring when present, the date of the first and last rings, and an estimate of the last possible felling date.

**Figure 4-8: *La Belle* Hull Dating Results**  
(After Szepertyski 1999:8-9 )

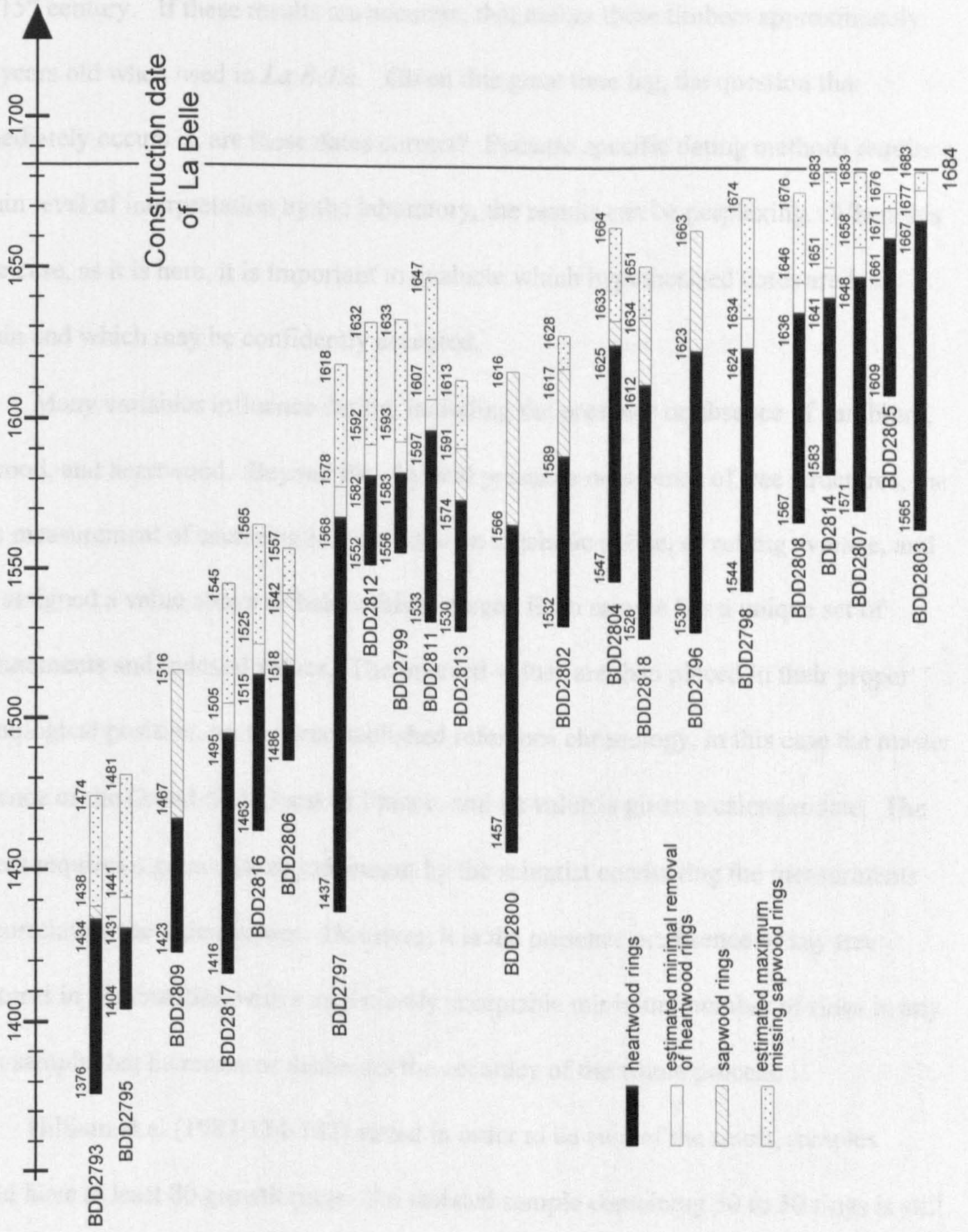
Laboratory Number	La Belle Sample Number	Growth Rings	Sapwood	First/Last Ring Position	Date 1 <sup>st</sup> Sapwood Ring	Date First/Last Ring	Date Last Possible Sapwood Ring
BDD:2793	40	63	present	1 / 63	1434	1376 / 1438	1474
BDD:2794	41	98	absent	unable to place in chronology			
BDD:2795	42	28	absent	29 / 56	n/a	1404 / 1431	n/a
BDD:2796	43	134	present	155 / 288	1623	1530 / 1663	1663
BDD:2797	44	132	absent	62 / 193	n/a	1437 / 1568	n/a
BDD:2798	45	81	absent	169 / 249	n/a	1544 / 1624	n/a
BDD:2799	46	28	absent	181 / 208	n/a	1556 / 1583	n/a
BDD:2800	47	160	present	82 / 241	1566	1457 / 1616	1616
BDD:2801	48	59	absent	unable to place in chronology			
BDD:2802	49	86	present	157 / 242	1589	1532 / 1617	1628
BDD:2803	50	103	absent	190 / 292	n/a	1565 / 1667	n/a
BDD:2804	51	87	present	172 / 258	1625	1547 / 1633	1633
BDD:2805	52	53	absent	234 / 286	n/a	1609 / 1661	n/a

Laboratory Number	La Belle Sample Number	Growth Rings	Sapwood	First/Last Ring Position	Date 1 <sup>st</sup> Sapwood Ring	Date First/Last Ring	Date Last Possible Sapwood Ring
BDD:2806	53	57	present	111 / 167	1518	1486 / 1542	1557
BDD:2807	54	78	absent	196 / 273	n/a	1571 / 1648	n/a
BDD:2808	55	70	absent	192 / 261	n/a	1567 / 1636	n/a
BDD:2809	56	94	present	48 / 141	1467	1423 / 1516	1516
BDD:2810	57	44	present	unable to place in chronology			
BDD:2811	58	65	absent	158 / 222	n/a	1533 / 1597	n/a
BDD:2812	59	31	absent	177 / 207	n/a	1552 / 1582	n/a
BDD:2813	60	61	present	155 / 215	1574	1530 / 1590	1613
BDD:2814	61	59	absent	208 / 266	n/a	1583 / 1641	n/a
BDD:2815	62	65	absent	unable to place in chronology			
BDD:2816	63	53	absent	88 / 140	n/a	1463 / 1515	n/a
BDD:2817	64	80	absent	41 / 120	n/a	1416 / 1495	n/a
BDD:2818	65	107	present	153 / 259	1612	1528 / 1634	1651

Based upon these results, Szepertyski determined that 17 of the 22 dateable samples clustered into 5 groups with the remaining 5 samples falling outside this arrangement. Figure 4-9 organizes the samples chronologically, illustrating both their synchronization and Szepertyski's groups.

The results of Szepertyski's analysis revealed that the majority of the timbers in the construction of *La Belle* came from the greater Rochefort/Charente region. This finding supports that of the species identification and was expected. The four samples that could not be characterized are possibly from outside this area and may reflect the widespread practice of timber importing. Completely unanticipated, however, and quite astounding are the results of the dating analysis. Because of those results, nearly all of the timbers were reexamined and their dating evidence reevaluated.

**Figure 4-9: Synchronization and Dating of *La Belle* Hull Samples**  
 (After Szepteyski 1999:14)



## Dating

The oldest timbers analyzed by Schepertyski have a postulated felling date in the late 15<sup>th</sup> century. If these results are accurate, that makes these timbers approximately 200 years old when used in *La Belle*. Given this great time lag, the question that immediately occurs is, are these dates correct? Because specific dating methods require a certain level of interpretation by the laboratory, the results can be perplexing. When this is the case, as it is here, it is important to evaluate which hypothesized dates are less certain and which may be confidently accepted.

Many variables influence dating, including the presence or absence of cambium, sapwood, and heartwood. Beyond the physical presence or absence of tree structures, the basic measurement of each ring is indexed to an algebraic spline, or rolling average, and then assigned a value above or below this average. Each sample has a unique set of measurements and indexed values. The indexed values are then placed in their proper chronological position, on the preestablished reference chronology, in this case the master reference of the Grand-Sud-Ouest of France, and its value is given a calendar date. The process requires a good deal of judgement by the scientist conducting the measurements and correlating the index values. However, it is the presence or absence of key tree structures in combination with a statistically acceptable minimum number of rings in any given sample that increases or decreases the accuracy of the whole process.

Hilliam et al (1987:174-183) stated in order to be sure of the result, samples should have at least 80 growth rings. An isolated sample containing 30 to 50 rings is still possible to date, but with a lower level of confidence. Ideally, samples with less than 80 rings are not used in isolation, but as part of a site chronology with several other samples.



Further, the chronological overlap between samples should contain 50 to 80 rings to be statistically viable.

Group 1: The oldest sample from *La Belle*, BDD 2793 has its first and last rings dated to 1376 and 1438, respectively (refer to Figure 4-9). Fifty-nine heartwood rings and four sapwood rings, including the heartwood/sapwood boundary, are present. The presence of the sapwood boundary greatly increases the accuracy of dating because the number of sapwood rings in European oaks is statistically constant falling between 10 and 40 rings (Schweingruber 1989:146). Four sapwood rings were added to the 36 rings, allowing for the maximum number of missing sapwood rings. This sample also includes a signature year at 1426, in which 75% of all the samples have the same index value. If the processes by which this sample was measured, indexed, and referenced were accurately applied, allowing for the statistically accepted maximum of 40 sapwood rings in oak from this region, the felling date of 1474 for this sample is reasonable.

The same level of potential accuracy is not present in sample BDD2795 with its first and last rings dated to 1404 and 1431, respectively. This sample has only 28 dateable rings and no sapwood. This very low number of rings increases the difficulty of accurate dating. However, a signature year at 1426, in which 75% of all samples from *La Belle* have the same index value, is present (refer to Figure 4-7). According to Hilliam et al (1987:177, 179), a sample with less than 30 to 50 rings is dateable, but with a low level of confidence.

Because these samples are solely dependent upon each other for dating, three potential problems are present. The first is that neither have the requisite 80 growth rings for strong statistical viability. According to Hilliam et al (1987:177, 179), a sample with

less than 80 rings is dateable, but with a low level of confidence. The main criticism of short sequences is that ring patterns of 50 years or less may not be unique, that is, the pattern may repeat over more than one period of time (Huber and Giertz 1970:201-212). Confidence in the dating can be increased if numerous samples from the same source are available. This is not the case here.

The second problem is the very short 20-year overlap between the samples (refer to Figure 4-9). According to Hilliam et al (1987:177), this short overlap is not considered statistically viable because of the problem of repeating sequences. However these samples should not be evaluated in isolation but as part of the site chronology. When the relationships between the two oldest samples and the next two samples, BDD2809 and 2817, are considered there is still a problem of reliability. There are only 16 years of overlap between BDD2793 and 2809 and 23 years between BDD2793 and 2817. Between BDD2795 and 2809 there are only 9 years of overlap and between BDD2795 and 2817 there is only a 16-year overlap. None of these are statistically viable. The third problem is that both BDD2793 and 2795 have only one signature year, 1426, which they share (refer to Figure 4-7). Samples BDD2809 and 2817 are of no additional help because the short overlaps include the same signature year of 1426. The presence of only one year is not statistically reliable for inter-dating for the same reasons that short ring sequences present a problem.

While the very early dating of these samples is intriguing, supporting the result with total confidence without some additional corroboration is difficult. Szepertyski (1999:13) postulated that these very early timbers, indeed all of the timbers with final ring dates prior to 1664, may be timbers that came from older ships and reused in *La Belle* .

This suggestion has merit; dismantling of ships and reuse of materials was a common practice in shipyards. The Rochefort notary Tesson recorded one such contract between several *charpentiers de gros oeuvres*, shipwrights, blacksmiths, and an innkeeper (presumably for lodging during the process) for the demolition of one of the king's ships in July 1685 (ADCM 3E-XXXIV-3, piece 141).

The two timbers represented by samples BDD2793 and 2795 are third futtocks on the master frame, which may be simple coincidence. The shape of these timbers, when compared with the tight arcs required of the first futtock, is more open incorporating the largest construction arc in the frames, the breadth arc. Only at its uppermost end is there the requirement for a curve inward for the tumblehome above the level of the main deck. Therefore, this timber shape is not difficult to obtain, incorporates an arc that was likely widely used in similar frame elements from ships of this general size, and is not of great length requiring special selection. However, timbers of this type would have been in high demand because so many were used in the construction of a ship. In short, the third futtocks are good candidates for possible reuse.

Both of the timbers were checked for additional growth rings that were not included in the laboratory sample due to the limitations of the sampling process. Careful examination of BDD2793 revealed that 11 older heartwood rings, i.e. before the first ring in the sample, were not included; this increased the total number of age rings to approximately 74. It does not, however, change the tree's overall postulated final cutting date of 1474; it only adjusts its age at the time of cutting.

Examination of sample BDD2795 revealed that 20 older heartwood rings were missed, bringing the total to 48. Examination of the sample collection area with regard to

overall evidence of sapwood on the timber suggested the final dated ring appeared to be close to the sapwood/heartwood boundary. Allowing for an additional 10 years for minimal removal and 40 years for maximum sapwood rings, the result is a maximum tree age of 98 years. These findings do not alter the tree's possible final cutting date of 1481. Neither does the addition of growth rings preceding the first dated ring affect the overall dating of this timber, only the relative age of the tree when felled.

Lacking other corroborative samples for dating, embracing a 15th century date for these timbers given the short series, the statistically unviable overlapping rings and single signature year is difficult. One possible way of resolving the dating of these two samples is to subject them to comparative analysis against other site chronologies. Unless that occurs, the dates and results should be used with caution.

Group 2: The samples that Szepertyski placed in group two, BDD2817, 2816, and 2806 are with and without the sapwood/heartwood boundary (refer to Figure 4-9). Their growth rings are 80, 53, and 57 years, respectively. The dating result of sample BDD2817 is likely to be quite accurate with 80 rings and 13 signature years (refer to Figure 4-7). Five of the signature years with a 90% agreement in their index values additionally increase the internal reliability of the site chronology. While this sample does not include sapwood, the long heartwood sequence falls well within the statistically reliable limits for accurate inter-dating. The first and last rings are dated to 1416 and 1495, respectively. To this Szepertyski added 10 years for minimal removal, and 40 years for the maximum missing sapwood.

Sample BDD2816 does not include sapwood, but overlaps both sample BDD2817 and 2806 by a cumulative 51 rings, placing it within a statically acceptable range. The

inter-datation of these samples is likely accurate because it includes 15 signature years, 4 of which fall into the 90% category (refer to Figure 4-7). The first and last rings date to 1463 and 1515, providing 53 dateable growth rings.

Sample BDD2806 includes the sapwood/heartwood boundary, which increases its usefulness. The first and last rings date to 1486 and 1542, respectively, yielding 57 dateable growth rings. Because 24 sapwood rings are present, estimating the last probable felling date by adding the statistically accepted maximum of 16 rings is possible, resulting in a latest estimated felling date of 1557. The dating of this sample is further enhanced by the 15 signature years included, one of which is in the 90% category. While this sample overlaps BDD2816 by only 29 rings, it overlaps the next sample in the chronology, BDD2797, by its full sequence. These various elements taken together, strongly argue that the dating of this sample is accurate. Although samples BDD2816 and 2806 each contain fewer than the ideal 80 growth rings, the relationship within this group and among all the samples in the larger context of the chronology is such that this is of lesser consequence.

All three timbers were reexamined for evidence of missing sapwood rings. Examination of sample BDD2817 revealed 35 additional sapwood rings, bringing the total rings to 115. The last ring appeared to be at or near the cambial zone, which results in a change in the last possible felling date to 1531, well within the statistical norm of 1505 to 1545 postulated by Szepertyski (1999:14). No additional growth rings were found in subsequent reexamination of BDD2816. Examination of BDD2806 revealed 10 heartwood rings before the first ring in the sample, moving the first ring date back to 1476. An additional 18 sapwood rings were also found, bringing the overall total of

sapwood rings to 42. Because this is within the statistically accepted norm for missing sapwood rings, the latest possible felling is adjusted to 1560, a mere three years later than that postulated by Szepertyski (1999:13). Overall, the latest possible felling dates for all of the samples in this group are only slightly modified. Sample BDD2817 is moved back from 1545 to 1531, within the statistical norm, there is no change to sample BDD2816, and BDD2806 is advanced from 1557 to 1560.

Group 3: Five samples are included in this group, BDD2797, 2812, 2799, 2811, and 2813. Four of the five samples do not have sapwood (refer to Figure 4-9). The oldest timber in this group is found in sample BDD2797, which includes 132 growth rings. The first and last rings date to 1437 and 1568, respectively. While the sample does not include sapwood, the very long heartwood sequence strongly supports an accurate dating result. This sample includes 29 signature years, 4 of which have 90% agreement in their index values, further increasing its reliability for inter-dating (refer to Figure 4-7).

Samples BDD2812 and 2799 do not enjoy the same level of internal reliability. Both samples are without sapwood and have very short heartwood sequences of only 31 and 28 rings, well below the statistically viable minimum (refer to Figure 4-9). Both of these samples also suffer from only six signature years (refer to Figure 4-7). With the exception of the samples from Group 1, these two samples contain the fewest number of signature years.

With only 31 dateable rings, sample BDD2812 is one of the younger trees in the chronology. The first ring dates to 1552 and the last to 1582. Despite the small ring count, the sample does have good overlap with three samples in this group; 27 rings with sample BDD2799, 31 rings with sample BDD2811, and 31 rings with sample BDD2813,

the latter two overlapping by their entire sequence. To arrive at a last possible felling date for this tree Szepertyski (1999:13) added 10 heartwood rings, under the hypothesis of minimal removal, and a maximum of 40 sapwood rings, based upon the statistically accepted norm for trees less than 150 years. This provides a latest possible felling date of 1632. It is tempting to increase the maximum number of sapwood rings for this sample because of the very short heartwood sequence, younger trees (all other considerations being equal) having a somewhat greater proportion of sapwood to heartwood than older trees (Hilliam et al 1987:172). However, allowing for a maximum number of missing sapwood rings and minimal removal results in an overall hypothesized tree age of 81 years with nearly equal numbers of heartwood to sapwood rings. This compares very favorably with two other samples in the chronology of similar age, BDD2809 with 94 rings and BDD2806 with 84 rings. Both of these samples have complete heartwood and sapwood sequences that are divided nearly equally between the two categories. Thus, a latest possible felling date of 1632 is statistically reasonable.

A similar situation exists for sample BDD2799 with only 28 dateable rings, which overlaps by 27 rings with BDD2811, 27 rings with sample BDD2812, and 28 rings with sample BDD2813. The first ring in this sample dated to 1556 and the last to 1583. The overlap of both samples with BDD2797 is too short to be of statistical value. It is, however, the relationship of these samples to all of the others in this group that ultimately anchors these samples and produces acceptable last possible felling dates, despite their statistically questionable small number of dateable rings.

Samples BDD2811 and 2813 are closely related having heartwood sequences of 65 and 61 rings each (refer to Figure 4-9). Although less than the ideal of 80 dateable

rings, the two samples have good overlap with other samples in the group. BDD2811 has 36 overlapping rings with BDD2797, and 59 rings with sample BDD2813. While the former is less than ideal, the latter is statistically viable (Hilliam et al 1987:174-183). The first ring in this sample dates to 1533 and the last ring to 1587; within the sample's sequence are 10 signature years, providing additional support for its accurate dating (refer to Figure 4-7).

Sample BDD2813 includes the sapwood/heartwood boundary, greatly increasing the accuracy of the estimate of the last possible felling date. The first ring dates to 1530, with the first sapwood ring dated at 1574 and the last to 1591, for a total of 61 dateable rings. It has good overlapping sequences of 59 rings with BDD2811, and overlaps by 61 rings with BDD2800, which is its entire dateable sequence. Both of these fall within a statistically viable number of rings (Hilliam et al 1987:174-183). Furthermore, this sample includes 12 signature years (refer to Figure 4-7).

Three of the five timbers in Group 3 were reexamined for evidence of missing sapwood rings; the two timbers not reviewed are the hull and ceiling planks, samples BDD2811 and 2813. BDD2797, the oldest sample in the group, has a maximum of seven missing heartwood rings before the first ring in the sample. These additional rings do not alter the last possible felling date, only adjust the overall age of the tree at the time of felling by moving back its earliest date from 1457 to 1450. Sample BDD2812 did not have any missing rings; its felling date remains unchanged.

Reexamination of the timber from which BDD2799 was collected revealed that the sample was missing 18 of its oldest heartwood rings, moving the earliest date back from 1556 to 1537. It was further found to have 15 missing sapwood rings, to which is



added 25 rings to reach a maximum of 40. The addition of the missing sapwood moves back the latest possible felling date from 1633 to 1623. Once again it is tempting to increase the number of sapwood rings in the sample. However, the addition of the missing 18 older heartwood rings plus 15 sapwood rings brings the total to 86. This results in nearly equal numbers of heartwood and sapwood, which compares favorably with other samples in the chronology.

Group 4: Szepertyski places only two samples in this group, BDD2818 and 2804. Both samples have sapwood present (refer to Figure 4-9). The timber from which sample BDD2818 was collected has 83 heartwood rings plus 24 sapwood rings, for a total of 107 dateable rings. The first and last dated rings are 1528 and 1634, which places the latest possible felling date at 1651. This sample has an 86-year overlap with BDD2804 and a 70-year overlap with BDD2802, both of which are statistically viable (Hilliam et al 1987:174-183). This sample's long heartwood sequence, the heartwood/sapwood boundary, good overlap with other samples in this group and the chronology, and 17 signature years, further improves the accuracy of the chronology and dating of this timber.

Sample BDD2804 also has a long heartwood sequence containing 78 rings plus 9 sapwood rings, for a total of 87 dateable rings. The first and last rings date to 1547 and 1633. The long heartwood sequence, the sapwood/heartwood boundary, and 11 signature years supports the hypothesized last possible felling date of 1664. This sample has excellent overlap with the other samples in the chronology, including 86 years with BDD2804 and 104 years with BDD2796. When considered together, the dating of this sample is probably accurate.

Reexamination of the timber from which BDD2818 was collected revealed 15

missing sapwood rings, bringing the total number to 39 rings. Because this is so close to the statistical norm of 40 rings, a corrected latest possible felling date of 1649 is highly likely. The timber producing BDD2804 was not reexamined for additional sapwood rings.

Group 5: Five samples are included in this group: BDD2808, 2814, 2807, 2805, and 2803. None of these samples includes sapwood (refer to Figure 4-9). Based upon the hypothesis of minimal removal of sapwood and the statistically accepted maximum number of missing sapwood rings, all of the trees could have been cut a year or two before 1684. As such, they may have been selected for this ship specifically, but as likely were cut to build a ship of *La Belle's* general size. Sample BDD2808 exhibits a 70-year heartwood sequence containing nine signature years with one in the 90% category. Its long heartwood sequence and extremely good overlap with the other samples in this group in the chronology suggest an accurate date for this sample. Its first and last rings date to 1567 and 1636, respectively.

Sample BDD2814 contains 59 heartwood rings, the first and last dating to 1583 and 1641. While less than the ideal 80 rings are available, its complete ring sequence does overlap with sample BDD2803 and it has a statistically-acceptable overlap with samples BDD2807 and 2808 (refer to Figure 4-9). This sample has eight signature years, with one in the 90% category (refer to Figure 4-7).

Sample BDD2807 has a 78-year heartwood sequence containing 11 signature years with 3 in the 90% category (refer to Figure 4-7). Both the number of growth rings and the overlap with other samples are sufficient for accurate dating. In combination with BDD2808 and 2803, this sample serves to securely anchor this group within the

overall chronology. The first and last rings date to 1571 and 1648, overlapping nicely with the other samples in this group (refer to Figure 4-9).

The dating of sample BDD2805, with a heartwood sequence of only 53 years, is supported by its statistically acceptable overlap with the other samples in this group. Its first and last rings date to 1609 and 1661 (refer to Figure 4-9). It is the relationship with the other samples in the chronology and this group, coupled with 11 signature years with 2 in the 90% category (refer to Figure 4-7), that ultimately anchors the dating of this sample despite its limited number of heartwood rings.

Lastly, sample BDD2803 has the longest heartwood sequence in this group (refer to Figure 4-9). With 103 rings, this sample provides a secure foundation for comparison with the other samples both in this group and the overall chronology. Its first and last rings date to 1565 and 1667, respectively. Because it also contains 19 signature years, 5 of which are in the 90% category, it further improves the accuracy of the chronology and dating of this group of timbers.

The only sample reexamined for missing rings was BDD2805, which was missing 15 sapwood rings. The last sapwood ring appeared to be close to the cambial zone, which would place the last possible felling date for this tree at 1676. This is well within, albeit on the low side, of the statistically accepted range for missing sapwood. The cutting date for this timber may actually have been closer to 1683, however, which is consistent with the majority of the others in this group. As it is, a latest possible felling date of 1676 is a mere 7 years less and within a potential error factor for visual counts.

The timber from which sample BDD2808 was collected is the aft section of the keel (timber number 354). While the dendrochronology sample did not include sapwood

because of the limitations of the sampling process, the keel does exhibit intermittent sapwood on all the edges. This suggests the last dated heartwood ring is within ten rings of the sapwood boundary, confirming Szepertyski's hypothesis of minimal removal of heartwood in the shaping process. Adjusting the maximum missing sapwood rings to 37, based upon the 1684 construction date, places the last possible felling date at 1683.

Samples BDD2814, 2807, and 2803, were not reexamined for sapwood. They are a ceiling plank (timber number 99), a hull plank (timber number 385), and a filler piece for the main mast (timber number 67). The trees from which the ceiling plank and hull plank were produced were likely cut within a year of the construction. The small filler piece in the main mast (BDD2803) was likely a scrap of wood cut from a bulk. While the tree was probably cut just before 1684, it was not cut specifically for the construction of the ship.

Isolated Samples: Szepertyski (1999:14-15) separated 5 of the 22 dated samples and considered them as individual examples. Other than suggesting that they might be stockpiled wood, she provided no other explanation for this division.

Sample BDD2809 contains both heartwood and sapwood for a total of 94 dateable rings. This long sequence is ideal for individual dating and as a comparative marker for other samples. Its first ring dates to 1423, making it one of the oldest in the chronology. With 45 heartwood and 49 sapwood rings, the last possible felling date of 1516 is likely quite accurate, keeping in mind that younger trees have slightly greater numbers of sapwood rings in relation to their heartwood. This sample includes 18 signature years with four in the 90% category, suggesting that the dating is accurate. The timber from which sample BDD2809 was taken was reexamined for missing sapwood rings. While

no additional rings were found, this examination did reveal that the ultimate sapwood ring appears quite close to the cambial zone, further strengthening the dating results. This combination of evidence leaves little doubt about the early 16<sup>th</sup> century felling date proposed by Szepertyski (1999:14-15).

Sample BDD2800 contains the greatest number of growth rings in the assemblage. Because the sample includes 110 heartwood rings and 50 sapwood rings, its 160 dateable ring sequences made it an excellent comparative reference. Its first ring dates to 1457 and its last ring to 1616; this long sequence includes 34 signature years including five in the 90% category. In addition, it overlaps well with the other long sequences in the chronology from samples BDD2797 (132 rings), BDD2796 (134 rings), and BDD2818 (107 rings). Examination of the timber for missed rings revealed that the first ring in the sample was only seven from the center of the tree and the last sapwood ring is near the cambial zone. This moves back the earliest date to 1450 while leaving unchanged the last possible felling date of 1616.

Sample BDD2802 includes 57 heartwood and 29 sapwood rings providing a long and accurate sequence for dating (refer to Figure 4-9). The first ring dates to 1532 while its last dates to 1617. Within this ring sequence are 12 signature years that improve its accurate inter-datation (refer to Figure 4-7). While Szepertyski treats this as an isolated sample, its entire 86-ring sequence overlaps with sample BDD2800; it also has a 70-year overlap with sample BDD2804. This lengthy overlap is ideal from the standpoint of the statistical reliability of its dating, for which Szepertyski (1999:15) hypothesized a latest possible felling date of 1628. Reexamination of the timber from which sample BDD2802 was collected revealed an additional seven sapwood rings, the last of which appears close

to the ultimate ring. This finding only slightly adjusts the hypothesized felling date, reducing it to 1624. This is within the statistically accepted range for maximum missing sapwood rings and so 1624 is the likely felling date.

Several samples collected for dendrochronology analysis had extremely long ring sequences, BDD2796 is one of these with a total count of 134 rings (refer to Figure 4-9). Included within its 94 heartwood and 40 sapwood rings are 24 signature years, 4 of which are in the 90% category (refer to Figure 4-7). The first ring in this sample dates to 1530 and the last, which upon reexamination of the timber proved to be near the ultimate sapwood ring, dates to 1663. With this long dateable sequence, this sample is clearly a reference to which others in the chronology were compared. Further its long sequence overlaps samples BDD2800 by 86 rings, BDD2818 by 104 rings, and BDD2803 by 96 rings making this an excellent sample for inter-dating and chronology building. This combination of heartwood and sapwood, good overlap, and number of signature years, argues strongly for its accurate dating. Reexamination of this timber for additional heartwood and sapwood rings revealed that the ultimate sapwood ring is extremely close to the cambium, confirming its felling date of 1663.

Sample BDD2798 does not include sapwood, but with 81 heartwood rings it is an easily dateable timber. The first ring dates to 1544 and the last to 1624, so Szepertyski (1999:15) postulated a last possible felling date of 1674. This sample overlaps both BDD2818 and 2796 by its entire ring sequence, and overlaps BDD2803 by 60 years. Each of these overlapping sequences is statistically viable. This sample contains nine signature years, providing good internal cross dating. Examination of the timber for missing rings revealed 16 sapwood rings, the last of which is close to the cambial zone.

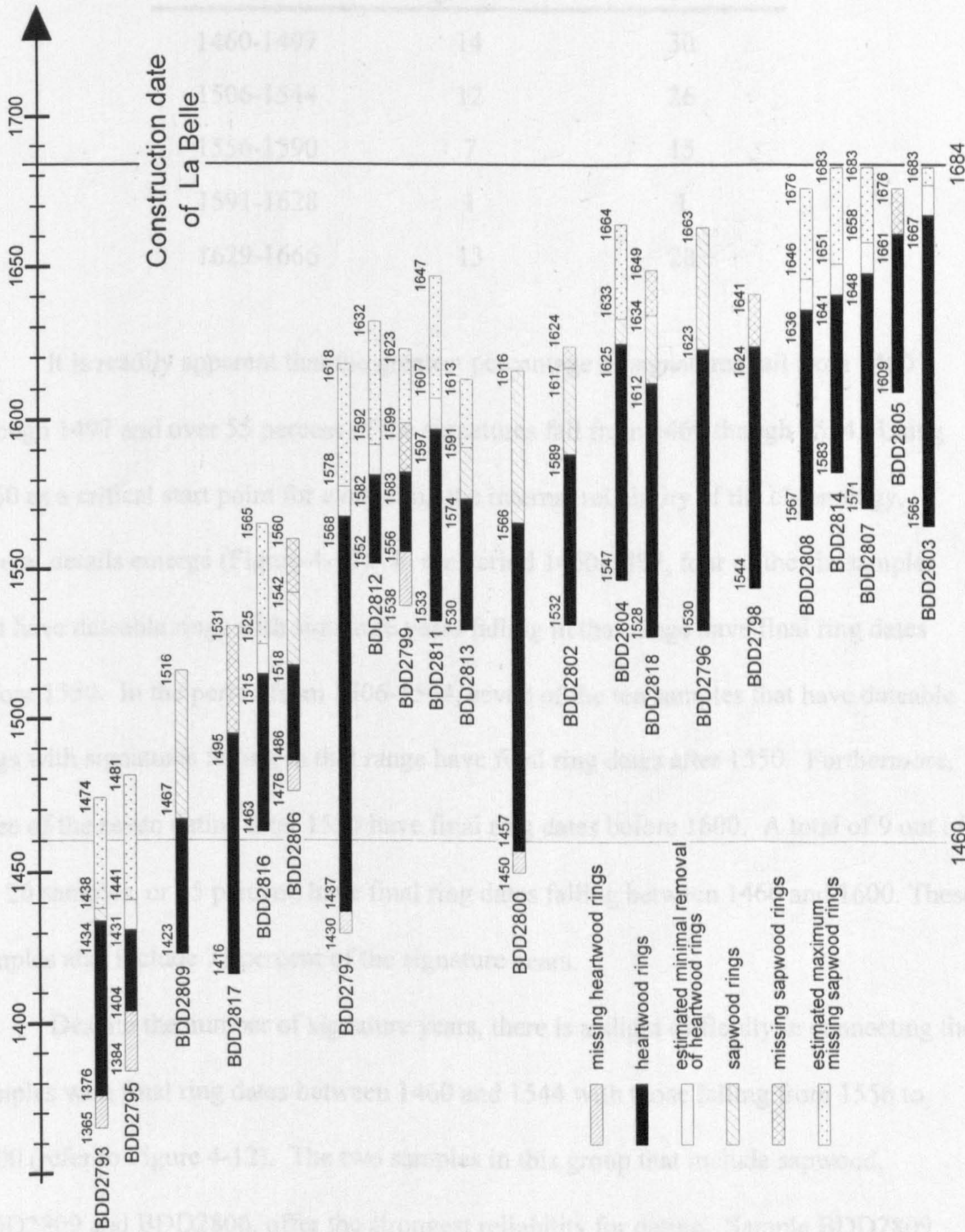
For this reason no additional sapwood rings were added. This modifies the last possible felling date from 1674 to 1641, which falls within the statistically accepted range for missing sapwood. The long sequence and good overlap, coupled with the additional rings, suggest that 1641 is an accurate felling date.

Figure 4-10 modifies the results provided by Szepertyski in Figure 4-9 with missing heartwood or sapwood rings and adjusts the first and last possible felling dates. With these adjustments, the latest felling dates for the samples clearly group into the late 15<sup>th</sup>, 16<sup>th</sup>, and 17<sup>th</sup> centuries.

### **Site Chronology**

Careful evaluation of each sample based upon the number of dateable and overlapping rings and number of signature years is fundamental for an overall evaluation of the site chronology, and it is the site chronology that must be confirmed to support the dating results. One of the problems inherent in the dating of the Group 1 samples, all with final dated rings in the 15<sup>th</sup> century, is the single signature value in 1426. That value falls at year 50 in the chronology and is separated by 33 years from the next signature year. The only other single detached signature appears in 1616, which is separated by 26 years from the previous signature year and by 12 from the next. However, unlike Group 1, none of the samples are dependent upon this single signature year for their dating. Figure 4-11 groups the signatures by felling year based upon the number of signature values present.

**Figure 4-10: Modified Synchronization and Dating of *La Belle* Hull Samples**





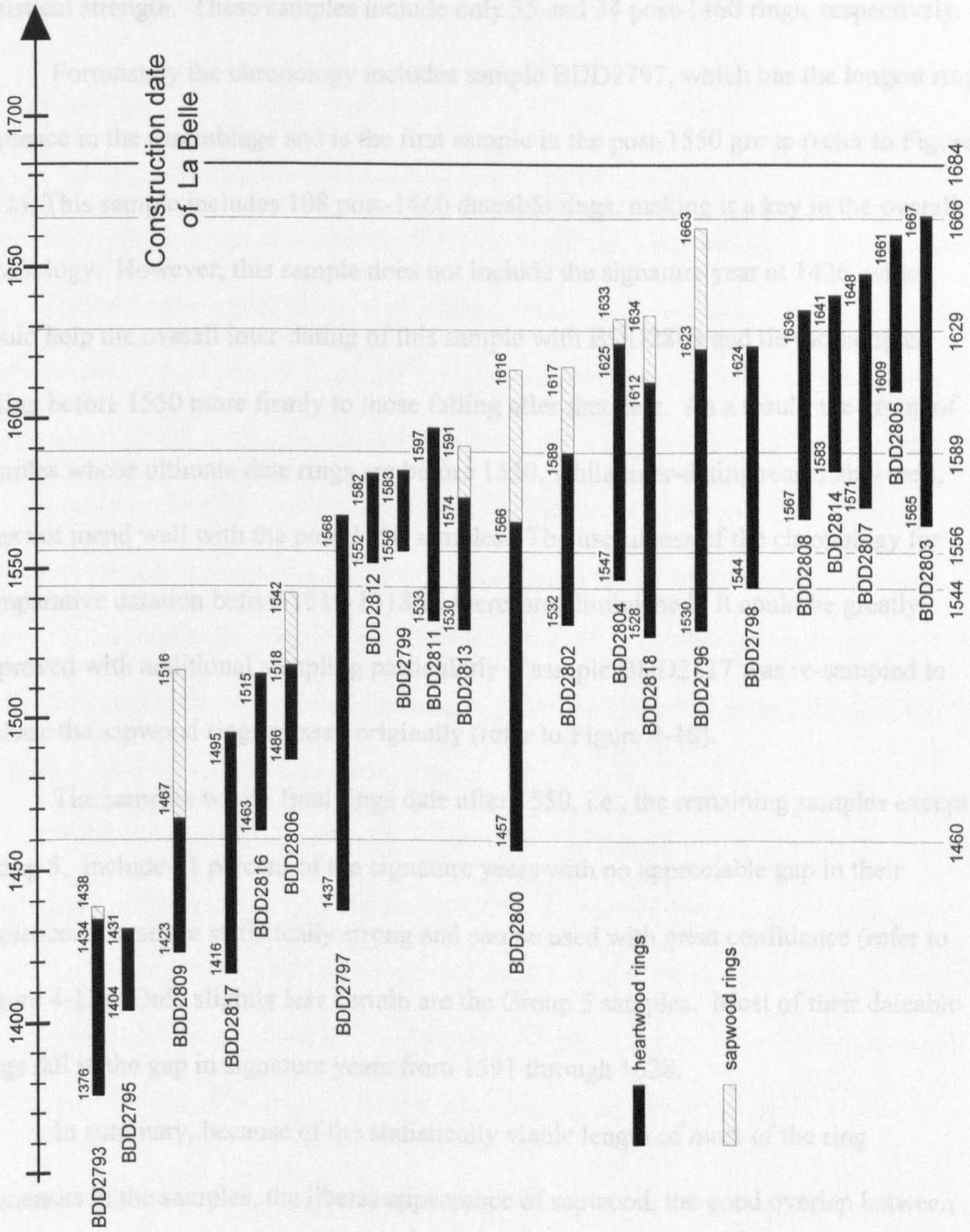
**Figure 4-11: Percent of Signatures by Subgroup**

Year	Number of Signatures	Percent of Total
1460-1497	14	30
1506-1544	12	26
1556-1590	7	15
1591-1628	1	1
1629-1666	13	28

It is readily apparent that the greatest percentage of signatures fall from 1460 through 1497 and over 55 percent of the signatures fall from 1460 through 1544. Using 1460 as a critical start point for evaluating the internal reliability of the chronology, several details emerge (Figure 4-12). In the period 1460-1497, four of the six samples that have dateable rings with signature years falling in that range have final ring dates before 1550. In the period from 1506-1544, seven of the ten samples that have dateable rings with signatures falling in that range have final ring dates after 1550. Furthermore, three of the seven dating after 1550 have final ring dates before 1600. A total of 9 out of the 20 samples, or 45 percent, have final ring dates falling between 1460 and 1600. These samples also include 71 percent of the signature years.

Despite the number of signature years, there is a slight difficulty in connecting the samples with final ring dates between 1460 and 1544 with those falling from 1556 to 1600 (refer to Figure 4-12). The two samples in this group that include sapwood, BDD2809 and BDD2806, offer the strongest reliability for dating. Sample BDD2809 contains only 46 post-1460 dateable rings and sample BDD2806 contains only 57. In

**Figure 4-12: Dateable Ring Sequence with Index Values**



addition, the two samples overlap by a statistically weak 29 rings. The inclusion of the other two samples from this group, BDD2817 and 2816, does little to improve the overall statistical strength. These samples include only 35 and 34 post-1460 rings, respectively.

Fortunately the chronology includes sample BDD2797, which has the longest ring sequence in the assemblage and is the first sample in the post-1550 group (refer to Figure 4-12). This sample includes 108 post-1460 dateable rings, making it a key in the overall chronology. However, this sample does not include the signature year at 1426, which would help the overall inter-dating of this sample with BDD2809 and tie the samples falling before 1550 more firmly to those falling after that date. As a result, the group of samples whose ultimate date rings are before 1550, while inter-dating reasonably well, does not mend well with the post-1550 samples. The usefulness of the chronology for comparative datation before 1516-1518 is, therefore, diminished. It could be greatly improved with additional sampling particularly if sample BDD2817 was re-sampled to include the sapwood rings missed originally (refer to Figure 4-10).

The samples whose final rings date after 1550, i.e., the remaining samples except Group 5, include 41 percent of the signature years with no appreciable gap in their sequence. These are statistically strong and can be used with great confidence (refer to Figure 4-12). Only slightly less certain are the Group 5 samples. Most of their dateable rings fall in the gap in signature years from 1591 through 1628.

In summary, because of the statistically viable length of most of the ring sequences in the samples, the liberal appearance of sapwood, the good overlap between samples, and number of signature years in the majority of samples, the overall dating results in the chronology are both accurate and consistent, even if surprising. Those

samples with final ring dates in the 15<sup>th</sup> century are highly suspect. Those in the first half of the 16<sup>th</sup> century should be use with a degree of caution but are internally statistically viable; the remainder can be used with confidence.

### **Age of the Trees**

Although the latest possible felling date of two of the trees from which the dendrochronology samples were collected is not resolved, what is clear is that many trees were of considerable age at the time of felling. As noted elsewhere, an extra effort was made to select for analysis timbers from each of the three age groups identified during the visual count: 30-60, 61-80, and greater than 90 rings. This careful selection attempted to avoid a sampling bias in favor of older trees; the success of which is reflected in the laboratory results in Figure 4-13. Nine of the 26 samples had ring counts less than 60 (35%), 10 had counts between 61 and 89 (38%), and 7 had counts greater than 90 (27%). Even allowing for the demands of choosing appropriate timbers, the samples were nearly equally divided among the three categories.

A tabulation of maximum ring counts<sup>4</sup> revealed that 16 of the 26 samples were from trees having more than 100 rings (Figure 4-13). Four of the samples were from trees that have a maximum ring count between 90 and 99, four of the samples were from trees with a maximum count between 80 and 89, one sample was from a tree with a maximum count between 70 and 79, and one sample was from a tree with a maximum count

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<sup>4</sup> This includes growth rings measured by the laboratory, missing sapwood and heartwood rings found during re-examination of the timber but not characterized by the laboratory, an allowance for minimal removal of heartwood, and maximum number of sapwood rings.

**Figure 4-13: Maximum Possible Ring Count of *La Belle* Samples**

Laboratory Number	Measured Growth Rings	Missing Heartwood/Sapwood from Sample	Maximum Missing Rings	Maximum Possible Rings
BDD:2793	63	11 heartwood	36	110
BDD:2794	98	none	50	148
BDD:2795	28	20 heartwood	50	98
BDD:2796	134*	none	n/a	134
BDD:2797	132	7 heartwood	50	188
BDD:2798	81	16 sapwood*	n/a	98
BDD:2799	28	18 heartwood/15 sapwood	25	86
BDD:2800	160*	7 heartwood	n/a	167
BDD:2801	59	2 heartwood/18 sapwood	22	101
BDD:2802	86	7 sapwood*	n/a	93
BDD:2803	103	none	16	119
BDD:2804	87	none	31	118
BDD:2805	53	15 sapwood*	n/a	68
BDD:2806	57	10 heartwood/18 sapwood*	n/a	84
BDD:2807	78	none	35	113
BDD:2808	70	10 heartwood	37	117
BDD:2809	94*	none	n/a	94
BDD:2810	44	none	34	78
BDD:2811	65	none	50	115
BDD:2812	31	none	50	81
BDD:2813	61	none	22	83
BDD:2814	59	none	43	102
BDD:2815	65	none	50	115
BDD:2816	53	none	50	103
BDD:2817	80	35 sapwood*	n/a	115
BDD:2818	107	15 sapwood*	n/a	122

\* last sapwood ring at cambial zone, therefore no additional rings are added

between 60 and 69. Because each ring represents a year of growth, 62 percent of the samples came from trees more than 100 years of age, 76 percent of the samples came from trees greater than 90 years, 92 percent came from trees greater than 80 years, and a full 96 percent of the samples came from timbers harvested from trees greater than 70 years of age. Given the apparent pressure on the Rochefort forests, this might suggest a sophisticated approach to forestry management at the resource end, a well-organized system of tree selection by the timber merchants, and a highly organized shipyard at the manufacturing end.

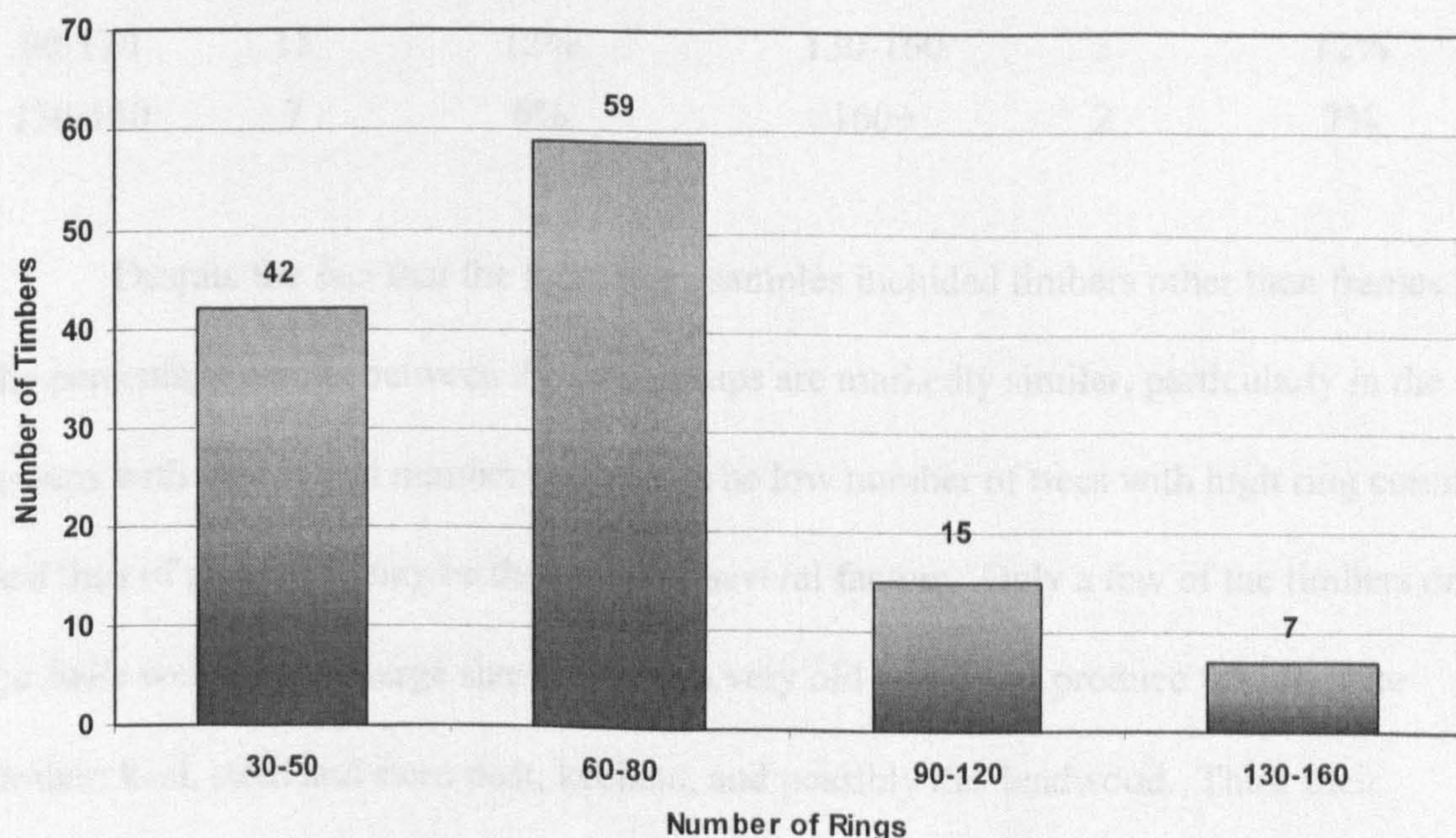
It is recognized that for oak to attain sufficient size for ship construction a minimum number of years must pass; this is generally accepted to be 40. Once past this minimum, however, the trees that are harvested must possess specific qualities that make them suitable for construction. For *La Belle* all of the trees in the sample group have corrected maximum tree ring counts of 60 years or greater; this immediately raises two questions. First, what are the general ages of the timbers used in *La Belle*? Second, was there a selection in the forest for trees of a certain age for specific uses?

While there are laboratory ring counts for only a fraction of the frame elements from *La Belle*, preliminary counts were made of all these timbers as part of the selection process for the dendrochronological analysis. The accuracy of the visual count, based upon follow-up examination, is  $\pm 8$  rings in timbers containing up to 80 rings and  $\pm 10$  rings in timbers with rings greater than 80. It should also be noted that none of the samples were identified in the laboratory as having cambium present (refer to Figure 4-8). Although there is a margin error in this approach, nonetheless, these ring counts are adequate as relative indicators. The frames are also the largest group of timbers in the

ship, therefore, evaluation of the ring counts can provide a reliable statistical sample within the limits of this approach. It should be noted that not all of the timbers were well enough preserved to obtain viable ring counts, however 123 of a total possible 133 frame elements were counted representing 93 per cent of the frame components.

Using uncorrected and unadjusted ring counts for the floors and futtocks, the timbers were sorted into groups based upon ring counts (Figure 4-14). The results reveal that these timbers fall into four main groups 30-50 rings, 60-80 rings, 90-120 rings, and 130-160 rings. Most of the timbers clearly fall into the 60-80 range with 59 timbers, followed closely by 42 timbers with 30-50 rings. These represent 48 percent and 34 percent of the total, respectively. The two groups with the highest ring counts, those with 90-120 rings and those with 130-160 rings, contain 15 and 7 timbers, representing only 12 percent and 6 percent of the total.

**Figure 4-14: Uncorrected Tree Ring Counts for La Belle Floors/Futtocks**



The question that immediately arises is whether this result simply an aberration, or do these percentages accurately reflect the timber ages in the ship? A comparison to the counts from the laboratory-sampled timbers (refer to Figure 4-13) is revealing. It must be kept in mind that the uncorrected group does not factor in rings added under the hypothesis of minimal removal (10 rings) or maximum missing sapwood rings (40 rings). Further, none of the laboratory sampled timbers have maximum possible ring counts below 60, so the lowest count category from the uncorrected group (30-50 rings) is dropped. Similarly, none of the uncorrected timbers have counts greater than 160, so adding an upper category is necessary (160+).

**Figure 4-15: Comparison of Uncorrected and Laboratory Counted Timbers**

Uncorrected Frame Components			Laboratory Sampled Timbers		
Number of Rings	Number of Timbers	Percentage of Total	Number of Rings	Number of Timbers	Percentage of Total
30-50	42	34%	60-80	6	23%
60-80	59	48%	90-120	15	57%
90-120	15	12%	130-160	3	12%
130-160	7	6%	160+	2	7%

Despite the fact that the laboratory samples included timbers other than frames, the percentage results between the two groups are markedly similar, particularly in the groups with the highest number of rings. The low number of trees with high ring counts, and thus of great age, may be the result of several factors. Only a few of the timbers on *La Belle* were of such large size that only a very old tree could produce the requisite timber: keel, stem and stern post, keelson, and possibly the deadwood. Thus, their relative numbers in the ship are quite low. Further, trees of great chronological age are



the fewest in the forest overall; presumably as soon as a tree was mature, it was considered for cutting to meet the demands of the yards. Of the trees that do reach 130 years or more, some were likely left uncut to serve as standards to help replenish the forest or may have been passed up because of insect infestation, inappropriate shape, or heart rot. Therefore, the low number of timbers with the greatest number of rings is not surprising. Because the percentages between the uncorrected and sampled timbers are so similar, this suggests that, at least in these two groups, the results are statistically viable.

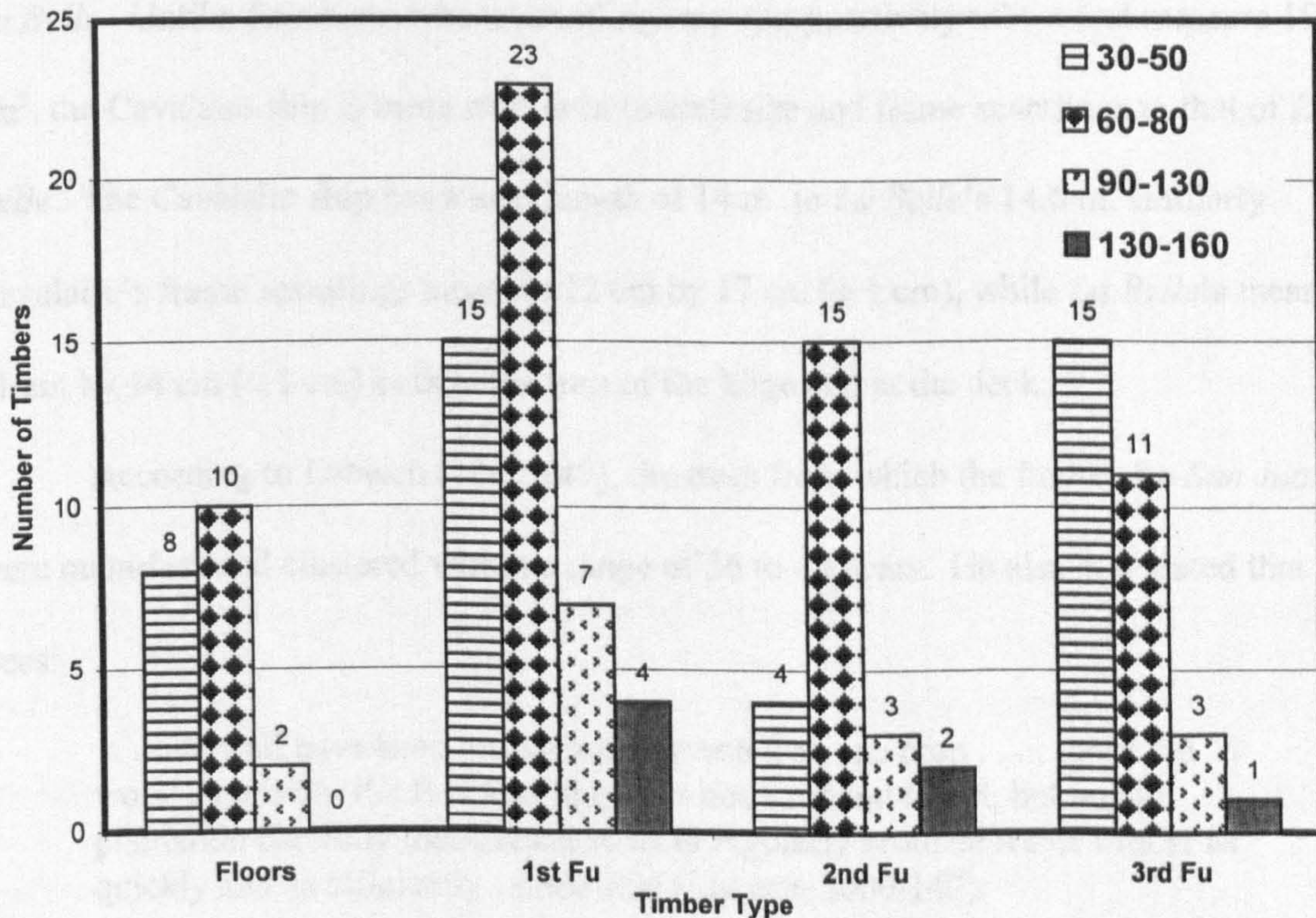
The relationship between the groups with the next highest ring count, those in the uncorrected category with 60-80 rings and those in the laboratory samples with 90-120 rings, is intriguing. In both groups these timbers are the greatest percentage; the difference between the uncorrected and laboratory groups is roughly 10 percent. What may be more relevant, is that these two groups are the clear leaders in relative numbers. This suggests trees of this age have attained a suitable size so that they can be used for a large variety of timbers in a ship. These may be the ideal timbers for the ship construction, large enough to produce plenty of timber of various shapes and sizes, and numerous enough to permit regular harvest.

The relationship between the two groups with the lowest ring counts, those with 30-50 rings in the uncorrected category and those with 60-80 rings in the laboratory samples, is surprisingly similar to that of the previous group. In both cases, these timbers are the next most frequently used and the differences between the uncorrected group and the laboratory group is roughly 10 percent. Clearly, trees in this age group are not overlooked in the forest because they too can provide a variety of timbers for ship construction.

Because the uncorrected group has a greater number in the 30-50 ring category than the laboratory group has in its counterpart at 60-80 rings, this may be an artifact of the sampling process. The samples included only frame elements on the one hand and a broader selection of timbers on the other. Nonetheless, it is reasonable to suggest that the overall percentage relationship between the uncorrected frame components and the laboratory samples are statistically viable.

Given these findings, the second question regarding selection of trees of a certain age for specific uses is relevant. Because of the limitations of the sampling process, only the frame components can be evaluated by function and age. In Figure 4-16 the function of the timber was correlated with their uncorrected age.

**Figure 4-16: Comparison of Uncorrected Tree Ring Counts By Timber Type**



There is a clear preference for trees in the 60-80 year category from the floors through the second futtocks, with a strong secondary preference for trees from 30-50 years. This trend is reversed in the third futtocks, where younger trees were preferred. Reflecting this preference, only 10 percent of the floors, 22 percent of the first futtocks, 21 percent of the second futtocks, and 13 percent of the third futtocks came from trees in the 90-160 category.

These findings differ from two other shipwreck sites that have been similarly examined for tree age and timber use applying visual counts: the Basque ship *San Juan* (1565), found in Red Bay, Labrador, and the Cavalaire-sur-Mer shipwreck (1470) off the coast of Provence, France. The Cavalaire-sur-Mer ship, also believed to be Basque-built, was dismantled and recorded in laboratory conditions similar to that of both *San Juan* and *La Belle*. Unlike *San Juan*, whose scantlings are comparatively robust and measure 19 cm<sup>2</sup>, the Cavalaire ship is more similar in overall size and frame scantlings to that of *La Belle*. The Cavalaire ship has a keel length of 14 m to *La Belle*'s 14.6 m, similarly Cavalaire's frame scantlings measure 12 cm by 17 cm ( $\pm 1$  cm), while *La Belle*'s measure 11 cm by 14 cm ( $\pm 1$  cm) both at the turn of the bilge and at the deck.

According to Loewen (2000:147), the trees from which the frames for *San Juan* were manufactured clustered within a range of 36 to 40 years. He also postulated that the trees:

. . . may all have been grown and harvested as one crop . . . [and] the wood supply for the Red Bay ship was not a natural forest, but an oak plantation carefully maintained so as to regularly produce frame timber as quickly and as efficiently as possible (Loewen 2000:147).

The ages for the Cavalaire ship frames exhibit a similar tight cluster at  $65 \pm 5$  years for 39

out of 54 timbers (72 percent); this remains fairly constant in all three categories studied: floor timbers, first futtocks, and second futtocks. Loewen (2000:148) suggested these timbers:

. . . paint a picture of a controlled oak population where about three quarters of the required pieces were harvested at about 65 years of age, and the remaining pieces were obtained from trees aged from 40 to 80 years. Such a population could only have been found in a plantation environment.

The timbers from *La Belle* do not reflect the same pattern (refer to Figures 4-15 and 4-16). Although there is a preference for timbers 60 to 80 years ( $70 \pm 10$  years), it is not as narrowly defined as that presented by *San Juan* or *Cavalaire*. Rather the pattern of timber selection is more equally divided across the timber supply for mature trees, i.e., between 30 and 80 years. In *La Belle*'s frames 34 percent come from trees 30-50 years and 48 percent come from trees 60-80 years (refer to Figure 4-15). If the pattern presented by the *Cavaliare* ship and *San Juan* suggest a plantation environment, then it is reasonable to suggest that the timbers from *La Belle* came from a forest that was not similarly managed. It is more likely that the forest was in transition from a natural to a managed environment as reliable supplies of appropriate timbers became harder to obtain.

### **Frame Shape and Forestry Practices**

If the trees for *La Belle*'s frames came from a forest in transition, is this reflected in the finished frames? Four elements were examined for each frame timber that relate to forestry practices: shape; location of the sapwood, waney and degraded wood; end grain; and tree diameter.

The first consideration is whether the frames exhibit a close relationship between

the sculpted arc of the finished timber and the natural curvature of the parent tree. This relationship was revealed by following the grain of the wood along the timber's shape and noting where the areas of waney wood occurred along each of the edges. Loewen (2000:145) described the results for *San Juan*:

In a curved timber such as a first futtock, which formed the turn of the bilge and the flaring section of the hull, the waney edges were concentrated in two areas along the length of the timber. Near the middle [of the timber], the waniness occurred on the two outboard edges, on each side of the convex face of the timber. This finding reveals that the relatively sharp curve of the futtocks was difficult to find in an oak and the original shape of the tree was slightly less curved than the eventual timber. Accordingly, waney edges were also preserved toward the ends of the timber, but on the inboard edges, that is on the concave of the timber.

This pattern is consistent with that found on *La Belle*, suggesting that the parent trees were less curved than the final shape of the futtock. This is true not only of the deeply curved first futtocks in the middle of the ship, but for the S-shaped first futtocks at the gripe and tuck and for the second futtocks.

Further evidence of this phenomenon is the relationship between the grain and the molded face. Examination of the starboard side first futtocks, which are the most complete and able to provide the most accurate information on grain, revealed that most often the grain was cut through by the mold. The grain regularly runs out at the turn of the bilge, shifting to just above or below that location as the curve of the futtock flattens moving away from the central flat. The problem of obtaining timber of the correct shape and length was described in the early 18<sup>th</sup> century:

For the same shape of hull, the English shipwrights use timber with lesser compass than that which we employ for our frames. The method which we employ . . . obliges us to use for them neither timber where the grain is too much cut, nor timber which is too short . . . The English shipwrights . . . are able to employ with equal success any timbers which

fall to hand, and that the grain of the timber should be followed or cut through by the mold matters not, so long as they are able to find the outside profile of the mold in the timber which they are working . . . in England as in France straight timbers are more readily to be found than timbers of sufficient compass . . . Were we able to imitate the English shipwright . . . we should also gain the advantage of being able to do without a great quantity of compass timber which is so indispensably necessary to our method (Ollivier 1737:67).

In the case of *La Belle*, this meant taking every advantage of the characteristics of the parent tree in fashioning a timber. With regard to forestry practices, this raises the issue of reliable supplies of trees in commercially viable quantities for shipbuilding, i.e., natural versus plantation environments. This relationship was addressed by measuring the offset of the curve of the first futtocks in the middle of the ship, near the quarters and at the stern. Although appearing pronounced, by drawing a line from one end to the other of the timber the central part was found to be offset from this line by only 15 to 35 cm. This contrasts sharply with the frames from *San Juan* where the offset was 50 to 70 cm (Loewen 2000:145).

Loewen (2000:145) noted that European oak trees today with a diameter of 30 cm and a length of 3 to 4 meters do not naturally occur with a curve that would result in an offset of 50 to 70 cm. He reasons that the trees from which the *San Juan* timbers were fashioned must have been trained to almost the precise shape required and were, therefore, from a plantation. Because the timbers from *La Belle* exhibit a curve offset of less than half of those from *San Juan*, it is reasonable to suggest they were fashioned from trees grown in a natural, i.e., non-plantation, environment.

The second consideration is whether a finished frame piece represented the entire section of trunk or branch. This was revealed by examining the end grain of each timber

and noting the location of the pith. In the *San Juan* study, Loewen (2000:145) found those timbers using the entire tree exhibited the pith in the center at the end, while those timbers representing half a tree's section had the pith offset to one side. Thus the majority of the frame timbers were fashioned from the entire section of trunk or branch and only a handful (six timbers) represented half a tree's section.

This [finding]. . . was confirmed by the presence of "waney edges" along the timber, that is, areas along the length of the timber where the normally-squared edges retained the natural roundness of the tree. When an entire tree had been used to make up the timber, "waniness" was observed on all four edges of the timber at some point along its length. In the case of the six half-sections, the waniness was observed along only two edges (Loewen 2000:145).

By comparison, examination of the end grain for *La Belle*'s frame timbers revealed that the pith was offset to one side in 90 of the 116 timbers (78 percent) where it was possible to study this feature. In only 21 of the timbers (18 percent) was the pith located in the center, and in 5 timbers (4 percent) the pith was not present in the surviving section. Further, waney edges were rarely found on all four edges of the timbers. While it might be suspected that only half of the tree was used in all 90 cases where the pith was offset, examination of the timbers revealed that in order to manufacture a timber of the correct shape most of the tree trunk or branch was required, resulting in wasted wood.

The third consideration is the correspondence of the tree's original diameter, not including the bark, to the finished timber. This was revealed by measuring the radius from the pith out to the waney edge at one end for each timber. In this manner it was possible to measure the radius of 121 of 133 timbers. For 86 of the 95 measurable futtocks the diameter was 25 cm ( $\pm 5$  cm), while for 14 of the 26 measurable floors the diameter was 30 cm. The scantlings for the frames were 11 cm x 14 cm ( $\pm 1$  cm) both at

the turn of the bilge and at the level of the clamp. When compared to the two predominant tree diameters, it reveals that at the finished section accounted for less than 50 percent of the parent tree's diameter and unless other uses could be made of the excess wood, a good deal of waste. This contrasts sharply with *San Juan* whose finished timbers consumed more than 50 percent of the parent tree (Loewen 2000:146).

When these elements are considered together, they suggest that 17<sup>th</sup>-century shipbuilders at Rochefort had access to a timber supply that was adequate but not ideal. First, the trees were not grown in a plantation environment and selection was more problematic because they had to take advantage of the natural curvature of trees rather than trees whose shape was created by the timber grower. Second, while one tree produced one large timber the use of naturally grown rather than trained trees resulted in less effective use of each tree. Third, because the timbers came from trees whose diameter was on average 50 percent greater than the finished section, there was a good deal of waste. In summary, while the timbers were coming from small forest tracts, they were not grown to meet the specific needs of the shipbuilding industry. Furthermore, the data suggest that far from being harvested in an uncontrolled manner the shipwrights and timber merchants were thoroughly exploring the forests to find suitable naturally grown trees.

### **Decline in Forest Stock**

When Colbert assumed control of the French forests in 1661, they were judged by many contemporary authors to be in poor condition. The surveys of 1663 found a disparity in the condition of the forests in the various regions, ultimately leading to the



Ordinance of 1669 and efforts to control and improve their condition. However, the decision to create a Royal shipyard at Rochefort in 1666 clearly suggests that the forests in that region could support such a venture. Although the forests in the Rochefort region did not come under any concerted control until 1702, they were still ostensibly producing timbers of great age and variety of shapes in support of a bustling and vibrant shipyard. This suggests that despite some problems those forests were an extremely rich and deep resource in the last four decades of the 17<sup>th</sup> century. While written accounts do describe a general decline in forest stocks in 17<sup>th</sup> century France, it is not known if this decline was also felt in Rochefort. The dendrochronology results shed some surprising light on this question (refer to Figure 4-10).

The three samples that were collected from first futtocks have maximum possible ring counts of 167, 134, and 86, placing them into the two highest ring count categories. The oldest timber, BDD2800 with 167 rings, also happens to be the oldest of the three with an estimated date of felling of 1616. The middle timber, BDD2796 with 134 rings, has an estimated felling date of 1663. However, the youngest timber, BDD2799 with only 86 rings, has an estimated felling date of 1623, falling between the two samples.

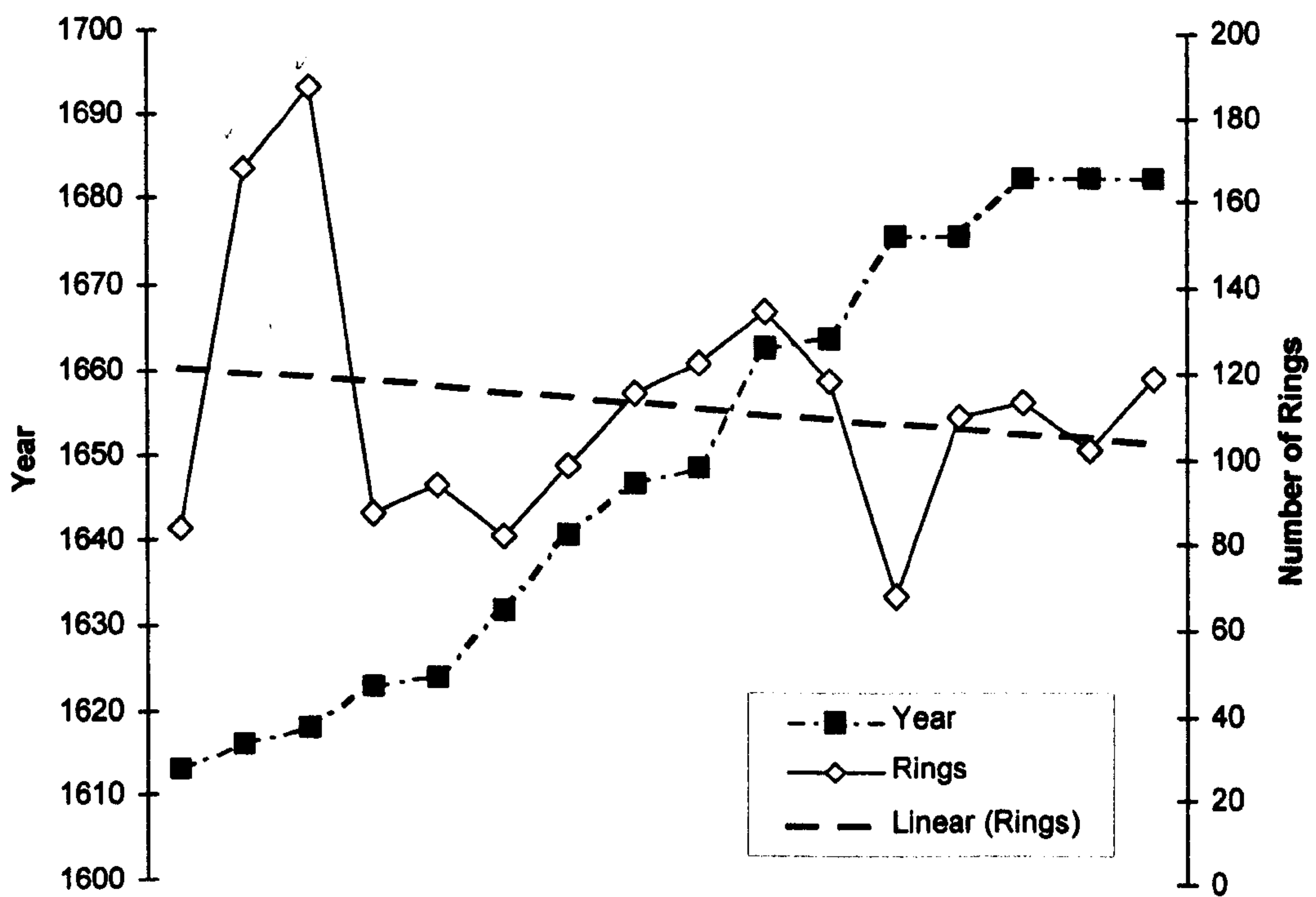
Three samples from second futtocks have ring counts of 186, 98, and 84. The oldest timber in the laboratory group, BDD2797 with 189 rings, was felled about 1618. The middle timber, BDD2798 with 98 rings, was felled about 1641. The youngest timber, BDD2806 with 84 rings, was felled in the 16<sup>th</sup> century and so is not a factor in the felling pattern in the 17<sup>th</sup> century.

The three floors sampled have maximum ring counts of 93, 81, and 68. The oldest timber, BDD2802 with 93 rings, has the earliest felling date at 1624. The middle

timber, BDD2112 with 81 rings, has a felling date of 1632. The youngest timber in the group, BDD2805 with 68 rings, is the most recently felled dating to 1676.

These results are intriguing because of their apparent ring-to-year-of-felling correlation; that is, the oldest trees chronologically are being cut the earliest in the 17<sup>th</sup> century and the youngest trees chronologically are being cut latest in the 17<sup>th</sup> century. This suggests an overall decline in the age of trees at the time of felling. While interesting, this may be an artifact of the frames and not reflect a larger pattern. Using a simple correlation/regression analysis with a linear trend line (calculated using least squares), a more in depth evaluation of all of the timbers dated to the 17<sup>th</sup> century was undertaken.

**Figure 4-17: Comparison of Year of Felling and Tree Rings**



The results in Figure 4-17 show that the decline, although not precipitous, was emerging. The average number of rings dropped from 120 at the beginning of the century to 105 by 1684. Was *La Belle*, however, a typical ship or is another interpretation possible? Based upon the species identification, the timbers used accurately reflect varieties of trees used in ship construction in 17<sup>th</sup>-century France. The results of the dendrochronological analysis provide clear evidence that many of the timbers came from the Rochefort region. Therefore, this ship can be considered a representative product. Because there is nothing to suggest the timbers used were anything but representative, then it is reasonable to suggest that the decline in the age of trees at the time of felling reflect a nascent pattern of decline in regional forest stocks. These results also support the finding that the majority of trees supplying the Rochefort arsenal were coming from a natural environment that, for the near term, still retained sufficient numbers of old trees to meet many shipbuilding needs but was showing signs of stress.

The point at which the line indicating year of felling crosses the line indicating number of rings is 1656. This date is six years before Colbert assumed administration of the forests and ten years before establishment of the Rochefort yard, inaugurating an intensive shipbuilding campaign. By 1680, as shipbuilding rapidly accelerated, it led to the planting of trees in Royal oak forests creating plantation environments that could provide timbers of the appropriate shape and size in commercially supportable quantities.

Trees older than 100 years were critically important for naval construction. The royal forests of Vierzon, where the age of exploitation ranged from 150-200 years in Colbert's day, was almost entirely reduced to coppice by 1780 with an age of exploitation of 25 years. In the forests of Haguenau, harvests in 1674 were limited to trees 200 years

old, extended to include trees of 150 years old in 1750, and by 1782 was reduced to include trees not more than 60 years old (Huffel 1926, III:183, 185n). The implications for the future of the Rochefort arsenal were, apparently, predestined to include the potential for local timber shortages and a necessity to import timbers for ship construction.

These results also illustrate a sophisticated approach to the management of the many small forest plots in the Charente River basin. This requires a thorough knowledge of both the forest, likely down to individual trees, and the requirements of shipbuilding. Thus, the timber contractors and the forest owners were forced to work closely together; the former to meet the increasing demands of the shipyard, the latter to find suitable trees while not stripping the forest bare and losing a major source of income.

The presence of so many first futtocks that have the grain cut by the mold and are not finished on their ends, the composite floors in the stern, the use of small filler pieces in the forward mast step and elsewhere, looking much like scrap, all lead to the inescapable conclusion that the shipwrights were both creative and adaptable, using the available timber to its greatest possible extent, but not having timbers ideally suited for all of their needs. This being the case, there is every reason to believe that timbers from dismantled ships would be reused in the construction of new ships.

### **Reuse of Timbers**

The dating results of the samples from *La Belle* are unquestionably thought provoking. Based upon their reevaluation for missing sapwood and heartwood rings (refer to Figure 4-10) 11 of 15 confidently-dated samples have their last possible felling

date prior to 1665. Because of the long history of harvesting trees in the Rochefort region for ship construction, this finding is not remarkable. However, to postulate that felled trees remained in the forests from 30 to 65 years before their first use, particularly given the clearly demonstrated need for ship timbers, seems unrealistic. If these early felling dates simply reflect stockpiling, it should be remembered that timbers having their last possible felling dates of 1663 and 1664 (BDD28804 and BDD2796) would have required storage for 20 years before first use. Given that twenty years was a reasonable life-span for a ship in the late 17<sup>th</sup> century, these timbers could easily be recycled and reused.

Finally, the statistically strong dating of timbers other than the frames should be considered. The lower stringer on the starboard side dates to 1565, the main mast partner on the starboard side dates to 1664, and the main mast buttress on that same side dates to 1649. One of the two ceiling planks sampled dates to 1613, one of the two hull planks sampled dates to 1647, and the central section of the keelson dates, however tentatively, to 1516. The mixing of old and new timbers is amply demonstrated by the aft section of the keel, a second ceiling plank, a hull plank, and the main mast filler, which all date to 1683. If *La Belle* was a completely new ship, rather than a ship incorporating used timbers, then nearly all of the timbers should have dated to the few years just prior to its construction.

As more thoroughly discussed elsewhere, reuse must be based upon a variety of factors, not just dating. In this context, however, it is entirely reasonable that some of *La Belle*'s timbers had a different provenance.

## **Climatological Inferences**

Not surprisingly, both regional climatic variation and immediate growth environment play a key role in the development of tree rings. In oak, normal year to year variations in precipitation is reflected in the width of tree rings and is characterized as their mean sensitivity measurement. A period of low precipitation that continues for more than a year results in groups of narrow rings, while good drainage and regular rainfall results in groups of wide, evenly spaced rings. A tree growing under a dense canopy with low light penetration forms narrow rings, while a tree grown in a more open environment with full light has wider rings. Trees growing in the same environment will exhibit very similar tree ring growth, which can be related to a regional norm that can help to localize the forest from which a particular tree was harvested.

The mean sensitivity measurement connects the year-to-year variations of the width of the rings to the dendrochronology sequence. Because the variability of this measurement is directly influenced by climatic variation and environment, this measurement provides a wider characterization of the influence of the climate on the dendrochronology profile. For example, a mean sensitivity measurement of .5 mm/year indicates a very closed environment with strong competition. A measurement of 1.0 mm/year indicates a closed environment with competition, and a measurement of 2.0 mm/year suggests a moderately open environment with some competition. While, a measurement of 2.5 mm/year indicates an open environment with no competition, a measurement of 4.0 mm/year shows a very open environment with no competition, and a measurement of 5.5 mm/year indicates an isolated tree.

A second evaluation method, called auto-correlation is also used to evaluate the

relationship between tree rings and the dendrochronological sequence. It evaluates the year-to-year relationship between rings within a given area. The correlation coefficients of several tree-ring series from one ecological unit (such as a small forest) are put into a matrix to learn if the ring series fits into the set. Serial correlation is a measure of similarity within a sequence with a time displacement of one or more years, providing information on the relationships within the series. The correlation coefficient is expressed as a decimal fraction, 0 means no relation, +1 means identical, -1 means negatively identical. Where the preceding year has influenced the year under investigation significantly, the correlation is high. This information can be used to learn when a tree has been under stress and the effect that it has on the growth of the ring the following year.

Szepertyski (1999:15-16) provided some information on the impact of the climate on the trees from which the sampled timbers were cut. That all of the confidently-dated samples come from the Charente region is clear; however, their forest environments are quite different. Figure 4-18 summarizes the growing environment, numbers of rings, and modified dates of felling for each of the samples.

**Figure 4-18: Dendrochronology Samples By Group with Forest Environment**

Laboratory Number	Forest Environment	Timber Identification	Maximum Possible Rings	Date First/Last Possible Ring
Group 1				
BDD:2793	closed, with competition	3 <sup>rd</sup> futtock, fwd, master frame	110	1365/1474
BDD:2795	open, no competition	3 <sup>rd</sup> futtock, aft, master frame	98	1384/1481

Laboratory Number	Forest Environment	Timber Identification	Maximum Possible Rings	Date First/Last Possible Ring
Group 2				
BDD:2817	moderately open, some competition	floor, 16 aft	115	1416/1531
BDD:2816	very open, no competition	stringer, lower run, stbd	103	1463/1565
BDD:2806	moderately open, some competition	2 <sup>nd</sup> futtock, stbd, 11 aft	84	1476/1560
Group 3				
BDD:2797	very closed, strong competition	2 <sup>nd</sup> futtock, stbd, 10 aft	186	1432/1618
BDD:2812	moderately open, some competition	floor, 2 aft	81	1552/1632
BDD:2799	isolated, no competition	1 <sup>st</sup> futtock, stbd, master frame	86	1537/1623
BDD:2811	moderately open, some competition	hull plank, no provenance	115	1533/1647
BDD:2813	very closed, strong competition	ceiling plank, port	83	1530/1613
Group 4				
BDD:2804	open, no competition	main mast partner, stbd	118	1547/1664
BDD:2818	open, no competition	main mast buttress, stbd	122	1528/1649
Group 5				
BDD:2808	moderately open, some competition	keel, aft section	110	1567/1683



Laboratory Number	Forest Environment	Timber Identification	Maximum Possible Rings	Date First/Last Possible Ring
BDD:2814	moderately open, some competition	ceiling plank, stbd	102	1583/1683
BDD:2807	moderately open, some competition	hull plank, stbd	113	1571/1683
BDD:2805	moderately open, some competition	floor, 4 fwd	68	1609/1676
BDD:2803	moderately open, some competition	main mast filler, aft	119	1565/1683
Isolated Samples				
BDD:2809	open, no competition	keelson, central section	94	1423/1516
BDD:2800	open, no competition	1 <sup>st</sup> futtock, port, 9 forward	167	1450/1616
BDD:2802	open, no competition	floor, 10 forward	93	1532/1624
BDD:2796	open, no competition	1 <sup>st</sup> futtock, port, 5 forward	134	1530/1663
BDD:2798	open, no competition	2 <sup>nd</sup> futtock, stbd, 2 aft	98	1544/1641

## Results and Analysis

The samples in Group 1 came from very different environments. The first sample, BDD2793, has a mean sequence growth of 2.4 mm per year, which indicates that this tree grew in an open environment where the trees were not in competition. The second sample, BDD2795, has a mean sequence of only 1.1 mm per year, reflecting a tree grown in the middle of the forest in a closed environment surrounded by many trees competing for resources (Szepertyski 1999:15).

These two samples are the oldest in the chronology and their dating is open question; however, their environmental characteristics are not as tentative. These are both third futtocks and would not have been heavy timbers, but they would have to come from tall reasonably straight trees. In addition, their sided and molded dimensions would not require a tree of great girth. A closed environment would favor a tree growing tall and straight with few branches and average girth. With 110 growth rings, sample BDD2793 is clearly from a tree that prospered, had a reconstructed circumference of 79 cm, and grew sufficiently straight to be used for a third futtock. The reconstructed circumference of all the samples discussed is based upon the doubled radial measurement from the center ring to the last clearly defined growth ring multiplied by  $\pi$  (pi).

An open environment would encourage a tree to grow quickly, but might also leave it more vulnerable to damage. Sample BDD2795 has only 98 rings, only a few less than its partner, but its circumference is 85 cm. This clearly reflects its open environment and low or no competition for resources. The closeness of the ring counts between the two samples suggests that while environment is clearly important, the critical factor in the selection of the trees from which these timbers came was length and girth.

The three samples from Group 2 also come from very distinctive environments. Two of the samples, BDD2817 and 2806, came from trees grown in the middle of the forest, in moderately open environments, and have average mean sensitivity measures for the region of 2.0 mm per year. The growth rings from these trees show the effects of some climatological stress. Sample BDD2816 on the other hand, was from a tree in a very open environment with little competition and with favorable growing conditions (Szepertyski 1999:15).

These samples are from a floor at 16 aft (BDD2817), a second futtock at 11 aft (BDD2806), and a longitudinal stringer (BDD2816). That the floor has a maximum of 115 growth rings is a logical outcome of the need to obtain a timber that is not necessarily long, but massive in its sided and molded dimensions and therefore from a tree with great circumference. A comparison of the circumference of this tree with 115 rings and 91 cm circumference and that of the tree for sample BDD2793 with 110 rings and only 79 cm in circumference, clearly reflects the differences in a moderately open and closed environment.

The second futtock in this group required a tree of some length but not great girth, therefore the presence of 84 rings is not surprising. A comparison of the 84 rings and 79 cm circumference of this tree with sample BDD2795 with 98 rings and an 85 cm circumference, also reflects the differences between a moderately open and an open environment. The sample from the stringer, with 103 rings, is a long relatively straight timber. It is from a very open environment, which is surprising as exposure to the elements might also result in twisting or bending of the tree making its use for such a timber inappropriate. This environment would encourage a tree to grow quickly and become quite large.

The five samples in Group 3 came from dissimilar environments as well. Two of the samples, BDD2813 and 2797, have a very low mean sequence growth at 0.5 mm per year. This reflects a very closed environment with many trees competing for resources. Sample BDD2813 also showed signs of stress. Samples BDD2811 and 2812 came from a moderately open forest environment and show the effects of some competition for resources. The last sample, BDD2799, had a growth rate of 5.5 mm per year. This

suggests that the tree was in a very open environment, perhaps even isolated. However, this sample also reflects a tree under a great deal of stress, perhaps because of a change in environment when a forest is replanted or when widely harvested. Sample BDD2813 exhibits similar stress (Szepertyski 1999:15-16).

These samples are from a ceiling plank (BDD2813), a second futtock at frame position 10 aft (BDD2797), a hull plank (BDD2811), a floor at frame position 2 aft (BDD2812), and a first futtock on the master frame (BDD2799). The ceiling plank and second futtock likely came from the same forest because of the similarity in their mean sequence measurement. They were also felled within five years of one another, 1613 and 1618, respectively. The ceiling plank, a long straight timber, has 83 maximum growth rings. Clearly, planks do not require trees of tremendous girth, but they do require trees that are tall and straight with few branches, which is more likely to occur in a closed forest environment. The second futtock on the other hand has a maximum of 186 growth rings. That the futtock has so many rings is likely the result of the necessity to obtain a long timber, but not necessarily one of great sided and molded dimension. Although this second futtock has a high growth rings count, it has a circumference of only 63 cm. This clearly reflects its very closed environment with strong competition for resources. A closed forest environment would also require many more years to produce a tree with the characteristics needed for a second futtock.

The hull plank (BDD2811) and the floor (BDD2812) may have come from the same forest because of the similarities in their mean sequences. They were also felled within 15 years of one another. The hull plank has a maximum of 115 growth rings, which is the same number of rings as sample BDD2815, a separate hull plank that was

not dateable within the chronology. The floor at frame position 2 aft (BDD2812) did not require a tree of great girth, but did require a tree of some height. Its maximum number of 81 rings and circumference of 72 cm compares favorably with other samples from similar environments. These measurements are likely average for a tree that could produce such a timber.

The first futtock on the master frame (BDD2799) required a tree of some height, but the timber's sided and molded dimensions would not need a tree of great girth for its manufacture. With a maximum of only 86 growth rings but a circumference of 97 cm, this clearly reflects an extremely open, probably isolated environment.

The Group 4 samples probably came from the same forest. Their mean sequences are identical and reflect trees grown in the middle of the forest, but in an open and favorable environment with little competition (Szepertyski 1999:16). The two timbers that produced these samples came from the main mast step assembly. Both timbers would have to come from large, straight trees, with a large circumference. With a maximum of 118 and 122 growth rings, respectively, and a girth of 94 cm and 100 cm, both trees clearly display the effects of an open growing environment with minimal competition.

The samples in Group 5 also probably came from the same forest. They all have similar mean sequence measurements and reflect trees grown in a moderately open forest where there is competition between individuals. The sequence values are the norms for the region. However, these samples also show the effects of a slow growth rate, suggesting a climatic change late in their growth (Szepertyski 1999:16). Except for BDD2805, all of the samples in group five, the keel, ceiling plank, hull plank, floor at 4

forward, and a filler, have maximum ring counts more than 100. Further, they were all cut within a 7-year period. All required tall straight trees, which would be favored in a moderately open forest environment where trees compete for resources.

The five isolated samples have mean sequence values very similar to the Group 4 samples. These too reflect trees growing in the middle of the forest but in an open environment with little competition (Szepertyski 1999:16). All of the isolated samples have maximum ring counts more than 90 and, except for the floor at 10 forward (BDD2802), would have required tall trees. The two first futtocks (BDD2800 and 2796) have very high ring counts, which is not surprising given the physical requirements of these timbers with a deep curve for the bilge arc. Their reconstructed tree circumferences are both more than 100 cm. The floor at 10 forward (BDD2802) required a tree with moderately large circumference to accommodate a substantial molded dimension. With a reconstructed circumference of 125 cm and ring count of only 93 it reflects a tree growing in an open environment. The one anomaly in this group is BDD2798, the second futtock with a maximum ring count of 98 and a reconstructed circumference of only 63 cm. This seems low in comparison to the other trees in the group with a similar ring count.

In summary, the climatological information provided by Szepertyski described six forest environments in the Charente region over nearly two centuries from very closed to completely open and isolated, with strong to no competition for resources. Five inferences emerge based upon this information, the first three of which relate to forestry practices. First, each dated group contained trees from different growth conditions suggesting that the timbers were not harvested from a single stand of trees or a single environment. This variability reflects the natural diversity expected in forests that

populate the river valleys in the central and coastal regions near Rochefort.

Second, only 3 of the 22 trees came from a closed forest environment, suggesting that the forests around Rochefort were not yet being managed as plantations. The three trees from a closed environment, all of which were felled between 1565 and 1618, may instead have come from a virgin forest dense with old growth. Third, based upon signs of stress in the samples, there was a shift in the forestry practices after 1664. It should be remembered that the Rochefort arsenal was established in 1666, which resulted in an increase in the need for local timber, for the building of ships and construction at the yard. All of the Group 5 trees, harvested between 1664 and 1683, exhibit stress due to a change in environment late in their growth. This may be the result of the necessary increase in harvesting or a change to coppice that would accompany a building increase in the region.

Two inferences regarding the relationship between environment and timber function also emerge from this information. First, a moderately open forest produced most of the long, straight pieces (planks, keel, etc.). Second, an open forest produced compass timber. This variability in forestry environments was essential, prior to the spread of plantations, to ensure sufficient numbers of timbers of the appropriate shape were available. It is no surprise then, that a moderately open forest favored long straight pieces and an open forest favored compass timber.

In attempting to identify, classify and compare the nuances of ship construction, the inter-related roles of past forestry management and exploitation should be considered essential components of a comprehensive study. Clearly this information provides a deeper context within which to evaluate the results of species identification and

dendrochronological analysis. Furthermore, the intriguing findings from the dendrochronology suggest that we should not overlook the ability of the wood itself to reveal much about past shipbuilding practices, and to pose questions begging for answers.



## Chapter V. The Design of *La Belle*

### Introduction

The design of wooden ships is a topic close to the heart of many researchers who have a keen interest in the evolution and study of water craft. *La Belle's* hull provides a rich laboratory within which to explore these realms. Its well-preserved remains also provide a unique opportunity to de-construct its design because the archaeological data includes precise, three-dimensional drawings of each frame timber.

Analysis of the hull has revealed the use of an ancient Mediterranean method analyzed by Eric Rieth in *Le maître-gabarit, la tablette et le trébuchet* (1996). Until the discovery of *La Belle*, no archaeological example had been identified that can be associated with this Mediterranean design method. Although several Atlantic vessels, particularly the 16th-century Biscayan wrecks from Red Bay (ca. 1565) and the English wreck *Mary Rose* (1545), have been related to the somewhat different design concepts found in early English shipbuilding manuscripts. The remains of *La Belle* provide the first archaeological evidence of the Mediterranean method, until now known only from Renaissance manuscripts and modern ethnology. The remains also contribute to the current debate, synthesized by Rieth (1996), on the transfer of Mediterranean shipbuilding methods to the Atlantic sphere.

Lending further support to this transfer of technology is the confirmation by Rieth

that the carpenter who likely designed *La Belle*, Pierre Mallet, came from Bayonne on the southwest coast of France (E. Rieth pers. comm. 2000). It was here that Pierre Mallet learned, and his shipwright father Honoré employed, traditional coastal Atlantic methods. By 1670, Pierre was working with his father in Rochefort where both Mallets were influenced by the Dutch carpenters there. After 1675 the younger Mallet, if he was not already aware of it, was undoubtedly exposed to Mediterranean methods of hull design by François Pomet, the *premier maître-charpentier* of Rochefort who came from the royal arsenal at Toulon. Moreover, it was Pierre Mallet who was chosen by Colbert to teach young carpenters at Rochefort, and later at Dunkerque, the essentials of contemporary ship design. By the time that *La Belle* was built, Pierre had achieved the title of *sous maître-constructeur*, i.e., sub or under master constructor, a position second only to his father who was the arsenal's *premier maître-constructeur*; together they held the two highest-ranking positions among the Rochefort shipbuilders. While Pierre Mallet's method has not been recorded, there is no doubt that the fusion of the classic and probably quite ancient Mediterranean technique and the Atlantic/Dutch influences are present in *La Belle*.

In order to provide a context within which to compare and understand the design of *La Belle*, the two traditions practiced in the late 17<sup>th</sup> century are described using contemporary treatises. With this context established, the design of the master frame and its modification forward and aft, the position of the balancing frames, and design of the remaining frames are presented. This is followed by a discussion of the surmarks found on certain frames and how they relate to the ship's design. The reconstructed lines plan and analyses of other aspects of the hull's conception are also explored.

While historical documents and treatises are important tools for understanding the broader picture of ship design, they can only provide a framework from which to work, particularly at the level of the individual ship. To be useful, even those that are specific to a particular ship must be carefully evaluated against the reality provided by the archaeological remains. One such archival document is a registry prepared a few months after *La Belle* was completed. Alluded to elsewhere in this study, the document is analyzed and compared to the archaeological evidence. The late-17<sup>th</sup> and early-18<sup>th</sup> centuries saw the production of several treatises on shipbuilding as it changed from an art to a science. These treatises took the form of instructions for builders providing many details beyond design and can fill in gaps left by other sources. Selected elements of the ship, not elsewhere discussed, are also compared to these shipbuilding instructions.

Lastly, the process whereby one moves from written sources to three-dimensional models, for example, the development of theoretical reconstructions, can be illuminating and enlightening. Model building is an accepted and often used technique in the archaeologist's attempt to put flesh on skimpy or incomplete bones. Therefore, a discussion of a recently completed theoretical reconstruction of *La Belle* concludes this chapter.

### **Contemporary Design Methods**

Four research questions tend to dominate the study of ancient hulls: How was the master frame designed? How were the frames forward and aft of the master frame designed or modified? Which frames were the *couples de balancement*, literally translated as balancing frames? If one has sufficient information to answer these

questions, it is possible to unravel the conception of the ship and to answer the fourth question: To which, if any, of the ancient ship-building traditions does the ship belong?

The two dominant European shipbuilding traditions contemporaneous with *La Belle's* construction are characterized as either Atlantic or Mediterranean. These are known from a handful of English manuscripts that describe the former and a larger number of Italian, Iberian, and French texts that describe the latter. Over time both traditions underwent change through the influence of the other.

### **The Atlantic Tradition**

During the 16<sup>th</sup> and 17<sup>th</sup> centuries the so-called Atlantic tradition was typified by the writings and drawings of a few individuals. The well-known *Fragments of Ancient English Shipwrihty* (Pepys Library, Ms. PL 2820, circa 1586 through 1630) was written by two unnamed authors. The first author is generally presumed to be Matthew Baker, who produced the drawings in the first section accompanied by text that is somewhat difficult to interpret. The manuscript was subsequently modified and expanded upon through the end of the 1620s by a second unnamed author, assumed to be John Wells (Barker 1991:63). Wells is also attributed as the unnamed author of a treatise cataloged by the Admiralty Library as *Manuscript 9* circa 1620 (Salisbury and Anderson 1958:2). At about the same time two other anonymous authors produced treatises on shipbuilding: the so-called Newton Manuscript circa 1600 (Cambridge MSS Add. 4005, Part 12) and the so-called Scott Manuscript circa 1590-1605 (Royal Institution of Naval Architects, Scott Collection MS 798). These four treatises, together with the writings of Anthony Dean in the *Doctrine of Naval Architecture* (1670), most clearly describe and define the

Atlantic method of hull realization.

The method was based upon a master frame mold comprised of three tangential arcs, with a hollowing arc towards the ends of the hull. To illustrate, starting at the keel, the shipwright first projected a straight, horizontal line to represent the floor of the hull. Then, from the outboard end of the floor, he projected a tangential arc upward, with a relatively short radius, to represent the turn of the bilge. Next, from the upper end of the bilge arc, a tangential arc with a longer radius was added to give shape to the outward-flaring futtock. A third tangential arc, often but not always with an intermediate radius, was added to the futtock arc to form the greatest breadth of the hull and to project the inward-angling dead works. Finally, from the upper end of the breadth arc, a tangential line shaped the ship's tumblehome. This resulted in precise geometrical components that corresponded to each of the elements of the ship's section design, as follows:

straight horizontal line	floor
circular bilge arc	bilge, turn of the bilge
circular futtock arc	futtock
circular breadth arc	beam, breadth
straight diagonal line	tumblehome

The next step in the design process was the modification of the frames fore and aft of the master frame. These frames were designed by systematically adjusting the master frame in three ways. First the length of the floor was incrementally reduced from one frame to the next; this was the narrowing of the floor. Second the horizontal line was incrementally elevated above the keel; this was the rising of the floor. To join the keel to the new, displaced, point at the outboard end of the floor, a line was traced empirically. Near the master frame this line might be a straight diagonal, while toward the ends of the hull it was a concave curve called a hollowing arc.

Integral to the method, and explicitly stated by each except Dean, was the third step of the process; the necessity to incrementally reduce the chord of the bilge arc from one frame to the next forward and aft of the master frame. At the same time, the length of the futtock arc was extended downward by a reciprocal amount to replace the length taken away from the bilge arc. This modification was called hauling down the futtock.

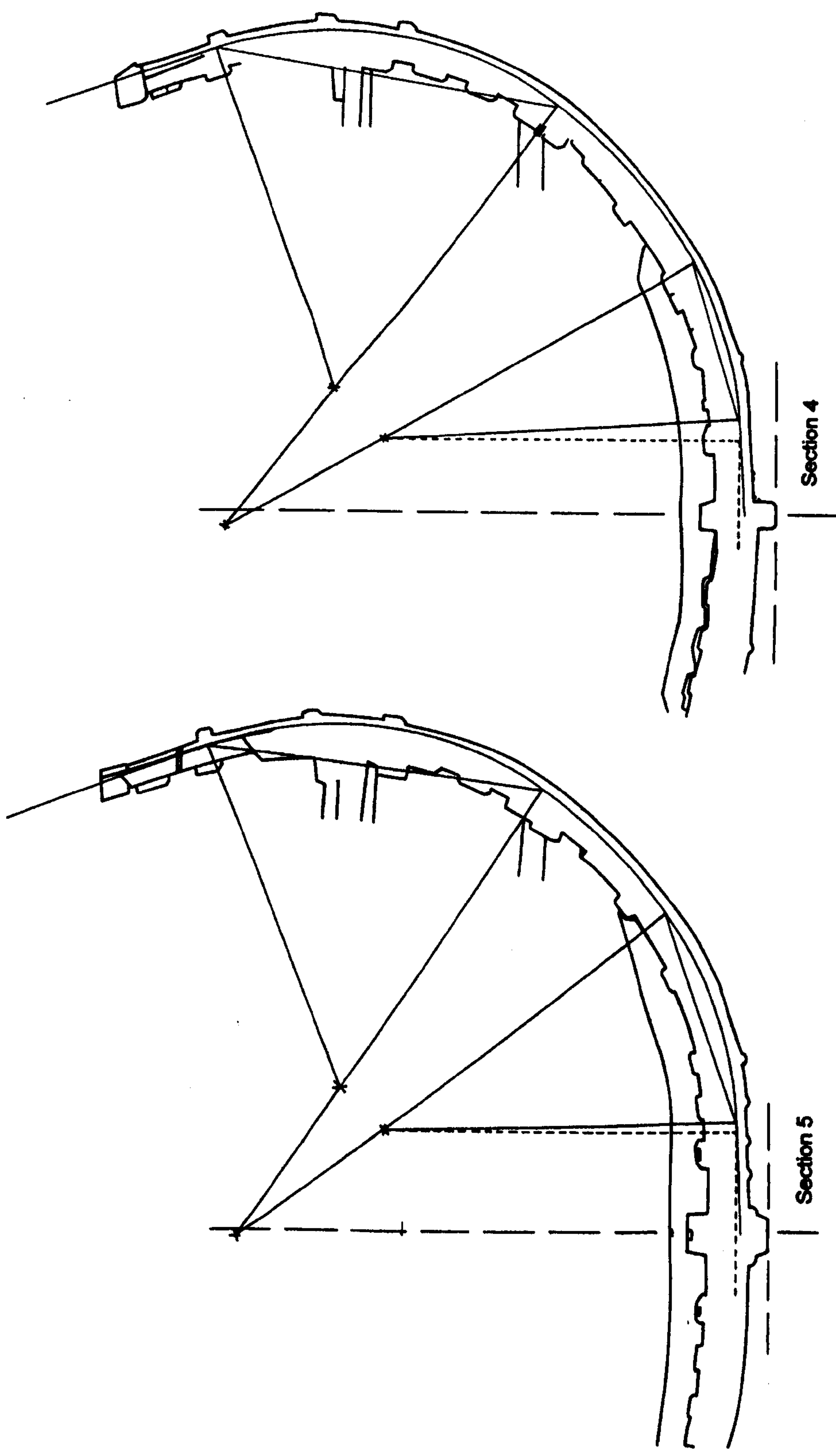
The whole process was described thus:

The floor mould hath three perpendiculars; the one for the middle line of the depth, the other two for the extremes of the flats. From the outward flat draw a straight line upon which you may put the risings afterwards on. From the middle line draw two other straight lines and upon them set the narrowing both aloft and alow as they are calculated in the table. Let the perpendiculars be drawn on the other side also; from the outward perpendicular set the risings forward on, from the middle line [set] the narrowing forward both aloft and alow as you did afterward on.

Upon the arc of the wrong head [bilge arc] draw a straight line for the substance thereof, upon which set out the haleing down of the lower part of the futtock upon the wrong head.

Upon the lower part of the futtock, from the middle section to the sine mark at the wrong head, draw a straight line whereupon set the haleing down of the futtock. Upon another straight line draw[n] from thence to the upper sine mark, set ou[t] the putting up of the futtock (Anonymous 1620 in Salisbury and Anderson 1958:35).

*Mary Rose*, Henry VIII's flagship built in 1509, was conceived using the Atlantic method. Raised from the sea floor in the late 1970s, this largely intact shipwreck has been the subject of extensive study by the Mary Rose Trust (Rule 1983). In 2000 an intensive effort was undertaken to document several frame sections in an attempt to confirm their arcs and modifications (Figure 5-1). Section five in the central group near the master frame clearly demonstrates a three-arc conception. Moving forward, section four illustrates the reduction of the bilge arc and the downward extension, or hauling



**Figure 5-1:** Two sections from the *Mary Rose*. Section 5, left, demonstrates the three-arc conception. Section 4, right, illustrates the reduction of the bilge arc and the hauling down of the futtock arc. Courtesy Mary Rose Trust.

down, of the futtock arc. One hundred years later *Sea Venture*, built in 1609, was also conceived using three arcs and the frames also modified through hauling down (Adams 2000). Ultimately, this simple method of frame conception and modification enjoyed nearly two centuries of use by English shipwrights.

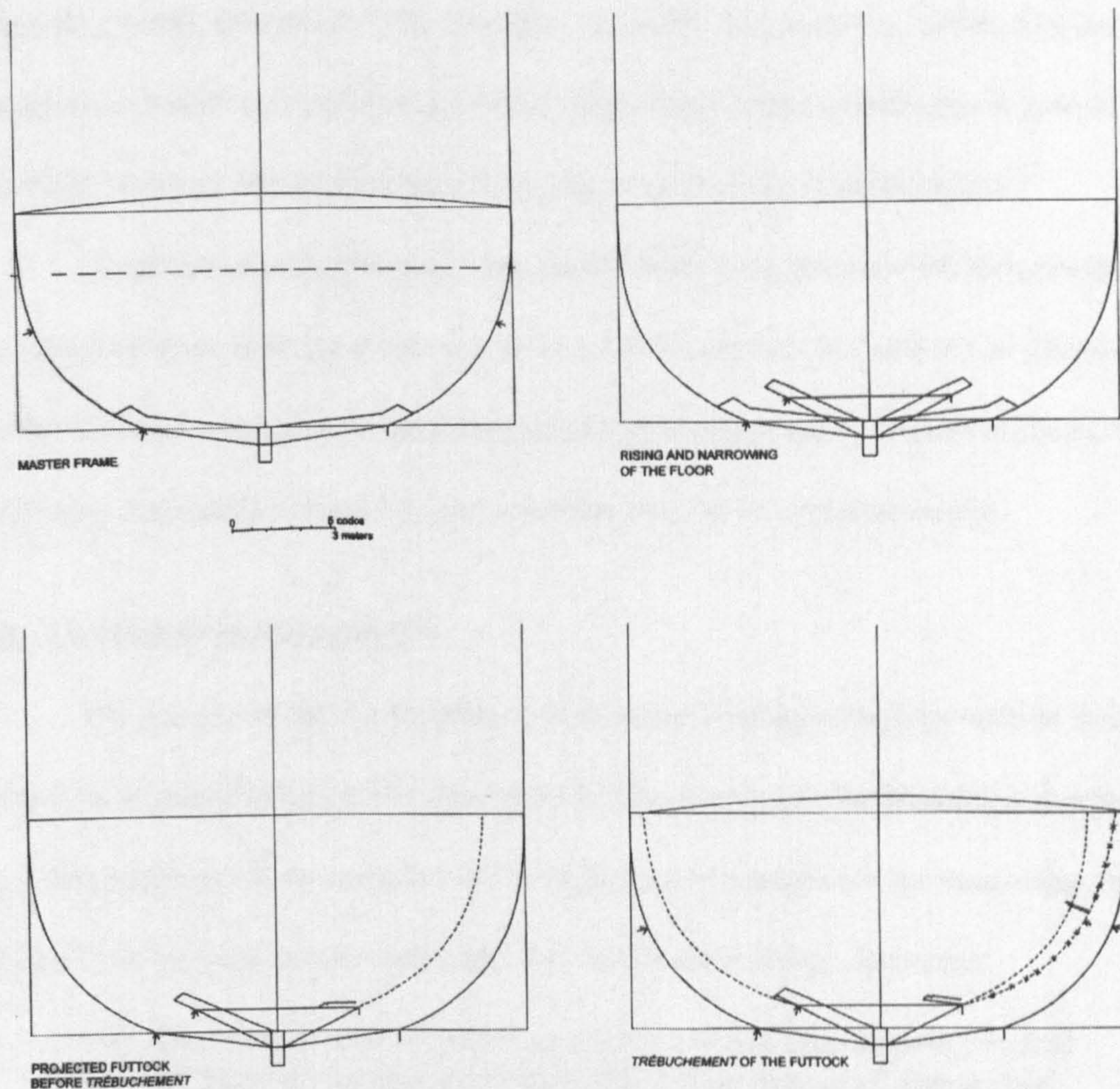
### **The Mediterranean Tradition**

Although having different roots, the Atlantic and Mediterranean methods of master frame mold design are indistinguishable in the first two steps of the process. Both were designed by projecting a series of tangential, circular arcs of varying radii. In the second step, forward and aft of the master frame both methods reduced the length of the floor by narrowing and elevated the floor by rising. They differ in the third step, the modification of the shape of the master frame toward the bow and the stern. In the Mediterranean method hauling down was absent and in its place was another modification called *trébuchement* in French (*espalhamento* in Portuguese, *joba* in Spanish, and *legno in ramo* in Italian). The anonymous English shipwright, assumed to be Matthew Baker, wrote that this Mediterranean modification was unknown to his countrymen:

. . . for as mych as I mene to intret of ther Linaramo del susto (a thng with ough the wich it is impossebell to make a prfet shipp by ane plot) wich order at this present ther is no inglech man parfety undestandeth . . . (Pepys Library, Ms. PL 2820, folio 16, ca. 1580).

The Mediterranean method consisted simply of tilting outward the combined futtock and breadth arcs from a pivot point at the outer end of the floor. The outward tilt was incremental from one frame to the next. In order to smooth out the “kink” created at the pivot point, the carpenter used his empirical experience (Figure 5-2).





**Figure 5-2:** The rising and narrowing of the floors and outward tilting of the futtock were illustrated in a 1680 treatise. Drawing by Marie-Andree Marchand after Gaztañeta, *Arte de fabricar reales*.

Rieth (1996) has undertaken a general analysis of the Mediterranean method of trébuchement as has Cruz Apestegui Cardenal (1992) in an analysis of the manuscript *Arte de fabricar reales* written by Antonio de Gaztañeta Yturribalagada in ca. 1688.

Another contemporary account of the method appears in a manuscript signed by M. de La Madeleine ca. 1712 (Bibliothèque du Musée de la Marine, Ms. R 711, *Tablettes de Marine*). Both treatises were predated by several that alluded to the technique including

Lavanha (1608), Oliveira (1570), Drachio (ca 1594), Timbotta (ca. 1450), and the anonymous *Fabrica di galere* (ca. 1410). These early manuscripts help to date the “ancient” method and to place its geographic origins in the Mediterranean.

As of this writing, the most complete French description of the trébuchement contemporaneous with the construction of *La Belle* appears in *Tablettes de Marine*. Rieth (1996:61-80) discussed both the manuscript and Mediterranean method in detail; the following discussion is based in part upon his analysis of that manuscript.

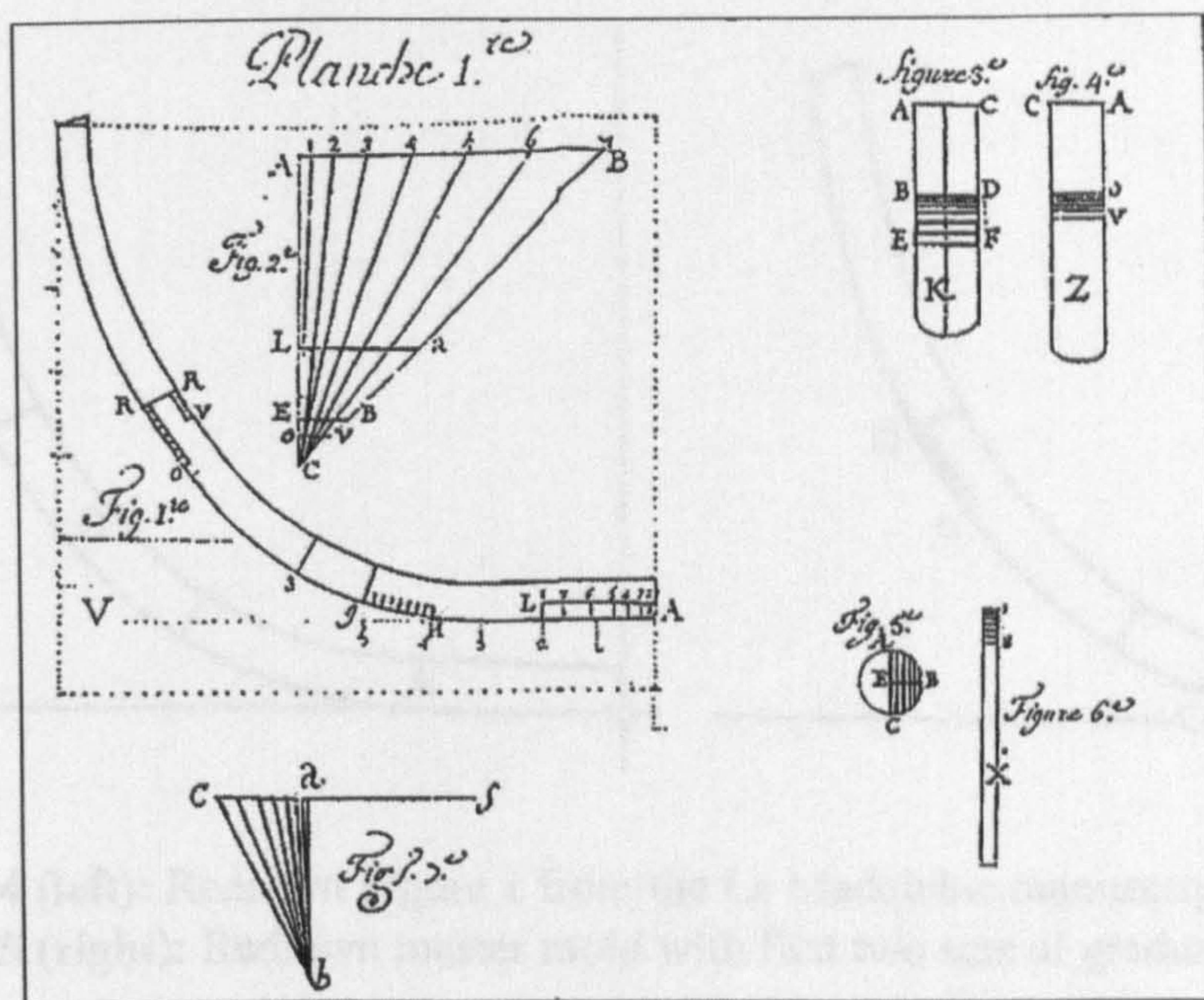
### **The La Madeleine Manuscript**

The portion of the La Madeleine manuscript that described the ancient design technique is found in folios 131 through 159. On these pages La Madeleine discussed in turn the master mold, the creation of the right-angled triangle for the narrowing, the tablets for the rising, and the trébuchet for the outward tilting. He noted:

Our first constructors, to whom geometry was not even known, worked with the help of a master mold with which they formed all frames that must interpose themselves between the floor timber that begins the runs of the rear and the one that begins the runs forward. They impart the rising to their floor timbers by the means of a tablet on which they mark the different risings of the floor timber, made by means of a right-angled triangle [and] reduce them according to an arithmetic progression, and determine the opening of their frames by the means of a stick called a trébuchet on which is marked the different trébuchements that give the openings to the frames (La Madeleine 1712: folio 131-132).

Fortunately, La Madeleine also provided several illustrations to guide the reader through the complexities of his ensuing discussion (Figure 5-3). Plate 1 from the manuscript illustrated all of the key elements. The master mold is Figure 1, the tablets are Figures 3 and 4, the right-angled triangle is Figure 2, and the trébuchet is Figure 6.

The master mold: The discussion of the master mold appeared in folios 141 to

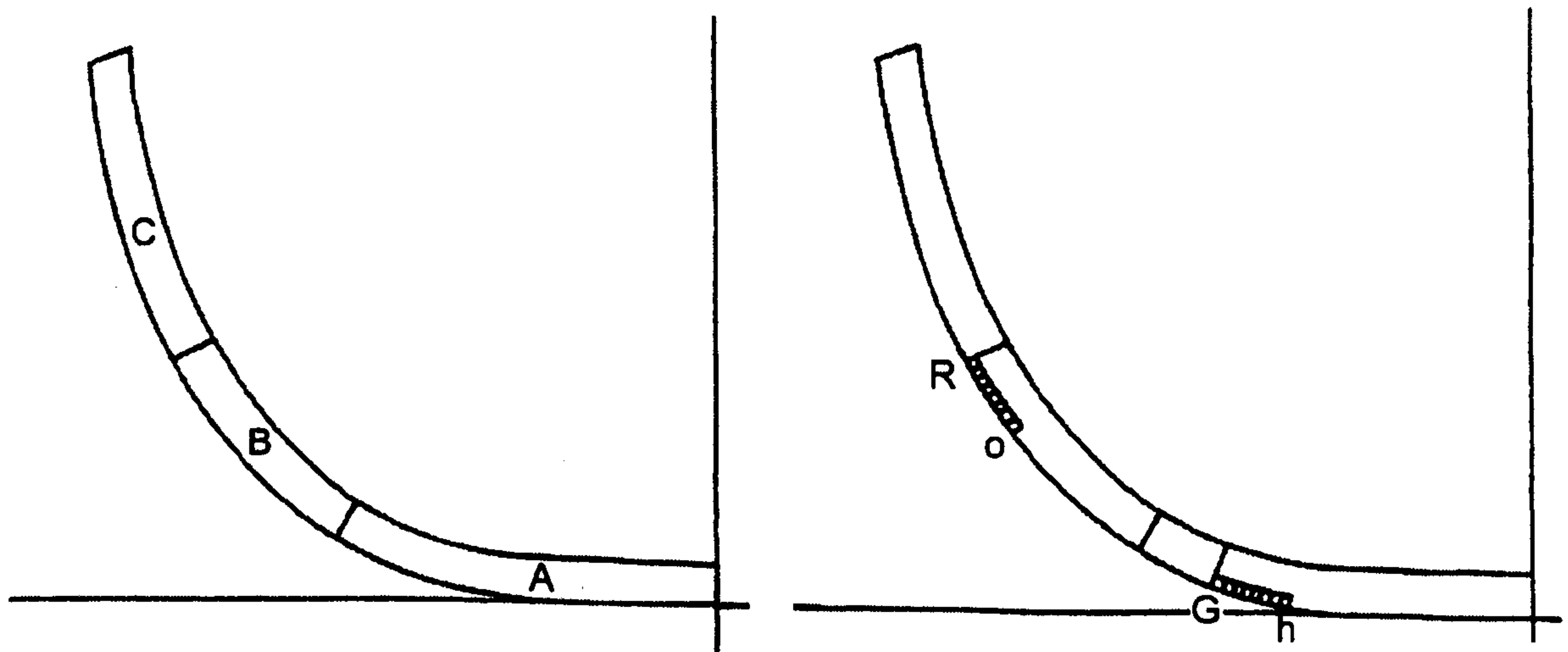


**Figure 5-3:** Design tools used with trébuchement from La Madeleine manuscript.

145. Those folios, analyzed by Rieth (1996:62-63) and paraphrased below, detailed the manner in which the master mold was created and prepared for modification of the master fame.

The master carpenter began the process by creating a full-sized master frame from a previously determined contour. He then created a master mold that replicated exactly one-half of the master frame and consisted of “. . . a board divided in three parts . . . on thin boards, if one is to work in full size. . . .” (du Monceau 1752:195). The master mold in three parts was illustrated by La Madeleine in Plate 1, Figure 1. However, for clarity in this discussion it is redrawn as Figure 5-4. The three parts of the mold correspond to: A, the floor and the turn of the bilge (the flat and bilge arc); B, the lower futtock (the futtock arc); and C, the upper futtock (the breadth arc).

The master mold had four sets of graduations, the first two of which were drawn



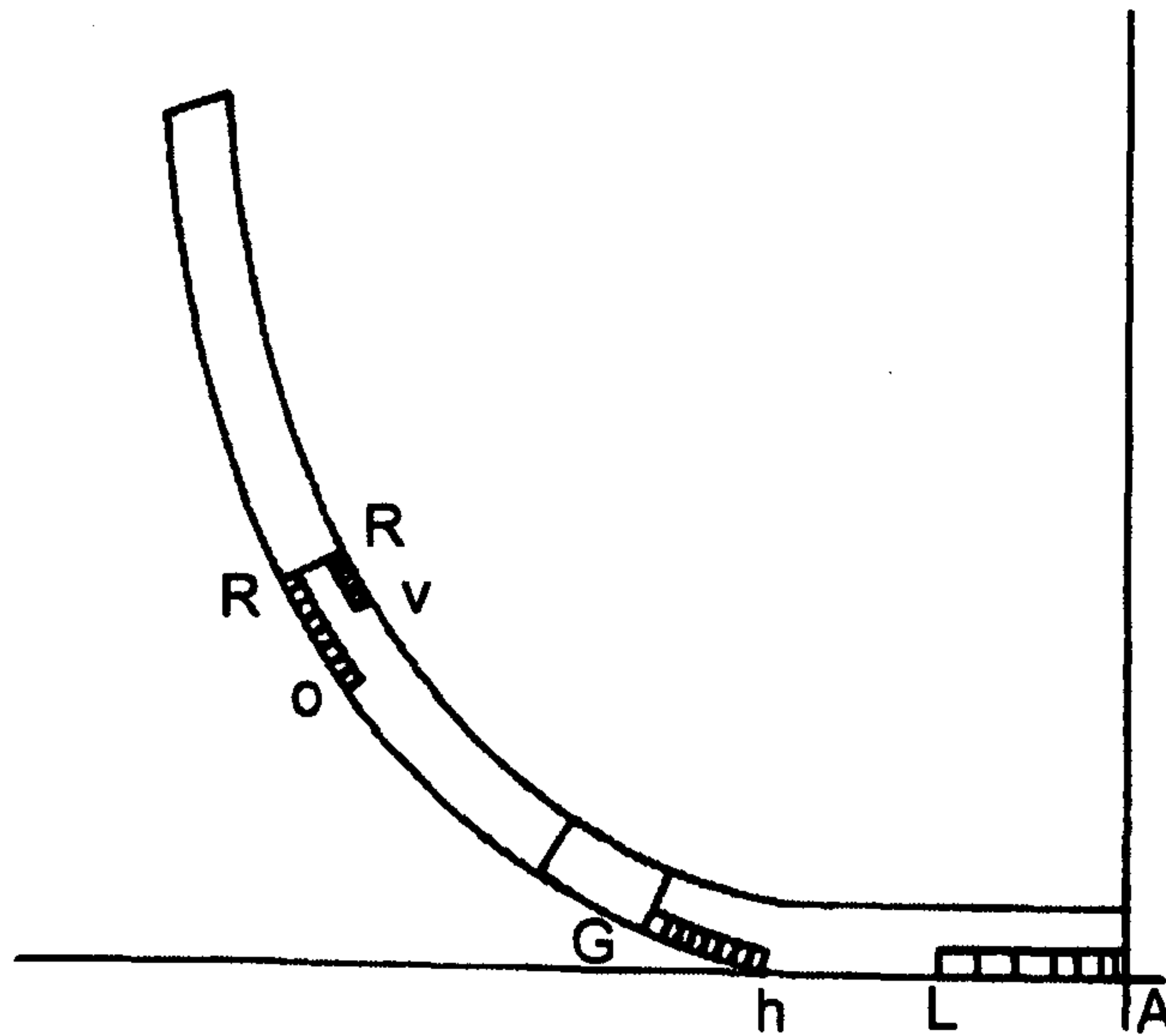
**Figure 5-4 (left):** Redrawn Figure 1 from the La Madeleine manuscript.

**Figure 5-5 (right):** Redrawn master mold with first two sets of graduations.

on the outside edge of the mold and shown as rectangles each equal to  $1/5$  of the length of the flat of the floor (Figure 5-5). The lower rectangle (Gh) was drawn beginning at the end of the flat, that is, at the lower edge of the turn of the bilge or bilge arc. The upper rectangle (Ro) was drawn ending at the top edge of the bilge arc and the beginning of the breadth arc.

Both rectangles were divided into equal parts based upon the number of frames between the master frame and the balancing frames forward and aft, i.e., the frames that began the run forward and the run aft. These rectangles had two functions. The lower rectangle (Gh) defined the shape of the turn of the bilge while the upper rectangle (Ro) determined the increase in the length of the futtocks from the master frame to the aft balancing frame. The increase in the length of the futtocks aft of the master frame to the rear balancing frame is double of those of the frames between the master frame and the balancing frame forward. To establish these graduations, a third rectangle (Rv) was created and drawn on the inside of the mold at the same location as the rectangle Ro

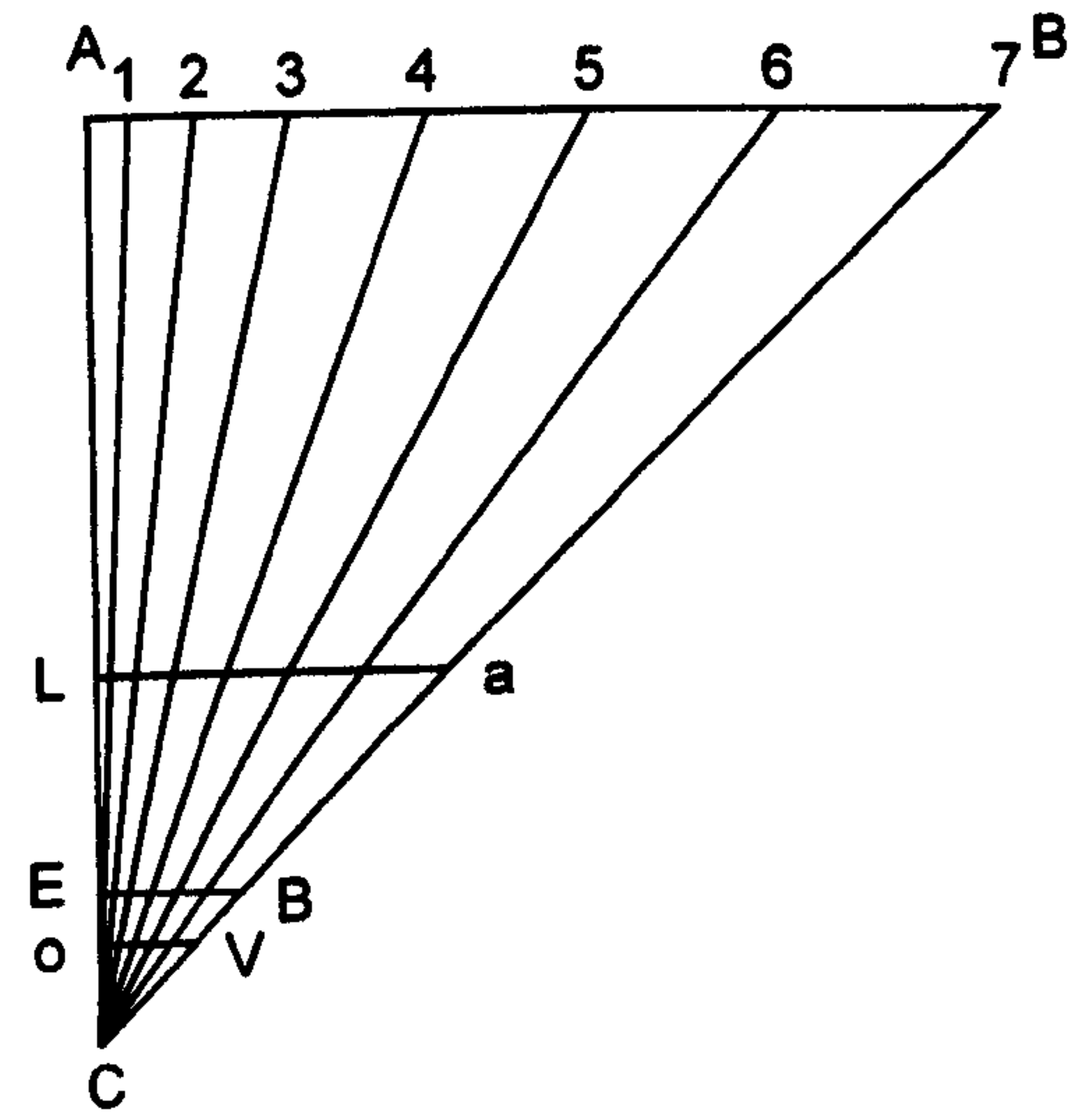
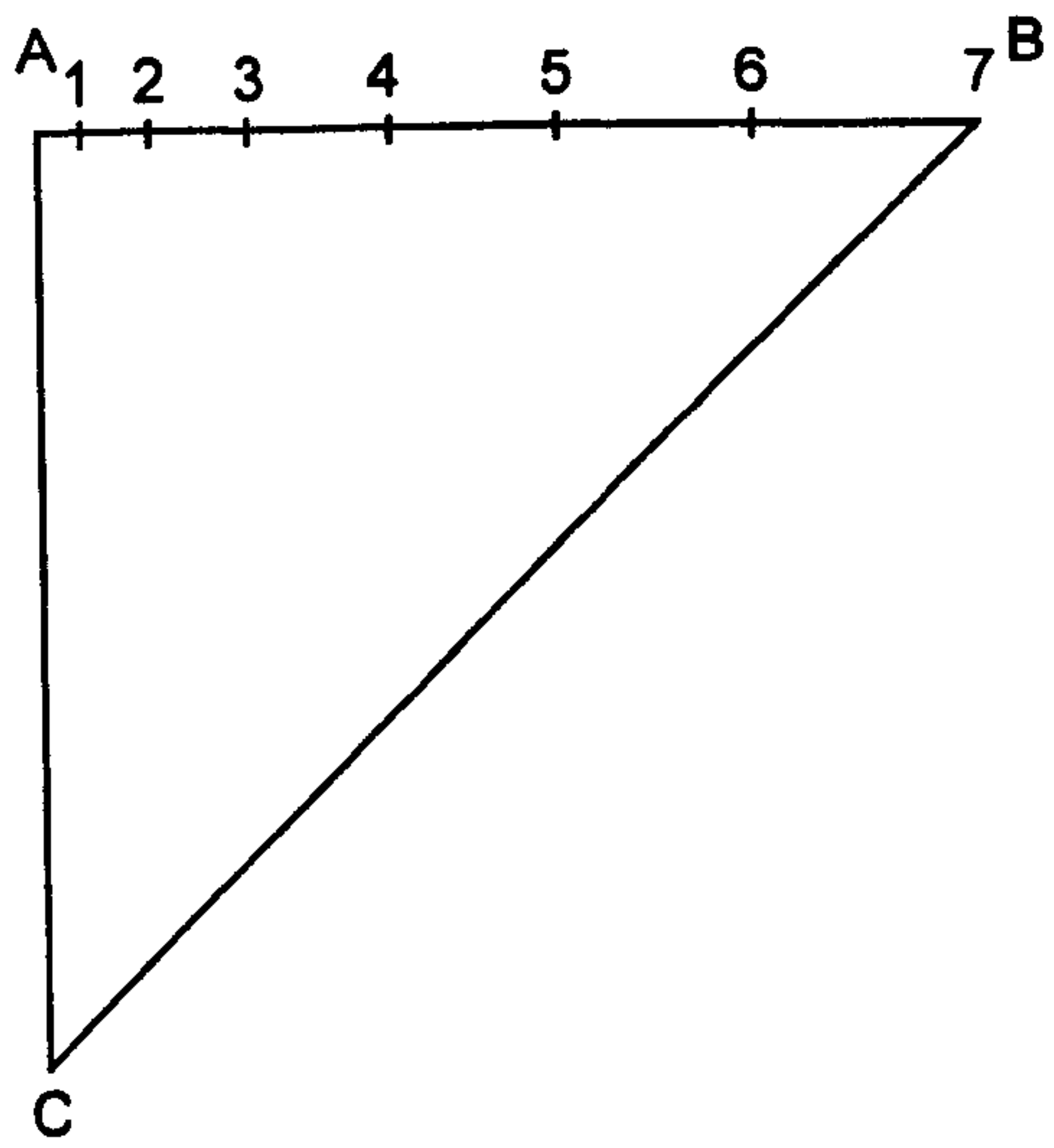
(Figure 5-6). The length of this rectangle was one-half that of rectangle Ro. Rectangle Rv was divided into equal parts based upon the number of frames from the master frame to the balancing frame forward.



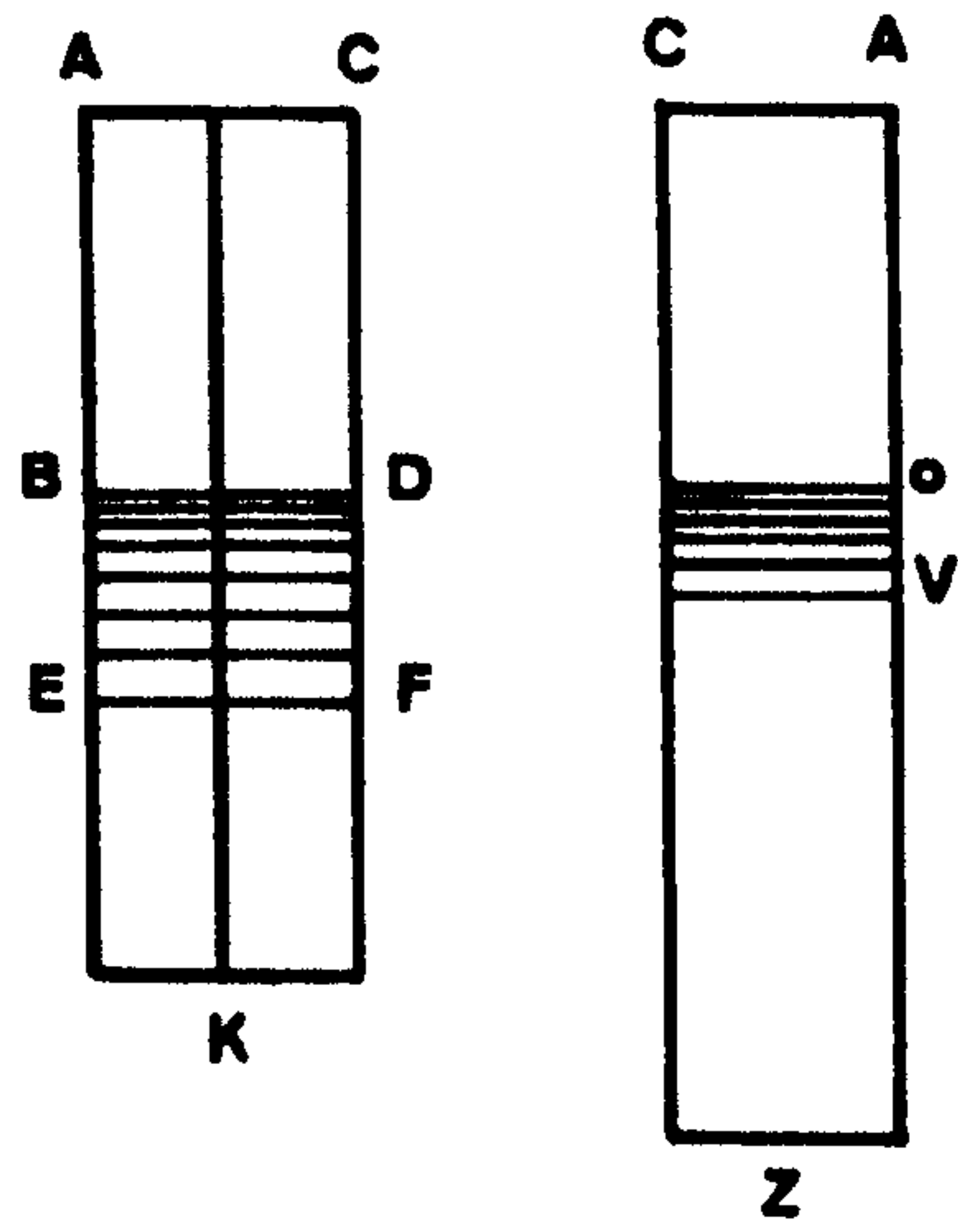
**Figure 5-6:** Redrawn master mold with third and fourth sets of graduations.

A fourth set of graduations was also drawn as a rectangle (AL) on the outside edge of the mold and beginning at the centerline of the master frame (refer to Figure 5-6). The purpose of this rectangle was to reduce the length of the flat. The length of the rectangle was equal to  $\frac{2}{5}$  of the length of the flat of the master frame. Rectangle AL was divided into as many parts as there were frames between the master frame and the balancing frames forward and aft. However, these graduations were not equal, but progressive and were determined using a right-angle triangle.

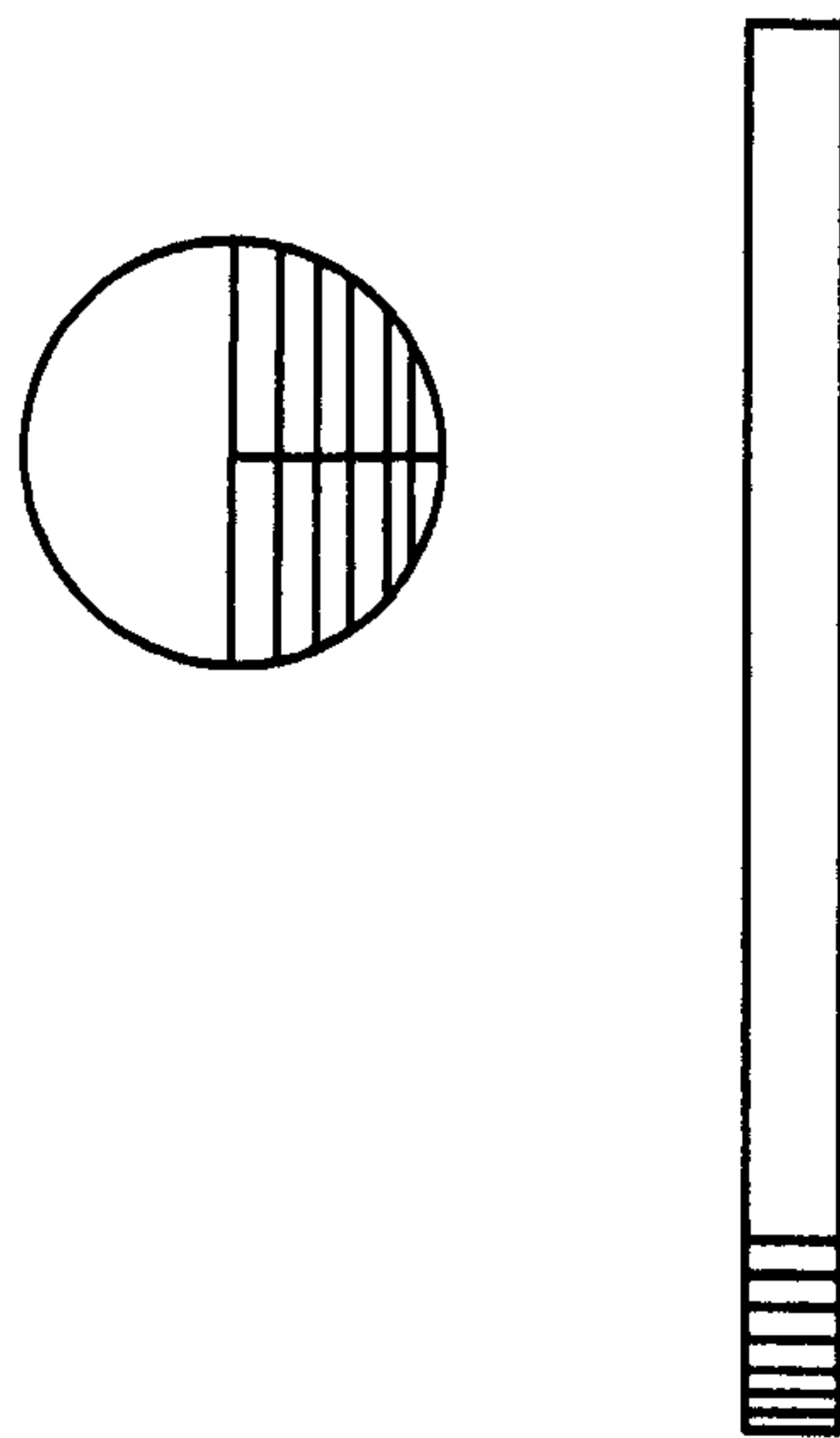
The right-angle triangle: This triangle was illustrated by La Madeleine in Plate 1, Figure 2 (refer to Figure 5-3). For purposes of clarity, however, it is redrawn as Figure 5-7. The discussion of the triangle appeared in folios 146 and 147. Those folios,



**Figure 5-7: The right-angled triangle**



**Figure 5-8: The tablets**



**Figure 5-9: The circle and the tablet**

analyzed by Rieth (1996:64-65) and paraphrased below, detailed the process of creating and applying this triangle.

The master carpenter began by drawing a triangle to full scale and starting at point A drew a line AB. This was divided into as many parts as there were frames between the master frame and balancing frames forward and aft. In the example provided by La Madeleine the line AB was divided into seven intervals increasing progressively from A to B. The first interval at A1 was determined arbitrarily by the master carpenter, “. . . on line AB the point A1 one will mark at will” (La Madeleine 1712:146). However, the next point, A2 was determined by doubling the distance from A1. “One will carry the double of A1 from 1 to 2, the triple [of] A1 from 2 to 3, the quadruple of A1 from 3 to 4, the quintuple of A1 in 4 to 5 and so forth progressively” (La Madeleine 1712:146-147). The last division, at point 7, terminated the AB line (Figure 5-7, top). The master carpenter then drew a perpendicular line from point A to point C that was equal in length to AB. The line CB was then drawn completing the triangle. From point C, lines were drawn to each of the divisions on AB (Figure 5-7, bottom).

The next step used the AL rectangle from the master mold, the length of which was equal to  $\frac{2}{5}$  of the length of the flat of the master floor. That length was marked on the AC line as AL. From point L, a perpendicular line was drawn to the CB line and marked “a” (refer to Figure 5-7, bottom). The divisions on line La were then marked in the AL rectangle on the master mold and were used to define the progressive reduction of the flat (refer to Figure 5-6).

The tablets: This instrument was used to determine the rising of the floor timbers and was illustrated in La Madeleine’s manuscript in Plate 1, Figures 3 and 4 (refer to

Figure 5-3). For purposes of clarity, however, these are redrawn in Figure 5-8. The discussion of the tablets appeared in folios 148 to 153. Those folios, analyzed by Rieth (1996:65-66) and paraphrased below, described the process of creating these instruments.

La Madeleine (1712:148) described the tablet as “. . . a small board of the width of the keel and of appropriate length to mark the increase in the rising of the floors.” The width of the keel is represented by line AC in Figure 5-8, left. The first step in creating the graduations on the tablet was “. . . arbitrary to the master carpenter and that in this example we determine to be 9 inches” (La Madeleine 1712:148). This value was marked as point B on a line drawn perpendicular to AC on the tablet. A perpendicular line, BD, was then drawn on the tablet.

The next step was to mark the rising value for the aft balancing frame on the tablet. According to La Madeleine, this value was equal to  $1/8$  of the height run of the rear, that is, the height of the first ribband at the stern post. It should be noted that this height was previously defined at the time of the establishment of the main proportions of the ship. The  $1/8$  value was measured from B and marked on the tablet at E and the line EF was drawn to indicate the rising of the balancing frame aft (Figure 5-8, left). This value, like that of the value from A to A1 on the right-angle triangle previously discussed, was determined by each master carpenter.

The master constructor now determined the intermediate values for the rising of the floors from the master frame to the balancing frame. To accomplish this he turned again to the ABC triangle (refer to Figure 5-7). To begin, the value of EB from the tablet was marked on the triangle at point E on the AC line and a perpendicular line was drawn to B on the BC line. It should be noted that the length of EB on the tablet was equal to



the length of EB on the triangle. The graduations on the EB line in the triangle were then transferred to the tablet commencing at line BD, which was the rising of the master frame, and ending at EF, which was the rising of the aft balancing frame.

Having completed the tablet for the rising of the aft floors, it was necessary to create similar graduations on a second tablet for the rising of the forward floors. The process was the same, however the value chosen for the height of the runs forward, i.e., the height of the first ribband on the stem post, was  $1/6$  rather than  $1/8$ . Once again using La Madeleine's example of 9 inches from a perpendicular line drawn from CA, that value was marked as point "o" indicating the rising of the master frame (refer to Figure 5-8, right). Measuring from point "o" the  $1/6$  value from the height of run forward was marked at point V. The value of oV on the tablet was then transferred to the ABC triangle (refer to Figure 5-7, bottom) on the line oV, drawn perpendicular to AC. The resulting graduations on the oV line in the triangle were then transferred to the tablet in a series of parallel lines, commencing at point "o" and ending at point V, corresponding to the master frame and forward balancing frame, respectively. This completed the tablets for the rising aft and forward.

The trébuchet: This instrument and its associated half-circle geometric construct, used to determine the outward tilting of the frames, were illustrated by La Madeleine in Plate 1, Figures 5 and 6 (refer to Figure 5-3). For purposes of clarity in the following discussion they are redrawn in Figure 5-9. The discussion of the trébuchet appeared in folios 154 to 158, which were analyzed by Rieth (1996:66-68) and paraphrased here. They described the process of creating the progression for the outward tilting of the frames.

La Madeleine (1712:154) described the trébuchet as “. . . a kind of stick of as little size as 1/4 inch square and about a foot and half long on which one marks the trébuchement that marks the opening of the frames.” According to La Madeleine, the first step was to assign a maximum value for the outward tilting of the balancing frame, which did not follow a particular formula but was determined by each master carpenter. La Madeleine (1712:154) stated, “We give in this example a foot less width [to the balancing frame] than the master frame.”

Having decided upon a value that reflected the difference between the master frame and balancing frame, the master carpenter had to determine the values for the intermediate frames. To accomplish this he created a circle whose radius, EB, was equal to the value between the master and balancing frame, in La Madeleine’s example that equaled one foot (Figure 5-9, left). The circle was then bisected by line AC, running perpendicular to the EB radius. The EB line was then divided equally by the number of frames between the master frame and the balancing frame forward. Then the master carpenter drew a series of parallel lines to AC at each of the points on the EB line. These parallel lines created progressive intervals from B to E. Each of these intervals corresponded to the trébuchement of a frame, from the slightest tilting at the first frame forward of the master frame, at B, to the greatest tilting at the balancing frame, at E. These graduations were then transferred to the trébuchet (Figure 5-9, right). This completed the trébuchet.

La Madeleine noted that the trébuchement was the same for the frames forward and aft, using only one trébuchet for all of the mold frames. He also noted, however,

“. . . this graduation of the trébuchet . . . by the means of the half circle . . .

gives with precision the trébuchement of the frames . . . [but that] in common practice most constructors . . . are content with taking the difference between the master frame and the balancing frame forward and, carrying this difference on the trébuchet . . . , they divide it in three equal parts between the master floor timber and the one that begins the runs [the balancing frame], so that the first division of the trébuchet . . . is the trébuchement of the 4th frame forward or behind the master floor timber. The 2nd division is for the 5th frame . . . and the 5th division is the trébuchement of the frame that begins the runs [i.e., the balancing frame]” (La Madeleine 1712:158.)

In other words, the first three frames forward or aft of the master frame were not affected by trébuchement. Their opening (i.e., narrowing) was reduced only by the value of the progressive reduction of the length of the flat of their floor timber.

Furthermore, the trébuchement, that is, the correction of their opening or outward tilt, for those frames between the fourth frame and the forward or aft balancing frames was achieved by the simple addition of equal values obtained by the division of the trébuchement of the balancing frame (e.g., one foot) in as many intervals as there were frames between the fourth frame and the balancing frame. This meant that the value of the trébuchement of the fifth frame was double that of the fourth frame, while the value of the trébuchement of the sixth frame was triple that of the fourth and so on up to the balancing frame, whose trébuchement was one foot in La Madeleine’s example.

The ribbands and frames at the extremities: La Madeleine also described the method of determining the shape of the frames from the balancing frames to the extremities of the hull in folios 181-185 (1712). These folios, analyzed by Rieth (1996:79-80) and paraphrased here, described how they were modified using ribbands as “molds” rather than the tablet and trébuchet because, “. . . the master mold does not know how to give [shape] to the other frames that finish the vessel to the rear and front, so it is

necessary to explain here the manner to form them” (La Madeleine 1712:181).

According to La Madeleine, after raising all of the frames formed by use of the tablet and trébuchet, the master carpenter marked the height of the run aft on the stern post and the run forward on the stem. These two heights were predetermined at the time of the establishment of the general proportions of the ship. The master carpenter then ran a ribband between these two points that also touched the end of the flat on the master frame. “This ribband thus established by the three points will determine the [end] point of the flat on all of the frames from the balancing frame forward [and aft], and this ribband is the one that we will call the ribband of the flat . . .” or the *lisse de fond* (La Madeleine 1712:182). This is also called the hull ribband.

The master carpenter then ran a second ribband at the height of the maximum breadth of the hull. This also required three points to establish its run: the first point was located on the end of the wing transom aft, the middle point was on the master frame at its greatest width, and the third point was on the stem at the end of a line that passed by the maximum breadth of the mater frame at the level of the base of the forward gun ports. This ribband “. . . marks the point of the hull at its greatest width on all the frames one will raise and that we will call the line of maximum breadth” (La Madeleine 1712:183-184) or the *lisse du fort*.

In between these two ribbands, two more ribbands were placed. The position of these two ribbands was determined by dividing the distance between the ribband of the flat and the ribband of maximum breadth in three equal parts on the fashion frame, the master frame, and the stem. These divisions, marked by two points at each location, were then used to run the two middle ribbands. Once these ribbands were in place, “. . . to

finish the vessel . . . it is only necessary to form the molds that fill in the places where one must place the [remaining] frames” (La Madeleine 1712:185).

While La Madeleine’s manuscript was not written until approximately 1712, 28 years after the construction of *La Belle*, it was not intended to illustrate a practice that was out of use. In fact, La Madeleine continued the manuscript with a discussion of the application and use of the master mold, the tablet, and trébuchet by means of drawings (1712: folios 185 to 193). Clearly the method was known to and widely used by master carpenters at this time.

### **The Coulomb Manuscript**

The trébuchement was only one of the methods of conceiving the hull employed by shipwrights in the third quarter of the 17<sup>th</sup> century. The second method was described in 1683 by François Coulomb in a treatise is entitled: *Livre de construction des vaisseaux cotenant le nom des pièces, leurs liaisons, et les proportions generales de al masture comme aussy pour les flottes et chaloupes, à Toulon 1683 par Coulomb fils Maitre constructeur des vaisseaux du Roy, dan l’Escolle de la Construction*<sup>1</sup> (BN, NAF 4670). As discussed elsewhere, Coulomb and a handful of others received special training in drawing and architecture and it was he who was charged with teaching construction at the Royal school in Toulon.

The Coulomb manuscript is particularly useful for the analysis of *La Belle* because of the discussion of the conception of the hull (folios 15-16 and 18-28). Thirteen

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<sup>1</sup> *Book of construction of the vessels containing the name[s] of the pieces, their relationships, and the general proportions of the masting as also to refine the flottes and shallops, [written] in Toulon 1683 by Coulomb son of the Master constructor of the vessels of the King, at the School of the Construction.*

folios were transcribed by Eric Rieth (1998) and these form the basis for the following translation and discussion of the second technique. Coulomb began with a discussion of the basics to determine the placement of the master frame and the balancing frames and then described the process whereby the reduction of the flat was determined:

(f° 15) Division of the keel. It is necessary to divide the keel in 6 equal parts and to take two of its parts / (f° 16) for the runs of the rear [and at] the F mark that is the place where one puts one floor timber. Then you take another of these parts for the runs forward [to] the G mark [and] that is the place where one must put again another floor timber and then you divide the three other parts of the keel in two equal [parts] and obtain the middle of the so-called two parts [and you] must put the master floor timber D. . .

(f° 18) Floor timber. [For example] ships, of any length of keel, that are composed of 36 floor timbers including the master one knows that there are 18 [floors] from D, which is the place where one puts the master floor, to G, where one puts the floor [balancing frame] that begins the runs forward, and the 18 other [floors] will be put from D to F, where one begins the runs of the rear. The said floors will be put at an equal distance [for] which they will take to themselves the width of the said floors plus 6 inches more. And the broadness of the said floors will be of 7 inches on edge, which is half of the thickness of the keel. To every rising / (f° 19) of the floors, one will put two nails and a peg without a tip that are chased through therein of the ship and penetrate [the] rising of the floor timber to two-thirds of the keel.

The length of the master floor will be taken as one half of the master beam, as it will be spoken here after, and for those [frames] that put themselves at the place of the runs forward at the G mark and to the rear at the F mark [i.e., the balancing frames], they must have two-thirds of the length of the flat of the master beam. And with regard to the length of other floors, it is necessary to take half of that which the floor of the runs forward has, less the length of the master, and divide it in as many equal parts as there are floors laid from D to the / (f° 20 illustration) / (f° 21) G mark and to take two of these parts to form an isosceles triangle. And that aforesaid triangle that you will produce, you mark on the master mold, and with the same adjust[ment]s and mold, one can find the so-called 36 floor timber reductions as one will see by the demonstration of it before (Coulomb 1683:15-21).

The isosceles triangle created by Coulomb provided the values for the reduction of the

flat for all of the mold frames, i.e., narrowing of the hull. Both the forward and aft values were marked on the mold.

The next step in the process was to determine the values for the rising of the floors from the forward to the aft balancing frame:

The rising of the master floor timber must be same thickness as the said floor timber [and] that is of 7 inches. And for the floors that put themselves at the beginning of the runs forward and of the rear, they must have two times more rise of the floor than the said master floor. This increase must serve to form a triangle similar to the one that has been made and to divide it in the same equal parts. And that said triangle that you /( $f^22$ ) will produce, you mark over the tablet. And by the same adjust[ment], one can mark all increases of the rising of the 36 floor timbers as one will see by the demonstration of the rule quoted (Coulomb 1683:21-22).

The results from the second isosceles triangle were then marked on a tablet.

To create the shape of the frames beyond the forward and aft balancing frames Coulomb, like La Madeleine, used ribbands. However, rather than being the source of the shape of the frame, as in the trébuchement, they were used by Coulomb only as guides. He began by determining the height of the first ribband, i.e., the run, on the stern and stem post:

Height of the run. To find the height of the run to the rear, you will take half of the height of the stern post, [which is] known from the ribband of the wing transom to the underside of the keel. At the B mark, in the middle of the so-called half, [at the] perpendicular marked S, you put a shape [ribband] that only acts as mold on which you adjust the plan of the ship. And for the height of ribband forward, you take a foot less than half that of the rear. This half will take itself below the keel at the place of the fore-foot. And to the /( $f^23$ ) tip of this height, one will put another shape that joins with the one of the rear and also acts as mold to give the plan to the said ship (Coulomb 1683:22-23).

Coulomb then provided a predetermined maximum reduction value and described the creation of a quarter circle to determine the remaining values and the progressive

reduction of the frames:

Crotches of the rear. From the floor timber that commences the runs of the rear to the stern post, one must put 20 crotches placed at equal distances similar to those of the floor timbers. They will also have the same thickness as the aforesaid floors. And to know the opening of the crotch that is put the close[st] to the stern post, it is necessary to take a quarter of the length of the flat of the floor of the runs to the rear [balancing frame]. And to find the reduction of the opening of the other crotches, it is necessary to take the three remaining quarters and to take half of it to form a quarter of  $\sqrt[4]{f^24}$  circle and to divide it in as many equal parts as there are crotches placed to the runs of the rear. And over the top of the quarter circle, must be pulled an oblique line. And at the place where the oblique line will cut the line, will be the reduction of the opening of every crotch as one will see by the demonstration of the rule so quoted (Coulomb 1683:23-24).

According to Coulomb, the next step was to determine the rising of the crotches

aft and then forward:

For the rising of the crotch. The one closest to the stern post must have three times more rising of the floor than the floor [beginning] the runs of the rear. This increase must serve to form another triangle like the one that has been made for rising of the floor timbers and divide it in as many parts as crotches must be placed in the runs to the rear  $\sqrt[4]{f^25}$ .

Crotches forward. From the floor timber of the runs forward [balancing frame], which is placed at the fifth part of the length of the keel . . . after dividing it in 6 equal parts, to the place where one finishes the runs forward on the stem, one must put 15 crotches placed in equal distances as those of the rear. And to find the reduction of every crotch, you use the rule here after explained. You take half of the length of the flat of the floor for the runs forward [i.e., balancing frame] and draw a straight line from it to form a triangle that will have the two sides. You divide one of its sides in 5 equal parts to which you give three of its parts for the foundation of said triangle. You erect on the 2 extremities  $\sqrt[4]{f^26}$  of the straight line that forms one of the sides of your triangle, a perpendicular line that will have as much height of the base of said triangle that you divide in 17 equal parts of which the two first parts of in top will be omitted or won't be counted. And you draw parallel lines to the one that formed the side of your triangle. The 15 internal parallel lines of your triangle will give you the opening of the crotches that must be placed from the floor timber forward to the stem post, as one will see it here by the demonstration below.



For the rising of the crotch that is put on top at the forefoot of the keel, it must be 2 feet more than the one of the floor timber that commences the runs forward. This increase must serve to form another triangle as has been made for the rising of the floors and divide it in as many  $(f^27)$  equal parts as one must put crotches for the runs forward. They are all fortified by good pegs [bolts] that are chased from the underside of the keel so that they pierce through the rising of the floor of the said crotches and are stopped between the two branches by washers and pins (Coulomb 1683:25-27).

This differs markedly from La Madeleine's manuscript. Coulomb extended the use of the master mold to these timbers, whereas its use was limited to only those frames between the two balancing frames in the trébuchement method of La Madeleine.

No mention was made of trébuchement, instead Coulomb adjusted the shape of the hull in the following manner:

The breadth of the ship at the place of its master beam, from hull planks to hull planks, is made a foot less than a third of the keel upon the ground. This proportion (is) for a vessel of the first to the second rank. And with regard to the third rank to the fifth, the proportions will be differing. Its breadth will be while taking a third of the structure of the keel on the ground and the quarter of the length of the stem to the stern post  $(f^28)$ . Join the products together and take half, which must give the breadth for a vessel of the fifth rank 27 pieces an inch at the place of its master beam. And at the place of the balancing frame forward, it must have the same width as at the place of the master beam. At the place where one puts the floor [balancing frame] that commences the runs to the rear, it must have a foot and half less breadth than at the place of the balancing frame forward. And at the place of the ribband of the wing transom, it must have 2 feet less breadth than what the two-thirds of the breadth of the master beam produces.

Rieth (1998:116) raised an important question in his discussion of this manuscript: Was it a reliable reflection of the practices of the Toulon master carpenters of the time? If later teaching practices and archived course materials can be used as a guide, then the method outlined by Coulomb did reflect then-current construction techniques. These two manuscripts clearly support the use of parallel methods of hull

construction from the last quarter of the 17th into the early 18<sup>th</sup> century. One other question, however, is raised by the Coulomb manuscript. Was he knowledgeable about and did he also use the trébuchement?

Once again, Rieth (1998:116) provided an answer in the form of two proportions documents for six ships built from 1690 to 1692 by both Laurent and François Coulomb. Both documents include reference to trébuchement. The first is, *Proportions of vessels of 70 pieces of cannons the Superb, l'Invincible, the Constant and l'Heureux built by M. Coulomb, the son, in 1690* (Ms J 355, folio 18 r and v, Musée de la Marine). Among the information included were the following dimensions:

- length of the flat of the master-floor;
- rising of the master-floor;
- width of the master-beam;
- length and height of the runs of the rear and the forward [i.e., length of the hull from the balancing frame to the stem or stern post and the height of the hull ribband from the top keel at the stem or stern post];
- rising of the floors of the balancing frames aft and forward;
- length of the trébuchet that begins at the fifth floor.

The same manuscript also contained, *Proportions of two vessels of 80 cannons built by M. Coulomb, the father, in Port Louis and named l'Orgueilleux and l'Admirable in 1690 and 1691* (Ms J355, folio 21 r and v, Musée de la Marine), which included:

- length of the flat of the master-floor;
- rising of the master-floor;
- width of the floor that begins the runs forward and width of the one that begins the runs of the rear [i.e., balancing frames];
- rising of floor timber that begins the runs forward and rising of the one that begins the runs of the rear [i.e., balancing frames];
- length of the runs of the forward and of the rear;
- height of the run forward from over the keel to the ribband [i.e., the height of the hull ribband ending on the stem post];
- height of the runs of the rear from the top of the keel to the ribband [i.e., the height of the hull ribband ending on the stern post];
- trébuchet forward;
- trébuchet aft.

## **Other Evidence**

The 1683 manuscript and the proportions documents are not the only evidence for parallel use of the direct rising and narrowing technique and of trébuchement. Drawings of two ships by François Coulomb, both of which were built by his father and dated 1683 and 1684, clearly illustrated both techniques. The first is *Marquis* (Figure 5-10), a 3<sup>rd</sup> rank ship with two decks built in Toulon between November 1683 and May 1685, *Proportions of a Ship of Two Decks made by Coulomb the Son* (Musée de la Marine PH 90252).

The drawing includes the elevation, the aft portion only of a vertical view, and a plan of the bottom. Six frames are shown in the elevation view and eight frames, including the master frame, are present in the vertical. Five ribband locations (*lisse*) are shown in each of the views. The effective result of the tablet and trébuchet being used, which results in non-logical but progressive arcs, is the appearance of curved ribbands on the vertical view. Noticeably absent are representations of triangles or half circles or instruments associated with trébuchement. It must be kept in mind, however, that this drawing was neither intended to be a plan nor directions for building the ship, but a visual representation of the ship's proportions. For that reason, the only following dimensions were provided:

- length from the stem post to the stern post;
- length of the keel on the ground;
- rake of the stem post;
- rake of the sternpost;
- the depth of the hold;
- flat of the master frame;
- width obtained at the place of the maximum breadth;
- width of the wing transom;
- height of the run of the rear;
- height of the run of the forward;
- width of the ship at the place of the ribband at the after part of the taffrail;

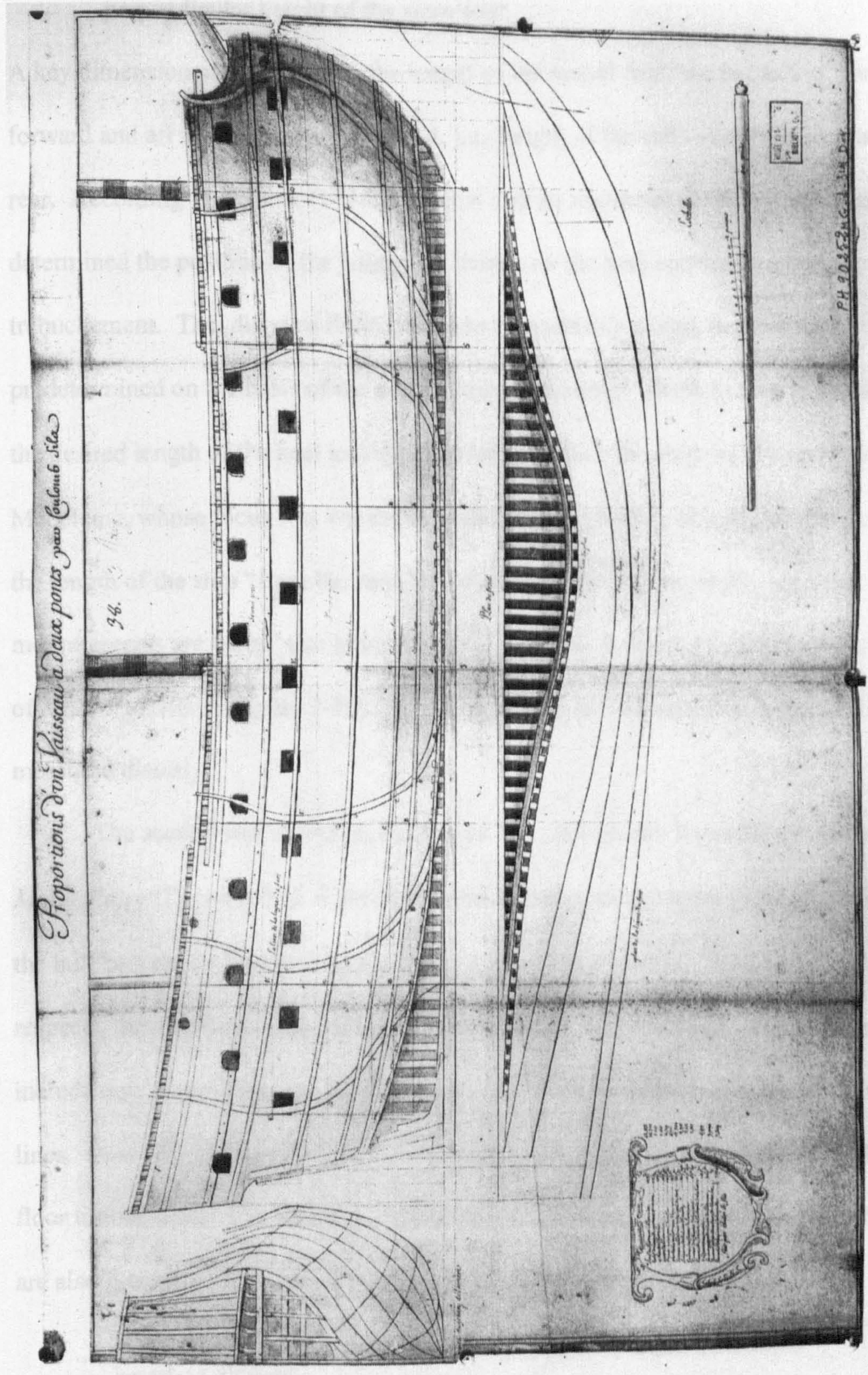


Figure 5-10: A two-decked ship drawn by François Coulomb and dated 1683. Photograph courtesy Musée de la Marine.

- perpendicular height of the stem post;
- perpendicular height of the stern post.

A key dimension not provided is the length of the vessel from the balancing frames forward and aft to the stem or stern post, i.e., length of the runs of the forward and of the rear. According to Ollivier (1736:164), this was an important dimension because it determined the position of the balancing frames on the keel and was used in the tablet and trébuchement. This distance did not need to be explicitly stated, however, as it was predetermined on the basis of the proportions of the ship. These in turn were based upon the desired length of the keel and the purpose for which the ship was being built. For *La Madeleine*, whose focus was warships, it was the first battery of a vessel that determined the length of the ship “from the stem to the stern post . . . from which origin all measurements are taken” (La Madeleine 1712, Article 1; Rieth 1996:53). In the drawing of *Marquis* (refer to Figure 5-10) the length of the run from sections 2 and 5 are easily measured directly.

The second was drawn on December 10, 1684 for the flutes *Dieppoise* and *Marseillaise* (Figure 5-11). This illustration includes an elevation view of the framing, the hull bottom, and vertical half sections of the bow and stern. While similar in many respects, there are some key differences between the two drawings. The vertical sections include only three ribbands, which are now shown as projections that result in oblique lines. Only the ribband for maximum breadth is illustrated in the plan view. The master floor timber, crotches forward and aft, the notched keelson, a scale, and other elements are also illustrated. Only eight selected measurements were included, they are:

- length from the stern post to the stem post;
- length of the keel;

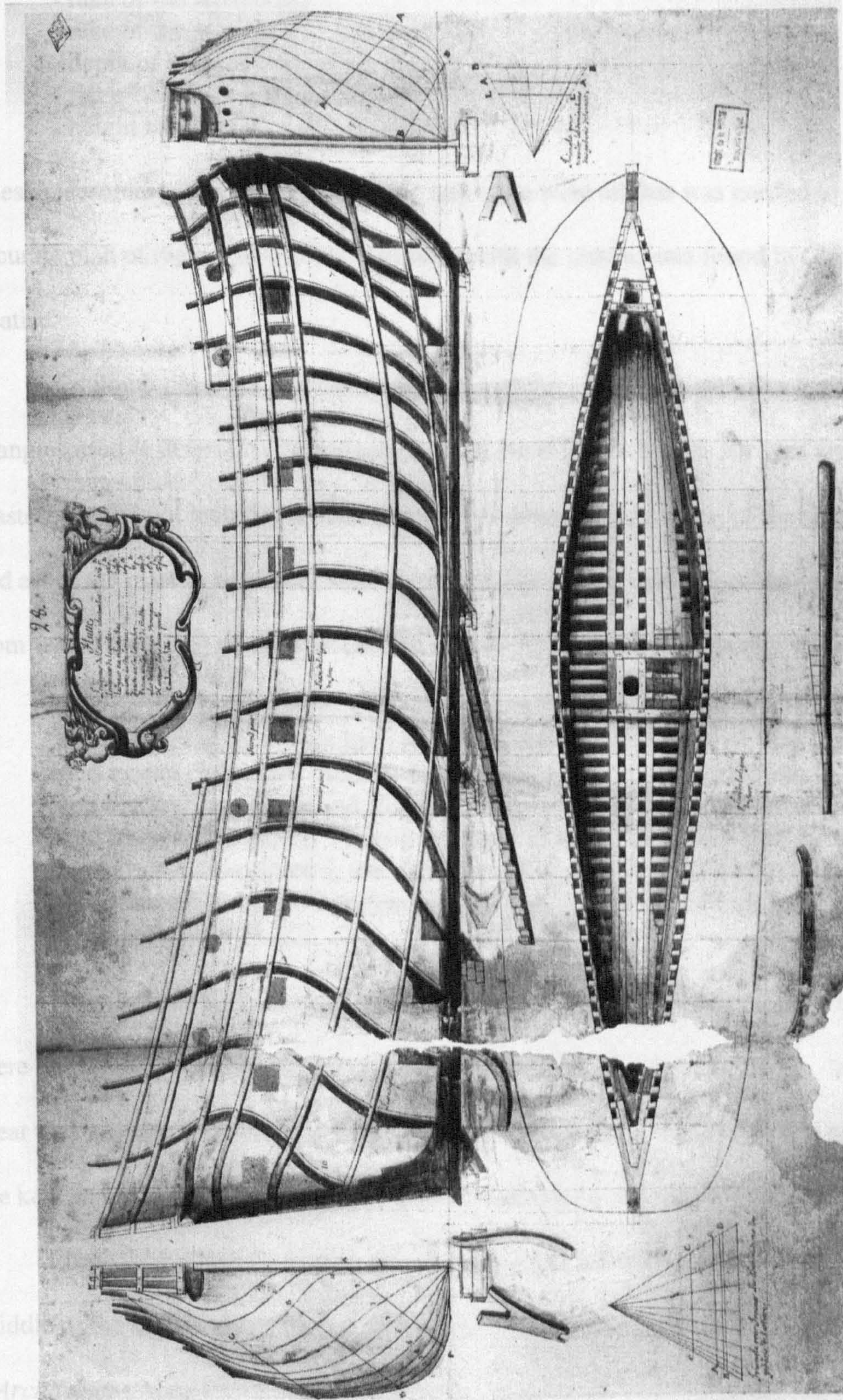


Figure 5-11: Flute drawn by François Coulob in 1684. Photograph courtesy Musée de la Marine.

- width of the master beam;
- rake of the stern post;
- rake of the stem post;
- depth of hold;
- flat of the master floor;
- height between decks.

These measurements with the illustration and scale were all that was needed to create an accurate plan of these ships, when combined with the instructions found in Coulomb's treatise.

Coulomb provided a bonus for later researchers by also illustrating the two triangles used to determine the reduction in the mold for the frames forward and aft of the master. He did not include the triangles used to determine the rising of the floors forward and aft of the master, however. Instead he provided a scale drawing of the master floor from which the rising could be measured and instructions for determining its rising:

And for the floors that put themselves at the beginning of the runs forward and of the rear, they must have two times more rise of the floor than the said master floor. This increase must serve to form a triangle similar to the one that has been made and to divide it in the same equal parts. And that said triangle that you /(<sup>f</sup>22) will produce, you mark over the tablet. And by the same adjust[ment], one can mark all increases of the rising of the 36 floor timbers as one will see by the demonstration of the rule quoted (Coulomb 1683:21-22).

The drawing also shows that mold frames extended the length of the ship and were not limited to the frames between the forward and aft balancing frame. In sum, it is clear that this ship was conceived on the basis of proportions stemming from the length of the keel and the master frame modified predominantly by rising and narrowing.

The tablet and trébuchet, however, did not fall out of favor until well into the middle of the 18<sup>th</sup> century. Du Monceau noted in the second edition to his *Elemens de l'Architectre Navale*:

The former constructors [were] ignorant of the methods of which we will speak . . . [and] had [to] imagine the middle hull at its greatest width mechanically . . . for with only the master couples they draw the pieces that they must use for the construction of the vessel a certain number of couples forward & aft, without making a plan . . . & as it is [now] abandoned entirely by the constructors, we suppress it in this second edition (1758:214).

In his first edition, produced just six years earlier, du Monceau (1752:194-204) provided a more complete discussion of the tablet and trébuchet.

For the purposes of this discussion of the conception of *La Belle*, it is important to recognize that the traditional trébuchement and what might be considered a modification of that technique by modest adjustments of the balancing frames, but clearly weighted to a straightforward rising and narrowing method, were known and used simultaneously by French shipwrights. Furthermore, that the fathers and sons Coulomb and Mallet used both suggests it was not generationally-delimited. Unfortunately, the reason for choosing one method over another is still unknown.

### **Reconstructing the Design**

The first step in unraveling the system of frame modification and the underlying design of *La Belle* required an examination of the master frame to identify its geometric components. That is, to learn the number of individual arcs that are present, their respective radii, center points, and the exact points along the frame where the successive arcs touched.

Second, the details of the three modifications, the rising of the floor, the narrowing of the floor, and the futtock modification, were sought. Because of the divergence between the Atlantic and the Mediterranean methods, the identification of the



futtock modification places *La Belle*'s in one of these two schools.

Third, it was necessary to identify the *couples de balancement* (balancing frames). These are known as *almogamas* in the Portuguese texts and *postreras* in the Spanish. These two frames were situated fore and aft of the master frame, typically about half way to the stem and stern post, where the systematic modifications ceased, and more empirical methods of hull design were implemented to give shape to the remaining bow and stern frames, i.e., the crotches, called *fourcats* in French texts.

## Method

In order to reconstruct the component arcs of the master frame (and the remaining frames), each individual frame was reconstructed on paper by aligning the drawings of the frame timbers in their original positions. For most frames, the timbers consisted of a floor timber and first, second, and third futtocks. The next step involved creating a series of arcs of different radii, from a common point, on a piece of transparent paper. This is similar to the method used in ceramics studies to determine the diameter of a bowl or plate. The radii for *La Belle*'s timbers were plotted at intervals of half a *pied du roi*, or 16.24 cm (the French foot is 32.484 cm). This template was used to identify the component arcs of each frame by trial and error.

Once the component arcs were identified, they were constructed as a set of tangential arcs on another transparent sheet. This compound template was again compared to the reconstructed frames in order to refine the radii and the touches of the successive arcs. Once fully refined, this template corresponded to the geometry underlying the master frame. Next, the chords of the component arcs were measured at

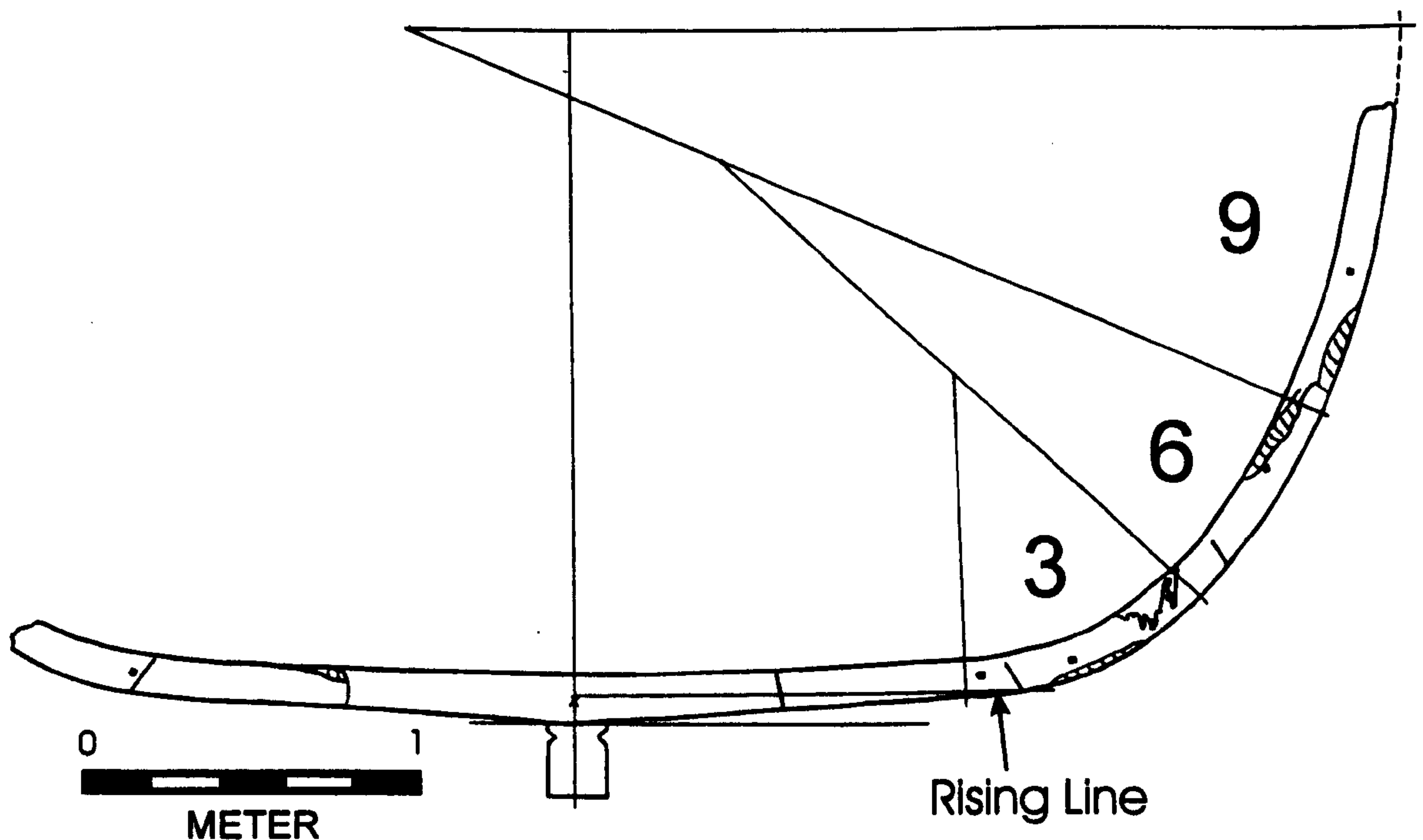
each frame, and plotted as graphs. This method was used as a test for the presence of Atlantic method of hauling down the futtock, which was predicated on the principle of varying the chords.

Last, a vertical line corresponding to that of the ship's central section was drawn on the compound template. The upper (breadth and futtock) arcs of the compound template were then placed over the upper portion of each frame. The angle between the template's center line and the vertical center line of each respective frame was measured and plotted on a graph. This method was used to detect the presence of the Mediterranean method of *trébuchement*, that is, the outward tilting of the futtock from a pivot point.

### **Master Frame Arcs and Modifications**

The master frame of *La Belle* was conceived on the basis of a flat floor that contained a rising of  $\frac{1}{4}$  *pied du roi* (8 cm) (Figure 5-12). A line extended from the rising point on the centerline also strikes the mold at the lower surmark (an in-depth discussion of the role of the surmarks appears elsewhere.) The bilge arc has a radius of 3 *pieds* (97.5 cm) and a chord of about  $2\frac{3}{8}$  *pieds* (77 cm). The futtock arc has a radius of 6 *pieds* (1.95 m) and a chord of about 2 *pieds* (66 cm). The breadth arc has a radius 9 *pieds* (2.92 m) and its chord could not be ascertained due to the loss of evidence at the upper end of the second futtock. The floor has a half breadth of 3 *pieds 7 pouce* (1.17 m) measured to the touch of the floor flat and the bilge arc. The three frames at midship are identical, i.e., the master frame, and frames at positions one forward and one aft.

The calculated modifications in the frames fore and aft of the midship section

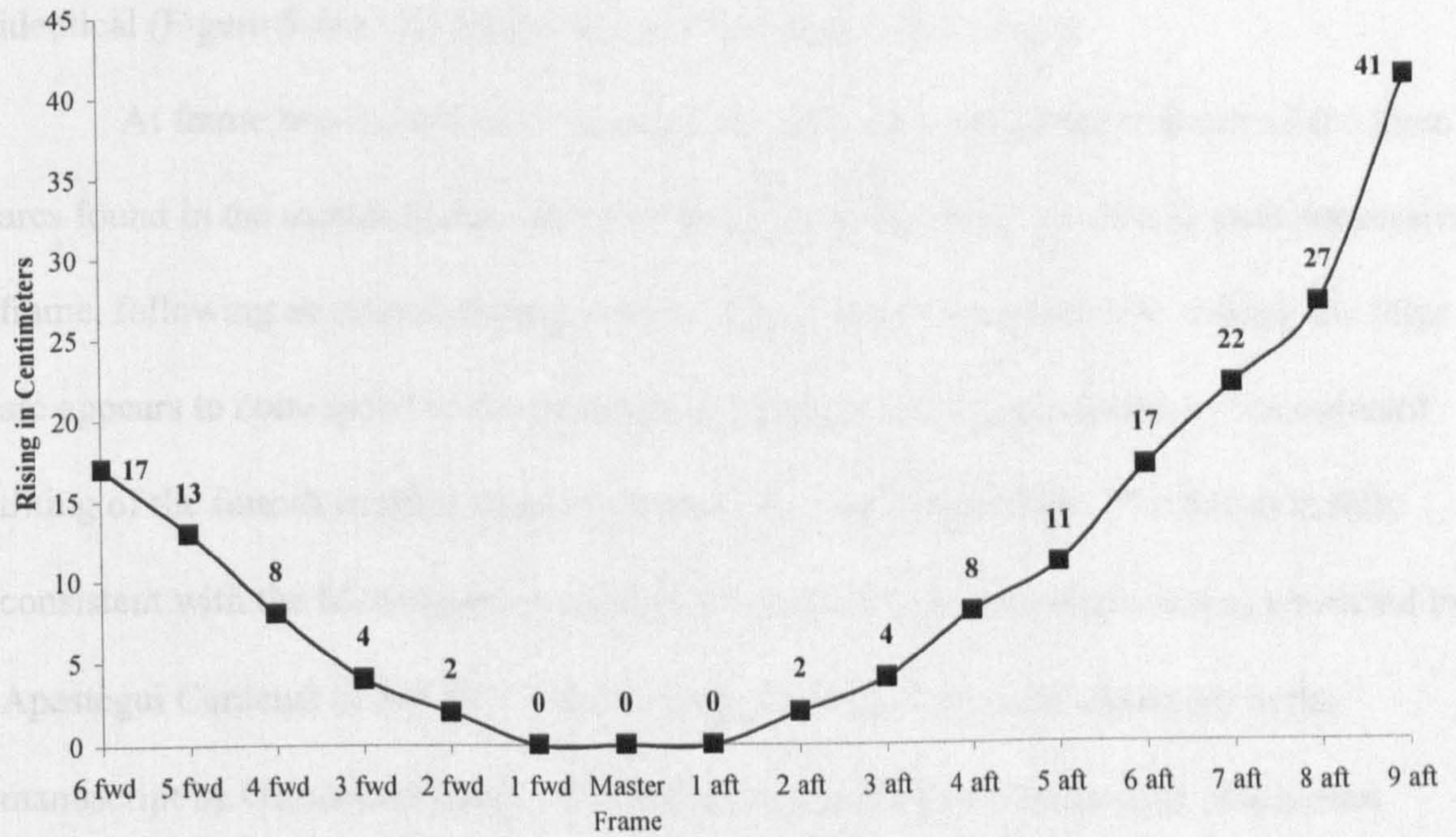


**Figure 5-12:** The master frame on *La Belle* showing its three-arc conception. Drawing by Donald H. Keith.

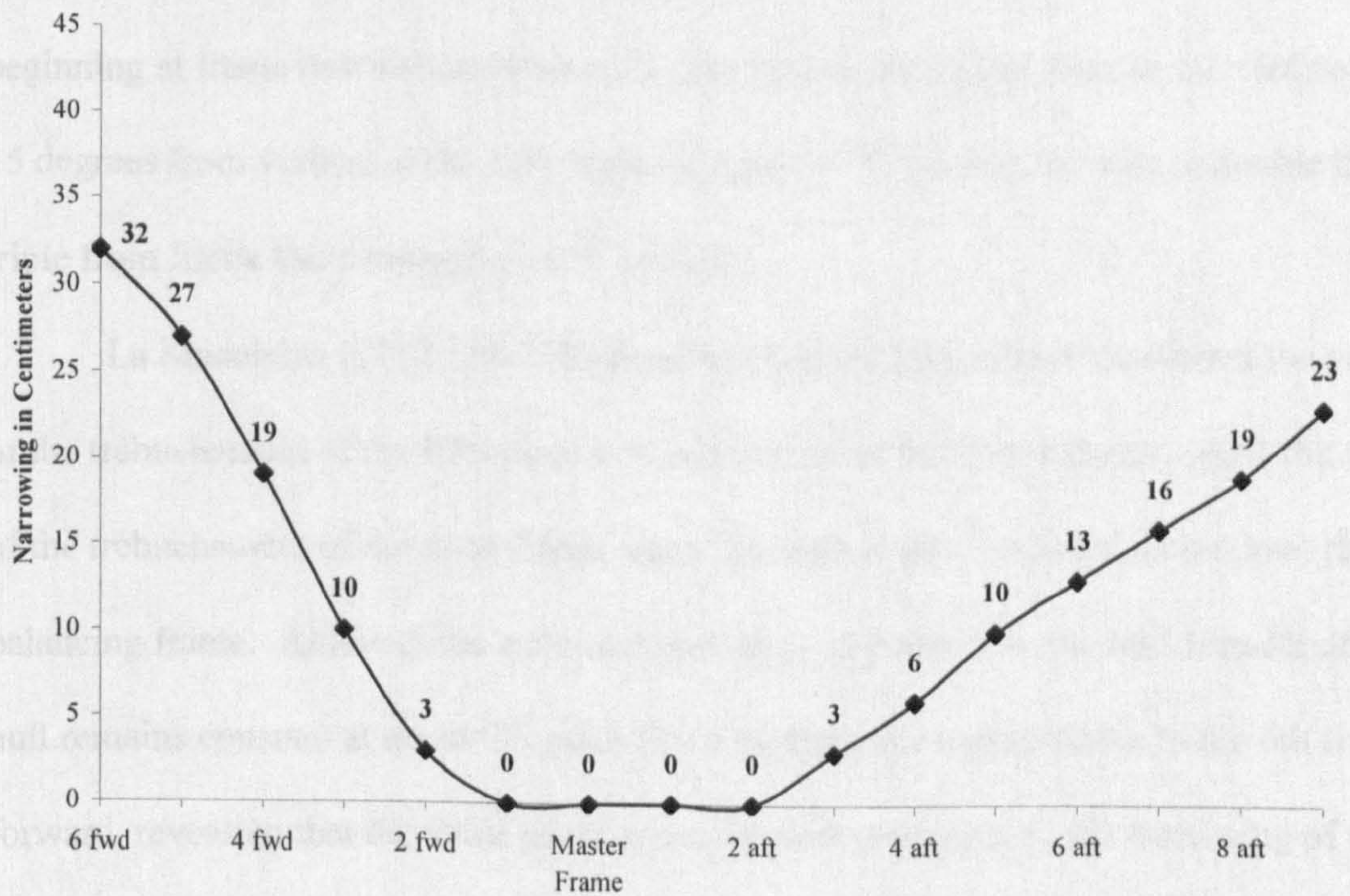
could be reconstructed as far as the sixth frame forward and ninth frame aft. In these frames, the modifications could be reconstructed as a geometric progression, which are illustrated in (Figures 5-13 and 5-14). Forward of the master, the rising to the sixth frame is approximately 6 *pouces* (17 cm) and the narrowing is 1 *pied* (32 cm). Aft of the master frame, the rising of the floor to the ninth frame is 1 *pied* 3 *pouces* (41 cm) and the narrowing 8 *pouces* (23 cm).

### **Design Forward**

Forward of the master frame the 3-*pied* bilge, 6-*pied* futtock, and 9-*pied* breadth arcs appear through frame five. After frame five the 3-*pied* arc disappears and only the futtock and breadth arcs (i.e., the 6- and 9-*pied* arcs) continue through frame seven



**Figure 5-13:** Rising of forward and aft frames.



**Figure 5-14:** Narrowing of forward and aft frames.

(Figure 5-15). The bilge and futtock arc chords in the master frame and frame one are identical (Figure 5-16). At frame two and thereafter, this changes.

At frame two the radius of the bilge arc does not correspond with any of the three arcs found in the master frame. Indeed, the radius appeared to increase in each successive frame, following an empirical progression. The failure to geometrically modify the bilge arc appears to correspond to the necessity of fairing out the kink created by the outward tilting of the futtock mold at its pivot point in the area of the bilge. This result is fully consistent with the Mediterranean modification called *trébuchement* and was predicted by Apestegui Cardenal (1992:13-32) in his analysis of the *joba* (*trébuchement*) in the manuscript by Gazteneta (1688). The manuscript includes an illustration of a master frame and a second frame that is modified by tipping outward (refer to Figure 5-2).

The outward tilting of the combined futtock and breadth arcs in *La Belle* is present beginning at frame two and continues in a progression that culminates in a deviation of 15 degrees from vertical at the fifth frame (Figure 5-17). In fact, the values double then triple from frame three through five in *La Belle*.

La Madeleine (1712:158-159) described this process, which meant that the value of the *trébuchement* of the fifth frame was double that of the fourth frame, while the value of the *trébuchement* of the sixth frame was triple that of the fourth and so on up to the balancing frame. Although the *trébuchement* stops at frame five, the half-breadth of the hull remains constant at about  $7\frac{1}{2}$  *pieds* (2.44 m) from the master frame to the 6th frame forward, revealing that the value of the *trébuchement* was equal to the narrowing of the floor at 1 *pied* (32 cm).

Forward of the master frame, the absence of hauling down the futtock was

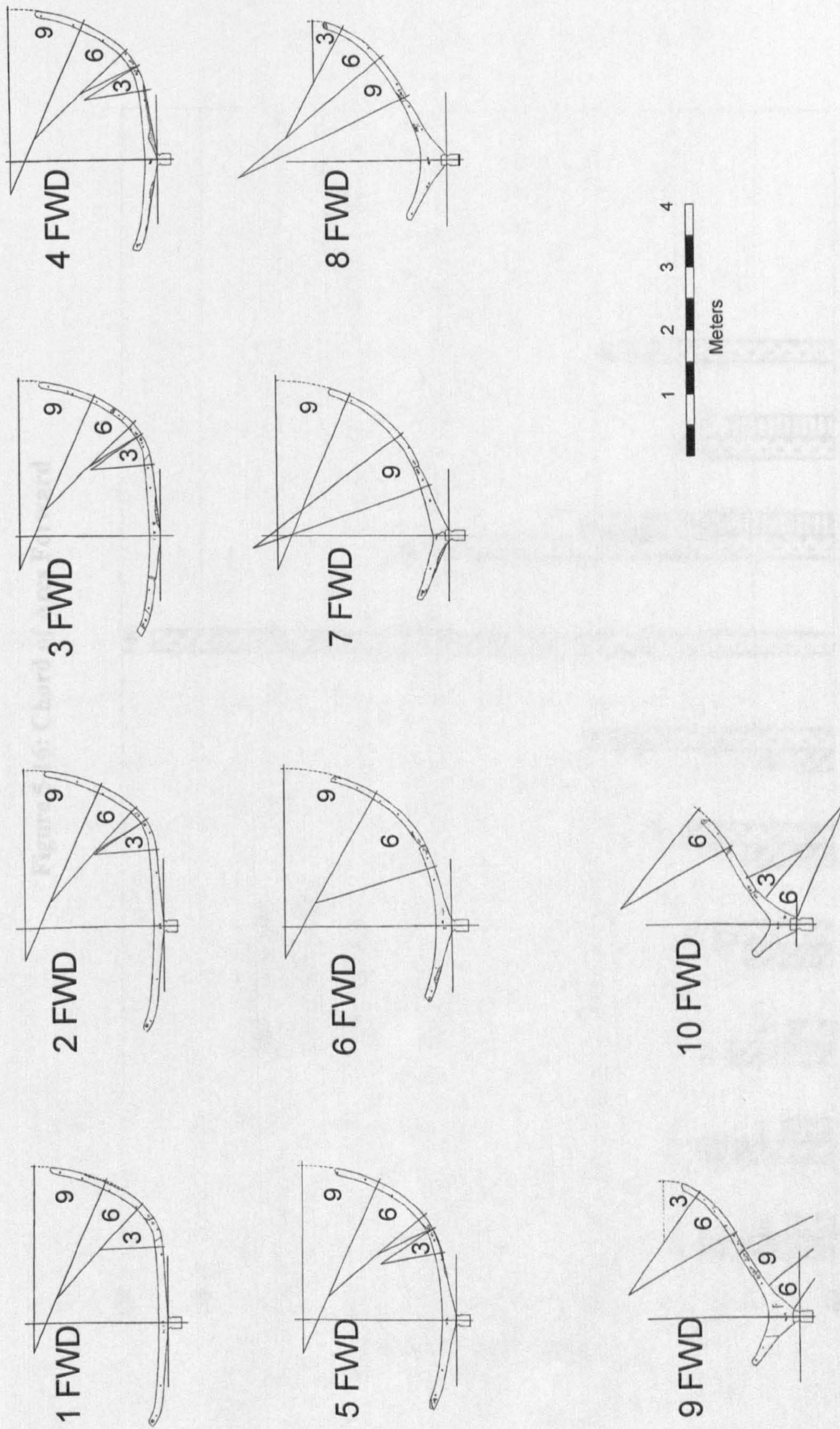
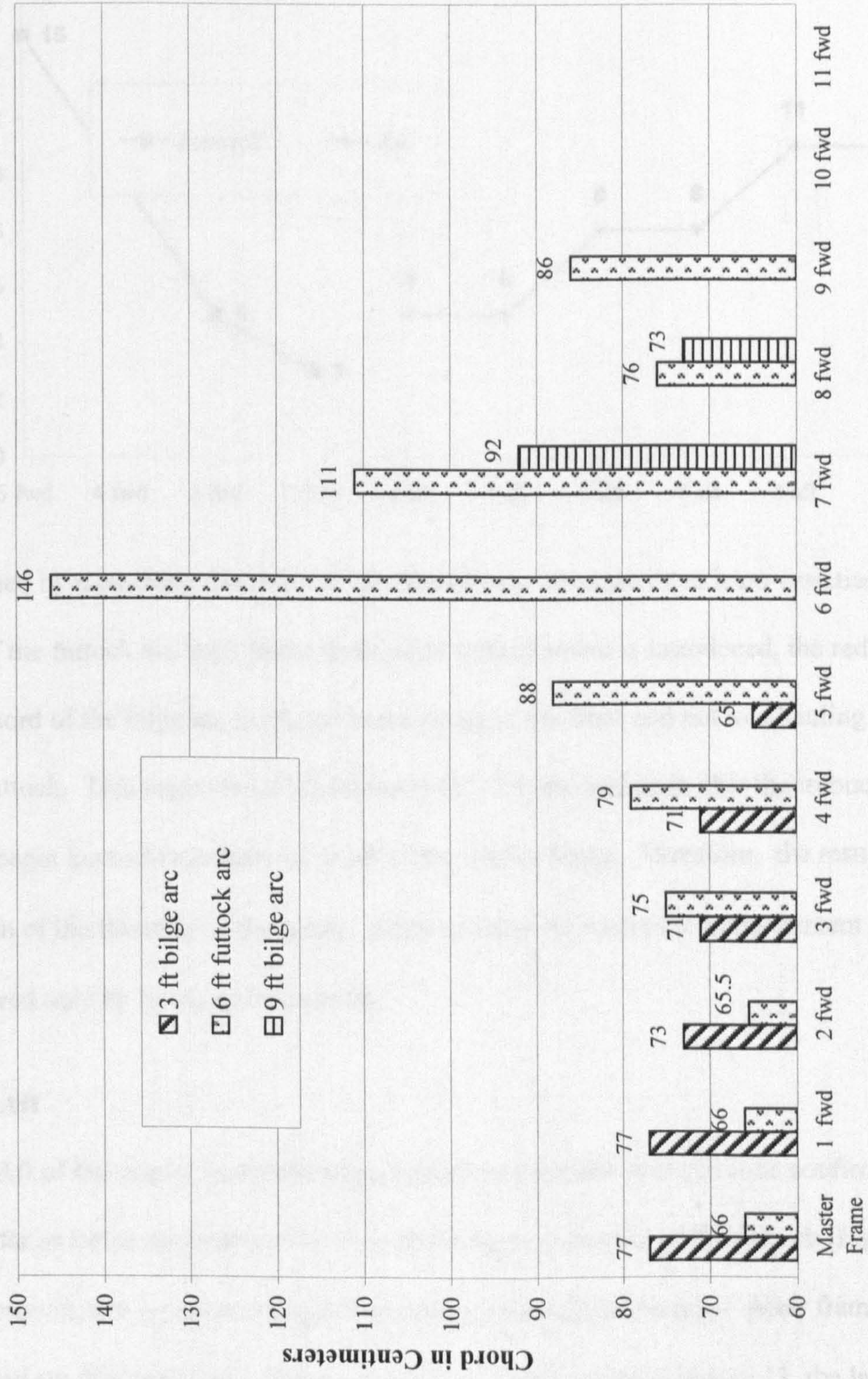
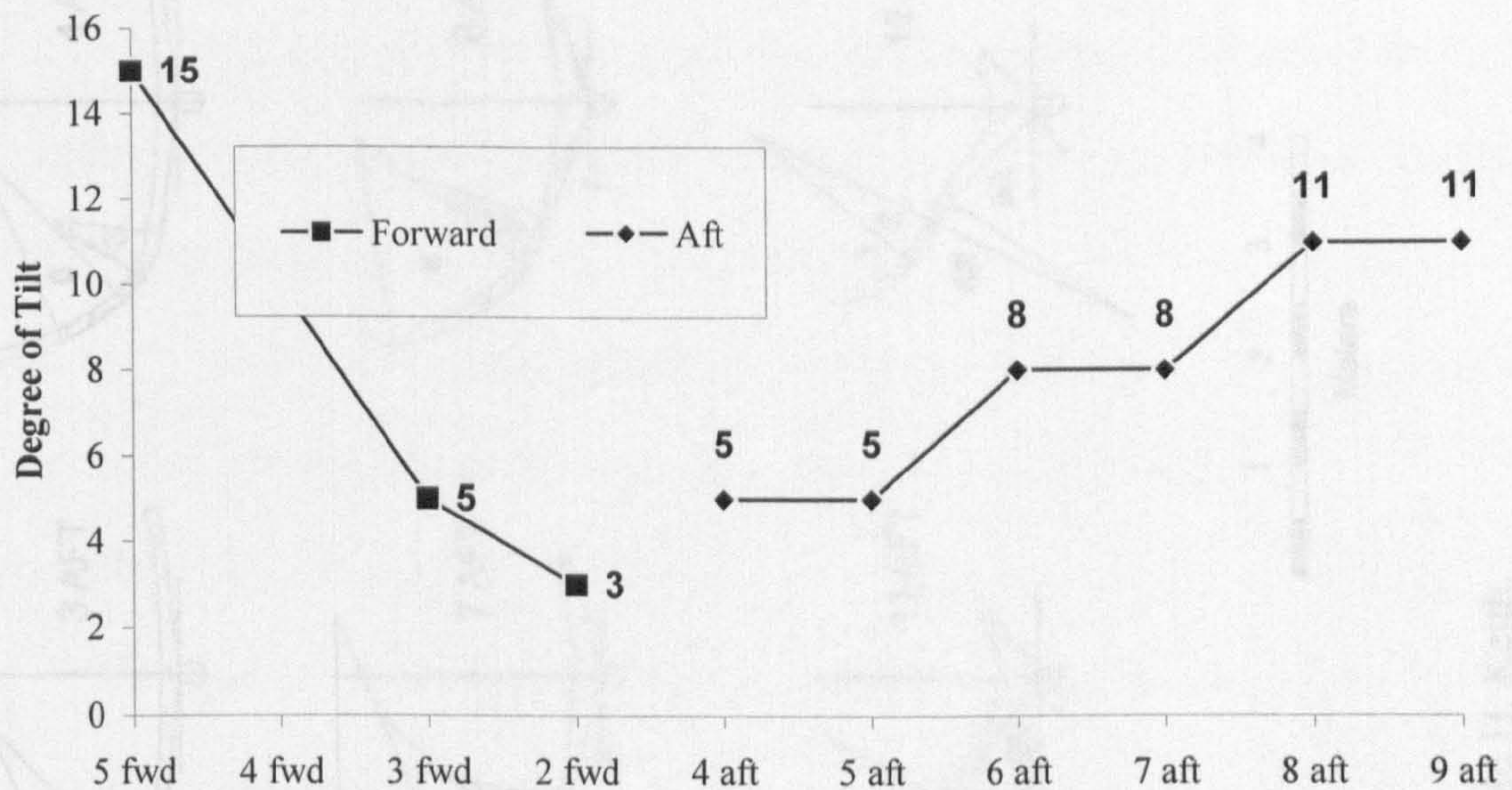


Figure 5-15: Forward arcs. Drawing by Donald H. Keith.

Figure 5-16: Chord of Arcs Forward



**Figure 5-17: Degree of Trébuchement**



established by measuring the chord of the futtock arc. Because there is no variation in the chord of the futtock arc until frame three, after trébuchement is introduced, the reduction in the chord of the bilge arc is related to the rising of the floor and not to a hauling down of the futtock. This supports La Madeleine's (1712:158) comments that the trébuchement did not begin immediately forward or aft of the master frame. Therefore, the resulting reduction of the floors from the master frame to the point where the trébuchement begins is achieved only by rising and narrowing.

### **Design Aft**

Aft of the master frame the bilge, futtock and breadth arcs could be confirmed only as far as frame seven due to the loss of the upper extremity of the futtock (Figure 5-18). However, the 3-pied and 6-pied arcs continue though frame nine. After frame nine the 3-pied arc disappears and only the 6-pied arc survives through frame 13, the last



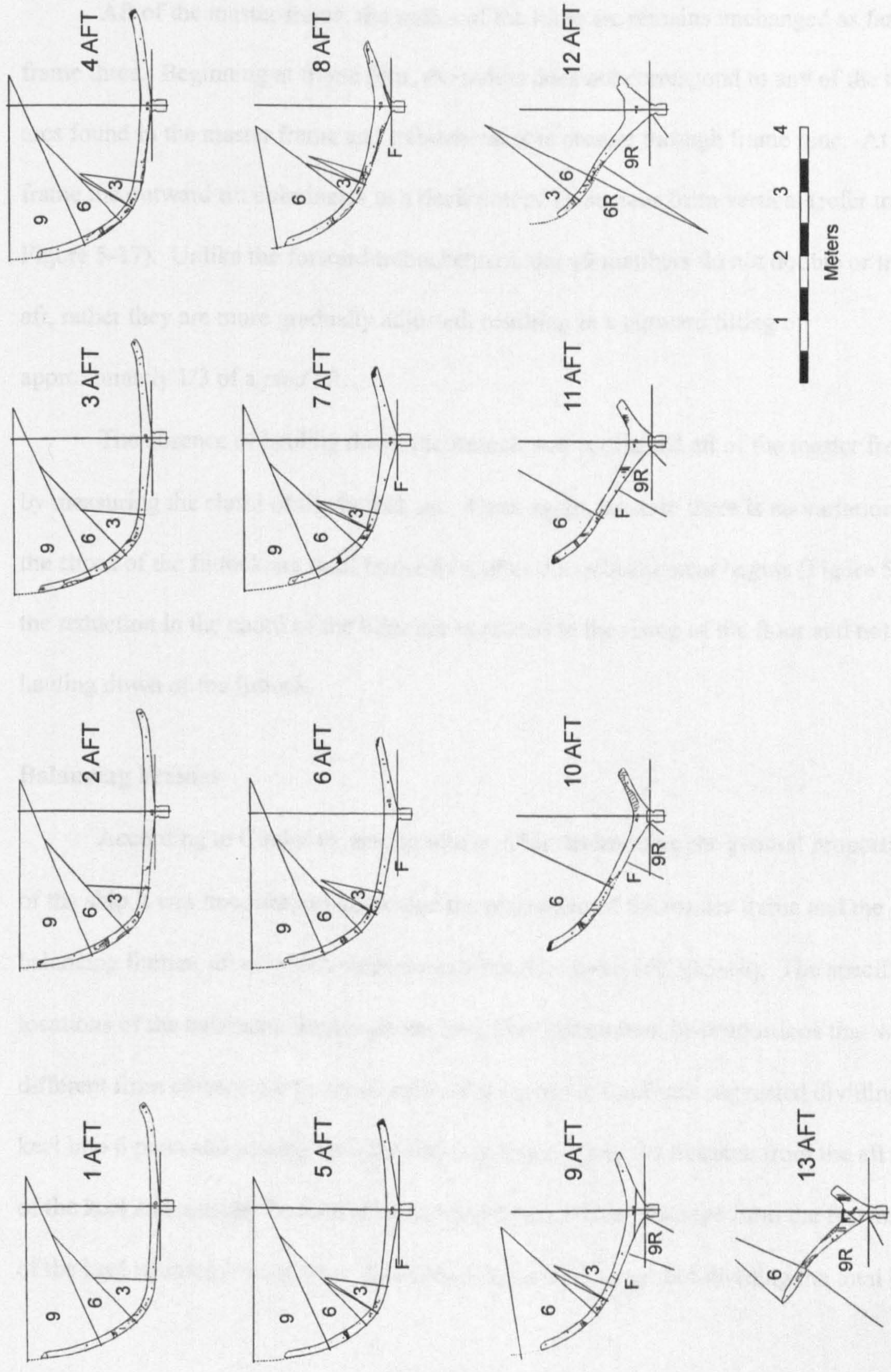


Figure 5-18: Aft arcs. Drawing by Donald H. Keith.

frame for which it was possible to determine arcs.

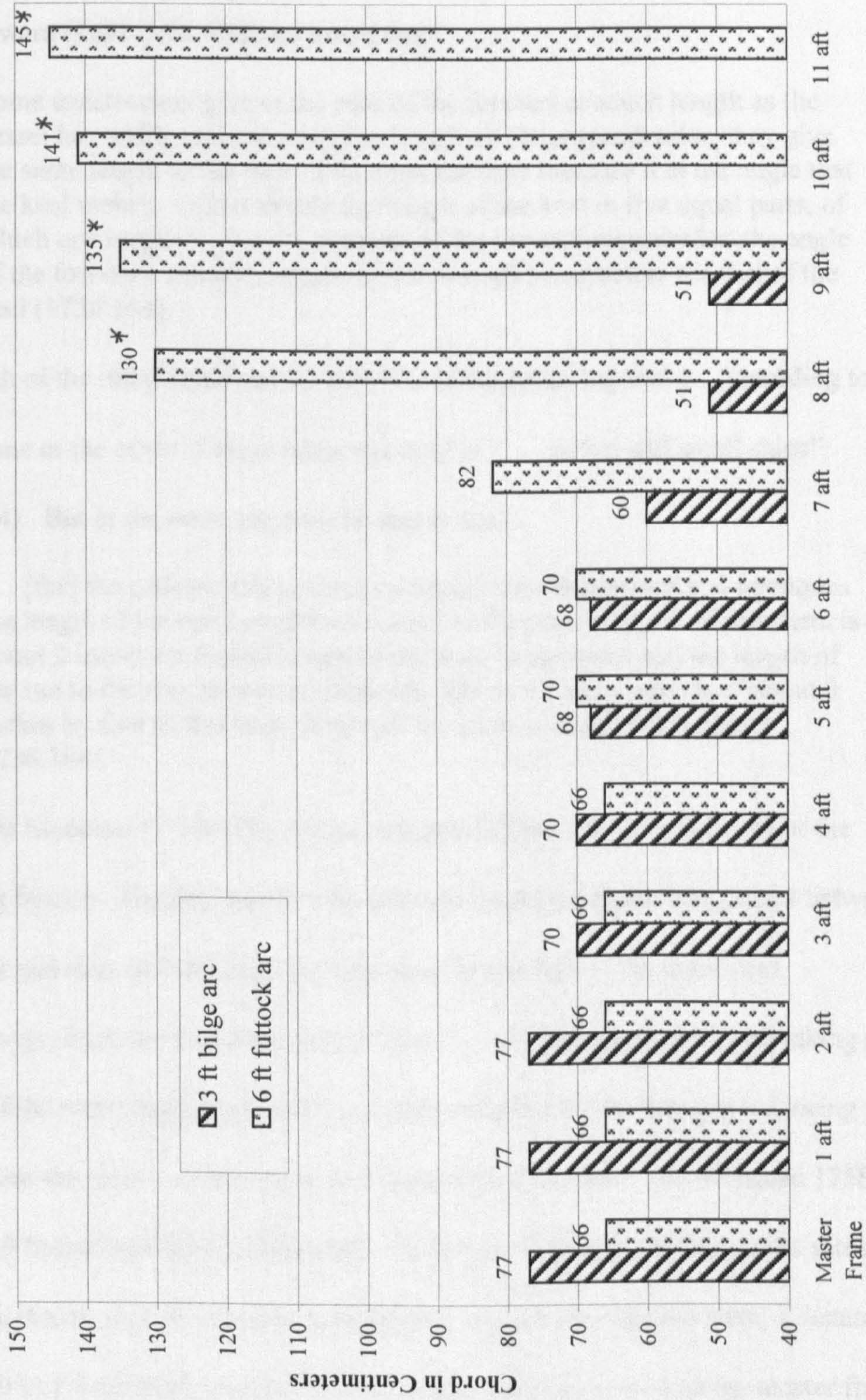
Aft of the master frame, the radius of the bilge arc remains unchanged as far as frame three. Beginning at frame four, the radius does not correspond to any of the three arcs found in the master frame and trébuchement is present through frame nine. At this frame the outward tilt culminates in a deviation of 11 degrees from vertical (refer to Figure 5-17). Unlike the forward trébuchement, the aft numbers do not double or triple aft, rather they are more gradually adjusted, resulting in a outward tilting of approximately 1/3 of a *piéd* aft.

The absence of hauling down the futtock was confirmed aft of the master frame by measuring the chord of the futtock arc. Once again, because there is no variation in the chord of the futtock arc until frame five, after the trébuchement begins (Figure 5-19), the reduction in the chord of the bilge arc is related to the rising of the floor and not to hauling down of the futtock.

### **Balancing Frames**

According to Coulomb, among others, after determining the general proportions of the ship it was necessary to determine the placement of the master frame and the balancing frames, all of which were pre-erected (Coulomb 1683:15-16). The specific locations of the balancing frames on the keel were determined by proportions that were different from constructor to constructor. For example, Coulomb suggested dividing the keel into 6 parts and placing the aft balancing frame  $\frac{2}{6}$  of the distance from the aft end of the keel and placing the forward balancing frame  $\frac{1}{6}$  the distance from the forward end of the keel (Coulomb 1683:16). An anonymous author suggested dividing the total length

Figure 5-19: Chord of Arcs Aft



\* Actual unknown due to lack of preservation

in four parts, taking one for the placement of the balancing frame aft and then dividing the total length in six parts and taking one of those for the placement of the balancing frame forward (1691:6-7). Ollivier noted that:

Some constructors give to the runs of the forward as much length as the vessel has width, and measure this length on the perpendicular; they give the same length to the runs of the rear, but they measure it at the angle that the keel makes. Others divide the length of the keel in five equal parts, of which one length is given to the runs of the forward measured to the angle of the fore-foot and two lengths to the runs aft measured to the end of the keel (1736:164).

The length of the run determined the position of the balancing frame. According to Ollivier one or the other of these rules was used in “. . . all big and small ships” (1736:164). But in the same sentence he stated that:

. . . [for] the galleys, half galleys, oared galliots, brigantines and felouques the length of the run forward, measured to the perpendicular of the stem, is about 2 inches by foot of length of the stem to sternpost and the length of the run to the rear, measured perpendicular to the stern post, is of about 3 inches by foot of this same length of the stem to stern post (Ollivier 1736:164).

Du Monceau (1758:173) offered two possibilities for the placement of the balancing frames. The first was that the forward balancing frame was placed between the mainmast and stem at a distance that was equal to one half of the main yard.

Alternatively, he stated that constructors were “. . . sometimes content with taking a quarter of the total length from rabbit to rabbit and placing [the forward balancing frame] . . . between the middle of the vessel and the rabbit of the stem” (du Monceau 1758:174).

For the aft balancing frame du Monceau (1758:174-175) suggested using the same approach, that is, placing it between the middle of the vessel and the stern, a distance that was equal to 1/4 the total length. These locations were predicated on the master frame

being placed in the middle of the vessel (du Monceau 1758:115). *La Madeleine* (1712) did not provide any specifics on the location of the balancing frame.

While these authors offered different opinions on where the balancing frames should be located and how that determination was made, du Monceau stated a key factor in their placement:

There is in the aft section a couple that must balance itself with the one of the forward, so that the runs of these two couples are even, having the same width . . . so that the water lines have equal openings to balance the vessel forward and aft of the master couple; that means that the parts included between these two couples have more or less as their center of gravity the plane of the master couple” (1758:175).

Unfortunately, none of the above offered formulae proved useful in confirming the balancing frames on *La Belle*. However, taking a cue from du Monceau that these frames must provide balance, their identification was advanced through a combination of conceptual and archaeological lines of evidence.

From the conceptual perspective, the design of the frames forward and aft includes those that exhibit *trébuchement* and those that do not. Beyond the central frames, *trébuchement* is present up to and including frame nine aft and up to and including frame five forward (refer to Figures 5-15 and 5-18). Each of these frames also retains, where it was possible to confirm, the 3, 6, and 9-*piéd* arc combination found on the master frame. Based upon this alone, frames five and nine appear to be the balancing frames.

From the archaeological perspective three pieces of information are useful. As noted previously, only selected frames exhibit a distinctive fore and aft fastener orientation indicating they were clearly pre-erected. In addition, certain frames were

inscribed with a surmark on their exposed face. The frames that exhibit these two archaeological features appear exclusively at positions divisible by three, i.e., at frames 3, 6 and 9 forward and 3, 6, 9, and 12 aft (refer to Figure 3-18). These frames are clearly unique within the construction matrix of *La Belle*, so logically it is among these frames that the balancing frames should appear. The archaeological evidence in combination with the presence of trébuchement supports the notion that the aft balancing frame is at position nine.

Placing the forward balancing frame at position five, however, does not fare as well archaeologically. It was not pre-erected and it does not have surmarks. Being pre-erected is an important element in all of the discussions of the process of ship construction with the use of trébuchement (Coulomb 1683, Anonymous 1691, and du Monceau 1758). Recognizing that a key element is balance, the position on the keel was considered. The frame at nine aft is situated at the mid-point between the master frame and the end of the keel, a position suggested by Ollivier, as noted above. This lends further support to frame nine being the aft balancing frame. Likewise, the mid-point of the distance between the master frame and the perpendicular from the stem is occupied by frame six, similar to that suggested by du Monceau. Lastly, there is a design mark on frame six and on all of the other pre-erected frames, which is absent on frame five. In combination with the other archaeological evidence, this suggests that frame six and not five is the forward balancing frame.

Because frame six does not exhibit trébuchement this raises other questions. Du Monceau (1758:214) noted that the tablet and trébuchet have limitations: "This method .. does not provide a means to draw more than the first six couples of the aft & the first

six of the forward.” While La Madeleine and others describe using the method beyond the sixth frame, it does suggest that at the point of the sixth frame some adjustments were necessary and some problems existed. The abandonment trébuchement after frame five forward, however, may have had as much to do with the size of the ship and the necessity to quickly adjust the shape of the hull as any inherent problems in the method.

Beyond the conceptual issues, it should be mentioned that among the forward pre-erected frames number six is anomalous for other reasons. First, as described previously in the discussion on assembly, this frame does not exhibit the three-and-three fastener pattern found on all of the other pre-erected frames. However, the orientations of the fasteners do match those of the other pre-erected frames. Second, the sided dimensions on all of the timbers that make up this frame are anomalous. Third, the frame exhibits anomalous fasteners on the inboard and outboard faces that do not relate to other archaeological features. Fourth, the surmarks on this frame are slightly off, that is they do not quite line up with the diagonal that is created by extending a line through the cross section of the ship. While the amount they are off is minimal and easily accounted for by the shipwrights during construction, it reinforces the anomalous nature of this particular frame. Despite its anomalies and lack of trébuchement, frame six is still the best candidate for the forward balancing frame

### **Crotches Forward and Aft**

Beyond the balancing frames the trébuchement is absent and other means were used to determine their modification. Because the crotches are dominated by the 6- and 9-*piéd* arcs, it appears that the method that Coulomb (1683:25-27) described was applied

here. Briefly, the width of the master mold was applied to the rising and narrowing of the crotches through a series of progressive reductions using an equilateral triangle.

Archaeologically, this should have produced a gradient line when tabulated graphically. Unfortunately, the chords of the *6-pied* arcs in these frames are highly variable due to lack of preservation (refer to Figures 5-15 and 5-18 and Figures 5-16 and 5-19). Beginning at frame six, the *3-pied* bilge arc disappears and the *6-pied* arc serves as both bilge and futtock arcs. At frames seven and eight the *3-pied* bilge arc is replaced by a *9-pied* bilge arc. At frame nine, the *6-pied* and *9-pied* reverse arcs and a short length of flat replaces the bilge arc below the *6-pied* futtock arc. A *3-pied* arc is present above the futtock arc on both frames eight and nine, evidence of the aft tumblehome. At frame ten, only a small portion of the *6-pied* arc survives.

At frames ten and eleven a bit of flat replaces the *3-pied* bilge arc and the *6-pied* futtock arc is present. At frame twelve the flat is absent and the *6-pied* futtock arc and *3-pied* arc for the tumblehome appears. At frame thirteen, only a small portion of the *6-pied* arc survives.

### **Surmarks and Diagonal Lines**

The discovery of surmarks on the pre-erected frames, while unanticipated, was not particularly remarkable for a ship built during this period. Several references to the use of surmarks appear in 16<sup>th</sup>- and 17<sup>th</sup>-century English manuscripts: the so-called Pepys Library manuscript ca. 1586-1630, the so-called Scott Manuscript ca. 1590, the so-called Newton Manuscript ca. 1600, the so-called Manuscript 9 ca. 1620, and lastly, the treatise by William Sutherland in 1766. Among the French, Ollivier mentioned the use of



“*reperes marques*,” literally translated as “reference-mark marks” in his discussion of the mold frames:

. . . All the timbers which make up the frame are shaped according to the molds given by the Builder, the floor to the floor mold, the first futtocks to the first futtock mold and so on for the other timbers, and the timbers are marked with the same reference-mark marks [surmarks] as are to be found on the molds (1736:118).

The location and use of the surmarks, at least in the construction of *La Belle*, is quite different than their use by the English. In the anonymous manuscript (ca. 1600) later copied by Sir Isaac Newton, it is clear that the surmarks were intended to indicate the touch of contiguous arcs:

They must be careful to observe when they make their moules that all these arks must be joyned together & that they may truly touch one with another & that all the touches be marked upon the moules & that all the surmarks must be so placed that the measures both of the halling down & pulling up & tumbling home be put upon his own ark & the hauling down & pulling up of the futtock must be put upon his own ark & the tumbling home wch is but the pulling up must be put upon his own ark (Barker 1994:21).

This is not the case in the design of *La Belle* because the surmarks on the master do not correspond to the touch of the arcs (refer Figure 5-12). With the exception of the upper mark at nine forward and twelve aft, they do not correspond to the touch of the arcs in any of the forward and aft pre-erected frames (refer to Figures 5-15 and 5-18). Clearly the surmarks were not intended to function as reference points for the arcs.

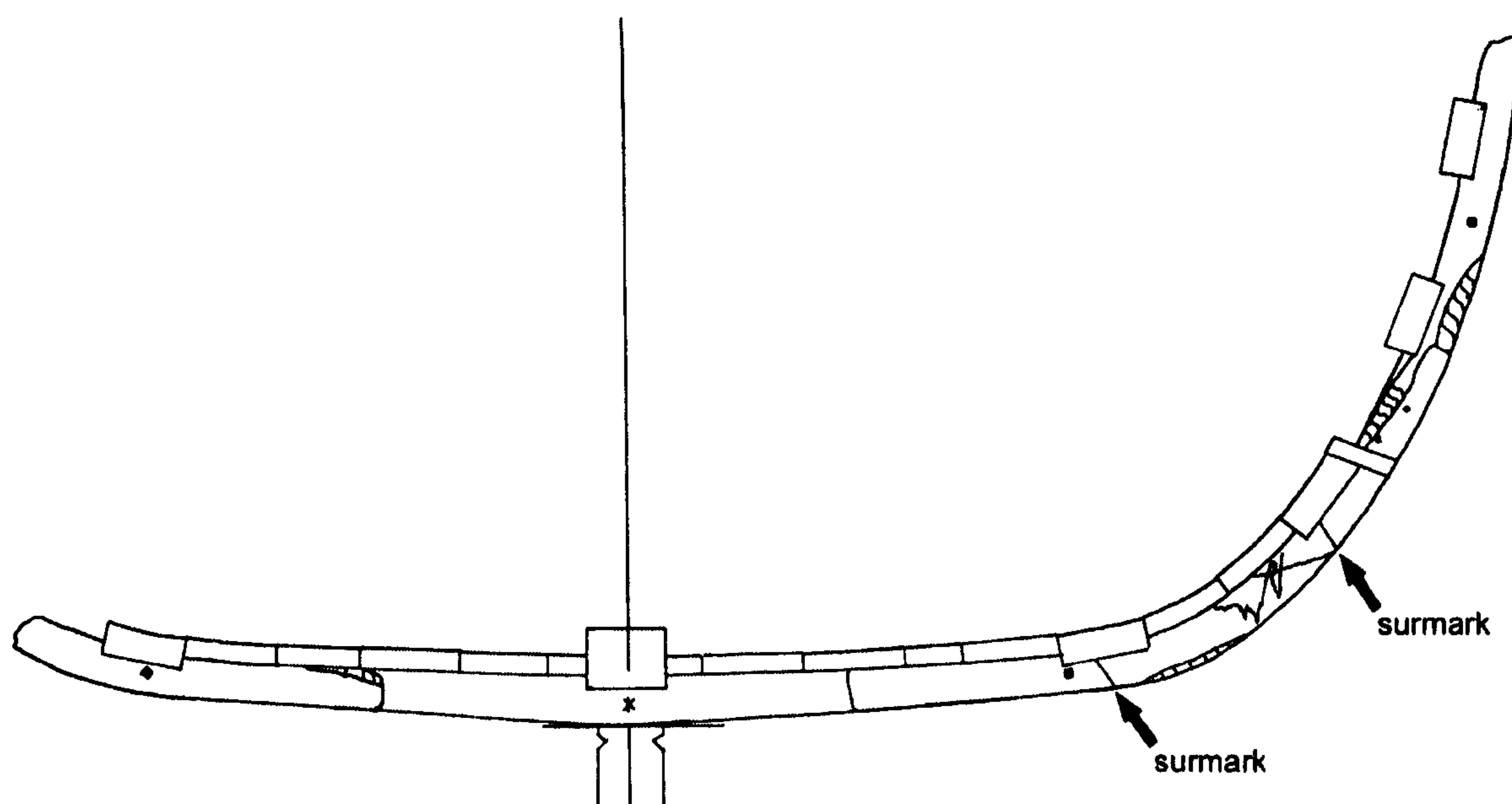
In contrast to the English approach, Ollivier provided some indirect information on how the surmarks were used:

. . . The assembly of the timbers is done on a piece of flat ground . . . . The floor timber is laid . . . with the second futtocks at the same level, one at either end of the floor, and the two fourth futtocks at the heads of the second futtocks and finally the two toptimbers at the heads of the fourth

futtocks. The whole mould of the frame is offered up to the timbers laid out in this manner. A chalk line is set in the middle of the frame with the help of compasses and secured by a nail to the block. The rules for the opening of the height of breadth and bulwarks are offered up to the frame and the futtocks are moved in or out according to the requirements of the rules or of the mould, until the frame has in all its parts the external shape represented by the mould. The floor and the futtocks are then secured in position by means of nails which are driven one on the inside and the other on the outside of each timber into each block. The mould and the rules are removed. The first futtocks are laid on top, half over the floor and half over the second futtocks, the third futtocks next, half over the second futtocks and half over the fourth futtocks; and finally, the fifth futtocks, half over the fourth futtocks and half over the top timbers. Once these timbers are position the rules are offered up again to check that the opening of the frame has remained exact, and once it is so, a plank is laid across at the level of the height of breadth or a little above which runs from one side to the other of the frame, which is called the cross-space of the height of breadth; at the height of the bulwarks is placed another similar plank called the cross-space of the bulwarks.

These two planks are lapped at their ends by about an inch over the frame timber and two or three holes are drilled in them which go down 1 or 2 inches into the frame timber. A saw kerf is made in the middle of each cross-spate to mark the middle of the frame as shown by the chalk line, and the cross-spates are numbered so that they can be put back in their place once the frame has been crossed over the keel . . . . When all the molded frames have been built, the first part of each frame, by which I mean the floor or the crotch to which are fastened the first futtocks and sometimes the second futtocks as described above, is crossed over the keel. The first ribband is set up. Shores are placed at this ribband, two for each frame, one on either side. A level is placed on a plank laid on its edge over the ribbands next to each frame and the shores are forced in on either side if the frame needs to be raised or lowered. When this operation is complete the futtocks which go to complete the frame are added . . . . The timbers forming the two sides of each frame are assembled simultaneously, and once they have been bolted the cross-spates are offered up and nailed to the frame timbers using the holes which were drilled when the frame was first assembled. Thus the frame takes up the same figure as it had when it was laid out on the ground. Once the cross-spates have been put in place, a plumb line is hung from the saw kerf marked in their middle and once all the shores are in place the frames where the plumb line does not fall true on the middle line of the keel are forced in or out. This practice of using a plumbline is not employed by all Builders (1736:118-119).

The key to understanding the role of the surmarks in *La Belle* is Ollivier's reference to the addition of the ribbands. When the interior structures are added to the master frame, illustrated in Figure 5-20, one aspect of their purpose becomes clear. The



**Figure 5-20:** Master frame with interior structure and surmarks Drawing by Taras Pevny.

positions of the surviving lower and upper surmarks correspond to the lower and upper notched ceiling planks on the master frame and, indeed, on all of the pre-erected frames. On their outboard faces this group of frame timbers also exhibits an unusual number of blind treenail holes. As noted elsewhere in this study, the French did not permanently attach the ribbands and there is good evidence to suggest that treenails were used, in part, for this purpose. The relationship between the surmark, the ribbands, and interior stringers is clear. Further support for this supposition is that all of the surmarks appear on the exposed faces of the frame, that is, they are clearly visible when the frame is completely assembled and in place over the keel, making it easy to accurately place the

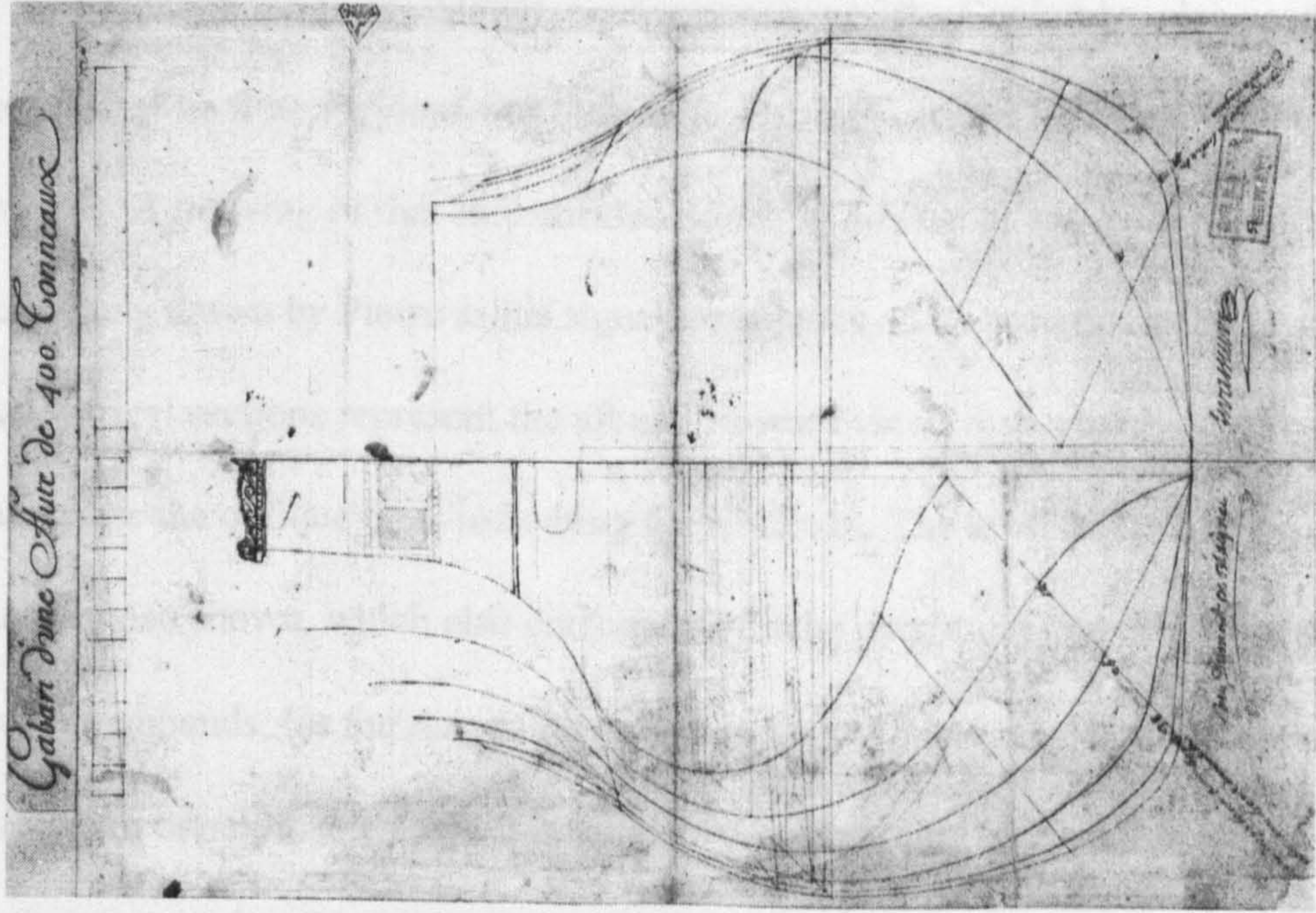
ribbands and later the stringers.

Another purpose of the surmark was in a graphic projection of the hull. The years 1680 to 1685 were a period of design evolution in the French marine. The ancient method of gabarit, tablette, and trébuchement did not make use of a lines plan. However at the new schools of construction, master constructors were teaching the new methods based upon architectural drawing techniques. Because of this change in method, when *La Belle's* surmarks are projected on a half breadth plan and the points are connected, they form parallel diagonals (Figure 5-21). As already demonstrated, these diagonals do not represent rising and narrowing, rather they are graphically projected control points for the shape of the hull.

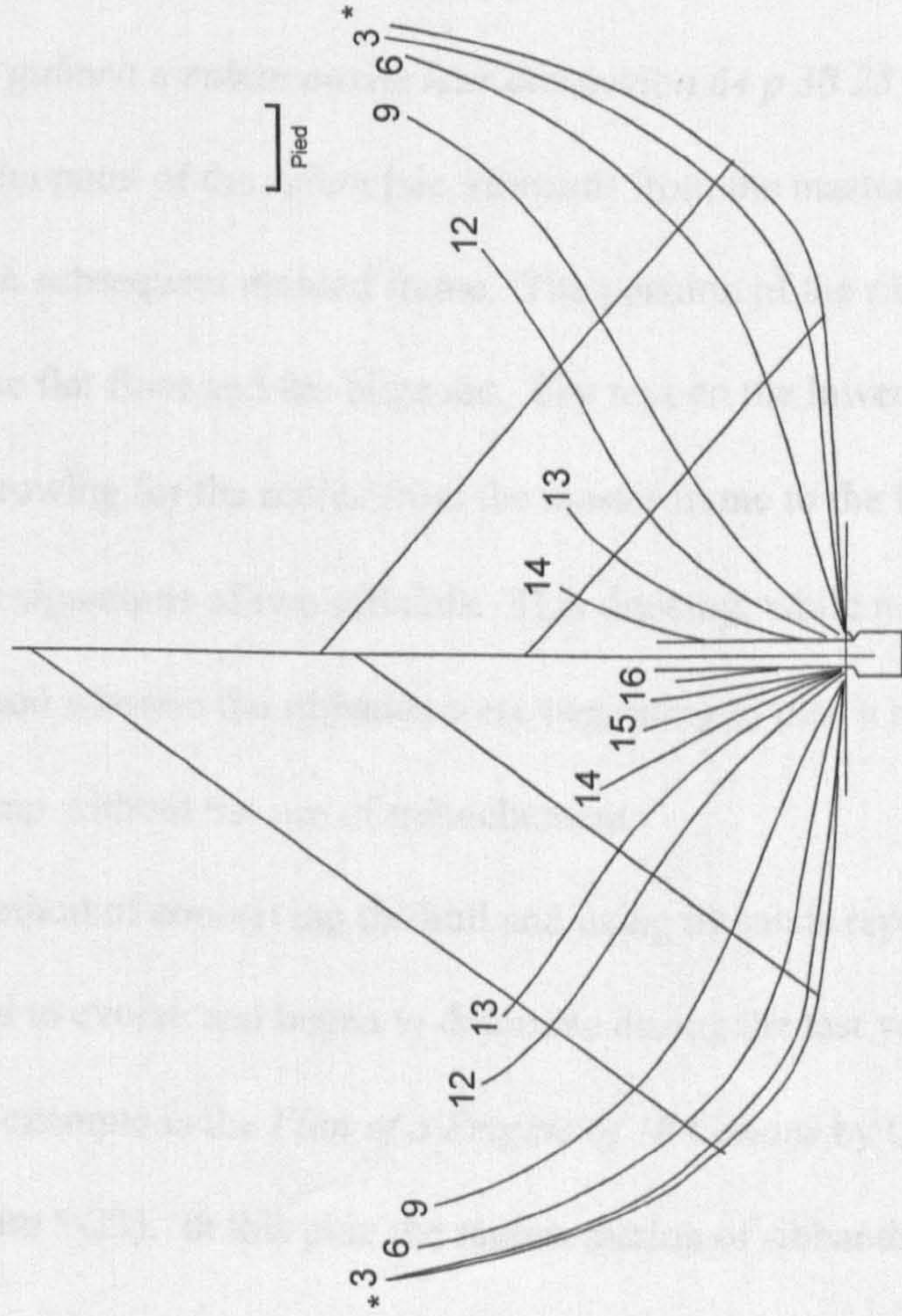
This approach to depicting and conceiving the ship was clearly based on an emergent architectural method in which the representation of the ribbands played a key role. This type of orthographic projection, although appearing earlier, was defined in 1697 by Hoste:

If one cuts the vessel by a plane that is perpendicular to the master floor, the curved line which will be the common section of this plane with the outside contour of the vessel, will express itself by a right [oblique] line . . . [so the ribbands] are not anything different than the common sections of the outside contour of the vessel with the plane perpendicular to the master floor that cuts the vessel (1697:146-147 in Rieth 1998:117).

Referring again to Figure 5-12 and based upon the annotations below the two triangles, the first ribband marks the end of the flat, the top ribband the point of maximum breadth, and the middle ribband the point where the value obtained for determining the opening (or width) of the frame was plotted. This is also the end point of the bilge arc. Each of these represent control points that were determined through a series



**Figure 5-22:** Molds of the flute *Profund* by Mallet 1697.  
 Courtesy Musée de la Marine.



**Figure 5-21:** Diagonal projections on *La Belle*'s half breadth plan.

of progressive reductions.

Honoré and Pierre Mallet, contemporaries of the Coulobes, also used both methods. The flute *Profund* was built in Rochefort between February 1684 and 1686 by Honoré. A drawing of that ship entitled *Molds of a Flute of 400 Tons* (Figure 5-22) was very likely drawn by Pierre as his signature appears on its accompanying documents. The two vertical sections represent the aft and forward views respectively. Quite clearly shown are the oblique lines indicating the ribbands. The level of the first deck for every mold is also shown, which also corresponds to the maximum breadth. On the right there are five ribbands, for the run, an intermediate ribband, and the ribband for the hull at its maximum breadth. Although it is quite faint on the right, a ribband for the second deck in the stern, and a ribband for the tumblehome were also drawn. The text on lower left reads: “*en des gabarit a ruban aussie leur dimunition 64 p 38 25 12 ½.*” This is the narrowing at the point of the *ruban* [sic, ribband] from the master mold (i.e., the master frame) for each subsequent molded frame. The position of the ribband appears to be at the touch of the flat floor and the bilge arc. The text on the lower right also indicated the amount of narrowing for the molds from the master frame to the forefoot (*ringeau*). At the bottom are signatures of two officials. This drawing, while not a plan of the ship, reflects a method wherein the ribbands were beginning to play a role in controlling the shape of the ship without the use of trébuchement.

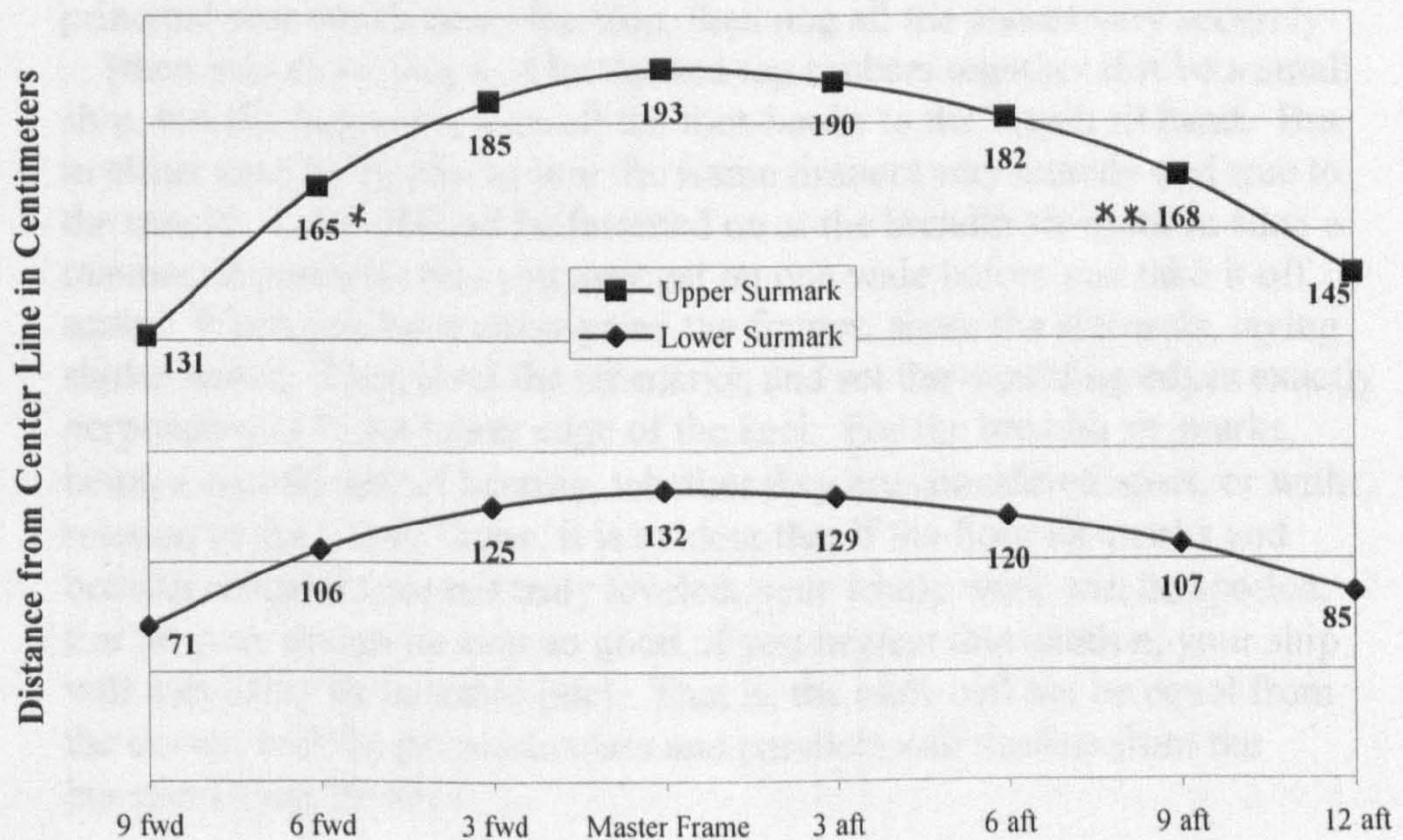
The method of conceiving the hull and using ribbands represented by diagonal lines continued to evolve and began to dominate during the last years of the 17<sup>th</sup> century. Another good example is the *Plan of a Frigate of 18 Canons* by Cochois dated January 17, 1697 (Figure 5-23). In this plan the representation of ribbands as oblique lines and



their use as control points in the ship's conception was more fully developed.

In *La Belle*, however, this is not the case. The ribbands, and by direct association the surmarks, do not control the shape of the hull because they are not located at the touch of the arcs. Rather, they serve as construction aids. Further evidence of their use in this capacity is provided when the horizontal distance from the centerline to each of the surviving surmarks are plotted on a graph (Figure 5-24). The difference in the distance between the lower and upper surmarks on each frame is 60 cm,  $\pm$  1 cm. This regularity argues against their use in a progressive reduction of the frames. This regularity, however, was useful for the builders.

**Figure 5-24: Half-Breadth of Frame at Surmark**



\* actual mark on frame  
166 cm is the point at which the projected diagonal intersects frame on lines

\*\* hypothesized based on other measurements

From the standpoint of understanding the conception, the regularity also made it possible to account for one surmark that was slightly mis-marked and for one that was



omitted. The upper surmark at six forward is actually marked on the frame at 165 cm from the centerline. However, when the diagonals are projected using all of the other surmarks, its distance falls at 166 cm, exactly 60 cm greater than the lower surmark. The upper surmark at frame nine aft was not marked on the timber, however, it was possible to project its location based upon the regularity of the other surmarks.

The use of surmarks and their diagonals as construction aids was clearly explained by Sutherland:

The frame timbers are to be first erected, which in some ships are every fourth and in others every third . . . [the] timber is commonly put on and bolted through the keel. Then hang up a ribband at the floor sir-mark [sic] and if the floor is fair, or rises gradually, nail that ribband and shore it with pieces of timber stout enough to bear the weight that may be put upon them. Observe to level the floor very exactly, since it is the first and principal seat which bears the ship, then nog all the shores very securely . . . [then join all of the] foot hooks and top timbers together if it be a small ship, but if a large one, then all the foot-hooks to the breath ribband. But in either case be careful to join the frame timbers very exactly and true to the mould. Let a ribband be fastened on at the breadth sir-mark in such a manner, if possible, that you may get on one wale before you take it off again. When you have cross-paled the frames, shore the ribbands, laying sholes under. Then level the sir-marks, and set the moulding edges exactly perpendicular to the lower edge of the keel. For the breadth sir-marks, being a second seat of bearing, whether they are considered apart, or with relation to the whole frame, it is evident that if the floor sir-marks and breadth sir-marks are not truly leveled, your whole work will be spoiled. For let your design be ever so good, if you neglect this caution, your ship will inevitably be lapsed [sic]. That is, the radii will not be equal from the center, and the perpendiculars and parallels will decline from the horizon (1766:79-80).

During the reassembly of *La Belle*, in fact, the surmarks and their associated ribbands were used as reassembly aids in much the same manner as described by Ollivier and Sutherland. Richard Steffy (1994:19) also noted the usefulness of diagonals, “. . . recently we found a . . . use for them in archaeology . . . as important reconstruction aids.”

The important element in considering the ribbands is their height at their endpoints at the stem and stern post. The height of the runs, *hauteur des façons*, is the perpendicular height of the lowest hull ribband, i.e., the *lisse du fond*, where it touches the stem and sternpost forward and aft. These heights were ascertained by the master constructor at the time the general proportions of the ship are determined, based upon a formula that varied from constructor to constructor. The subsequent positioning of the ribbands guided the shipwrights in the laying and leveling of all of the frames.

### **Lines Plan**

The lines plan reconstruction of the ship was only possible up to the level of preservation (Figure 5-25). Fortunately, this was such that it was possible to derive other elements of *La Belle's* conception. *La Belle's* length to breadth ratio is 3:1, which is based upon the length of the keel at 45 *pieds* and the breadth from the archaeological remains at 15 *pieds*.

As previously noted, the builders of *La Belle* used a three-arc system for conceiving the master frame. These arcs were also used elsewhere, notably in the arcs for the stem and deadwood. The outer arc of the stem was conceived using the 9-*pied* arc. The upper arc of the rabbet graded from the 9- through the 6- and 3-*pied* arcs from top to bottom, as does the inner arc of the stem. The inner arc of the deadwood, which nests inside the stem, not surprisingly, used only the 6- and 3-*pied* arcs.

### **Analysis**

The initial finding, that the master frame of *La Belle* reflects a three-arc conception, appears to confirm manuscript and previous archaeological evidence that

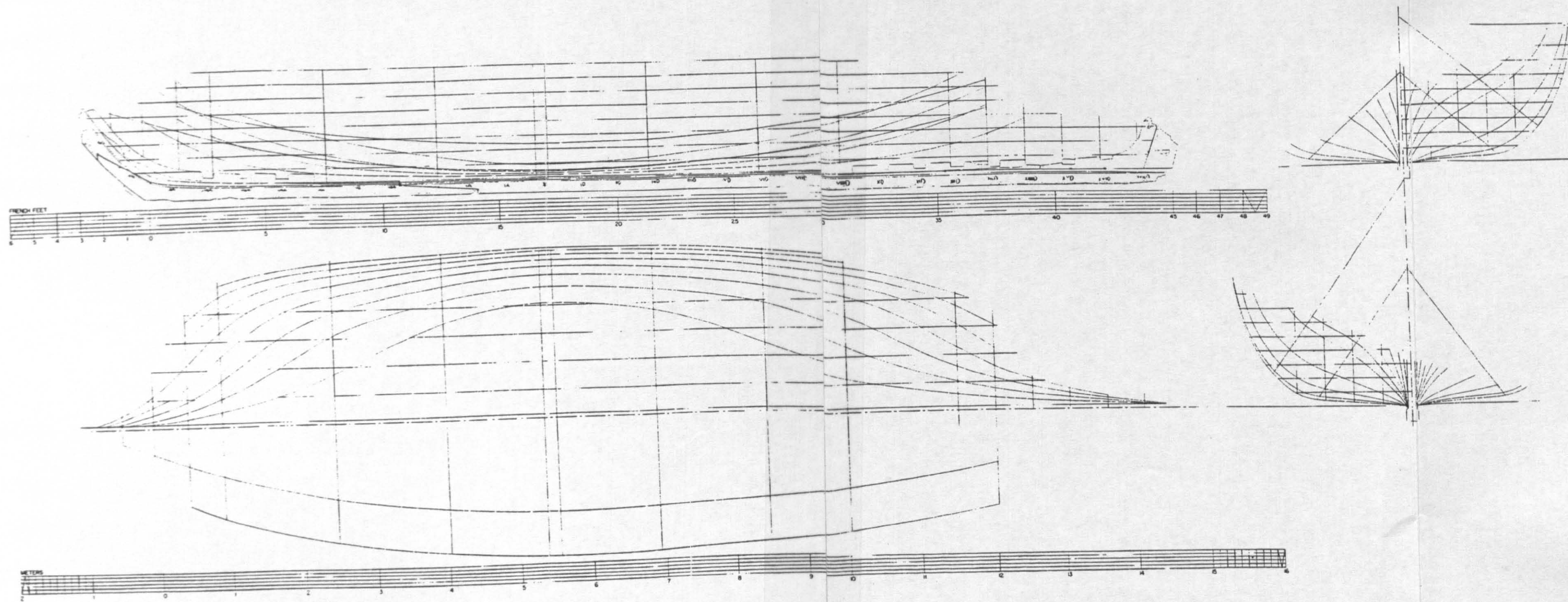


Figure 5-25: *La Belle* lines plan. Drawing by Taras Pevny.

such a conception was the most common way to design a master frame. However, *La Belle* contains a variation not found elsewhere in the archaeological record. Specifically, the progression of short, medium and long radii in the respective bilge, futtock and breadth arcs is atypical for both Atlantic and Mediterranean sources. In *La Belle* the longest radius was found in the breadth arc. This combination appears similar to that described by Fournier (1667:4), albeit with only two arcs, who commented on the ancient method that had the longest radius at the breadth arc. The longest radius at the breadth arc also appeared in an example in the anonymous *Fragments of Ancient Shipwrightry* (ca 1586:11) and is ascribed to an older Venetian system that had four arcs. The originality of *La Belle*'s conception does not, however, fundamentally alter the design method.

Interestingly, *trébuchement* was found only to the balancing frames. This echoes a practice documented in the French proportions documents previously discussed and in 1613 and 1618 Spanish shipbuilding ordinances (B. Loewen pers. comm. 2001). These texts, which contained concise technical descriptions of more than a dozen hulls ranging from less than one hundred to over one thousand tons, included the number of frames from the master to the *postreras*, i.e., balancing frames, as well as the values for the rising, the narrowing and the *joba*, i.e., *trébuchement*. In a small ship such as *La Belle*, the rising and the narrowing were applied to all the frames from the master frame to the balancing frames. The *trébuchement*, however, was not applied to the first two frames forward and the first three frames aft of the master. Because the forward narrowing of the floor was relatively rapid, the *trébuchement* ensured that the forward narrowing at the greatest breadth was less abrupt. This concept explains the phenomenon observed in *La Belle*.

The combination of a projection of the ribbands as diagonals for use as construction aids and the use of trébuchement in *La Belle* represents a transitional step in the development of the lines plan. As such this ship fills an important gap in our understanding of the evolution from the ancient methods where no lines plans were used to the graphic depiction of the hull using the lines plan.

### **Archaeological Reality and Inferences**

It is perhaps because archaeologists are often left with only the most minimal remains from which to reconstruct the past that we rely so heavily on other sources of information to fill in missing pieces and to guide our results. In a perfect world all the lines of evidence – treatises, registries and related documents, contemporary accounts, drawings or a lines plan, contemporary models, and modern speculative reconstructions – would be available and would perfectly reflect the archaeological remains. This is rarely, if ever, the case and this study is no exception.

Although the availability of treatises, registries, and contemporary accounts is extraordinarily fortuitous, they can create problems for interpretation, as has been demonstrated elsewhere in this study. The availability of illustrations or lines plans, apparently immutable representations, do not necessarily reflect reality. Contemporary models, theoretically less likely to be misinterpreted or flawed, can be misleading for the information they do not provide. Theoretical reconstructions, separated from their source by time and loss of knowledge, may be the most misleading of all. Each of these sources represents varying degrees of distance and variance from the archaeological remains. It is important, therefore, to carefully analyze each and evaluate their value.

## Proportions Document

While a number of documents were discovered that are directly related to *La Belle*, the one that has the greatest potential implications for the study of the hull is a notarized description (refer to Chapter 2 for more information on archival research and other documents). Entitled *Proportions d'une barque nommée La Belle qui a esté construite au port de Rochefort durant les mois de may et juin 1684 au por de 40 à 45 tonneaux*<sup>1</sup> (SHMR, Series IL<sup>3</sup> 19, f. 88v-89r), this record is a list of 18 key measurements of the hull. A literal transcription of those measurements is below. Numbers were added to facilitate the analysis discussion that follows.

### Figure 5-26 Transcription of *La Belle's* Proportions

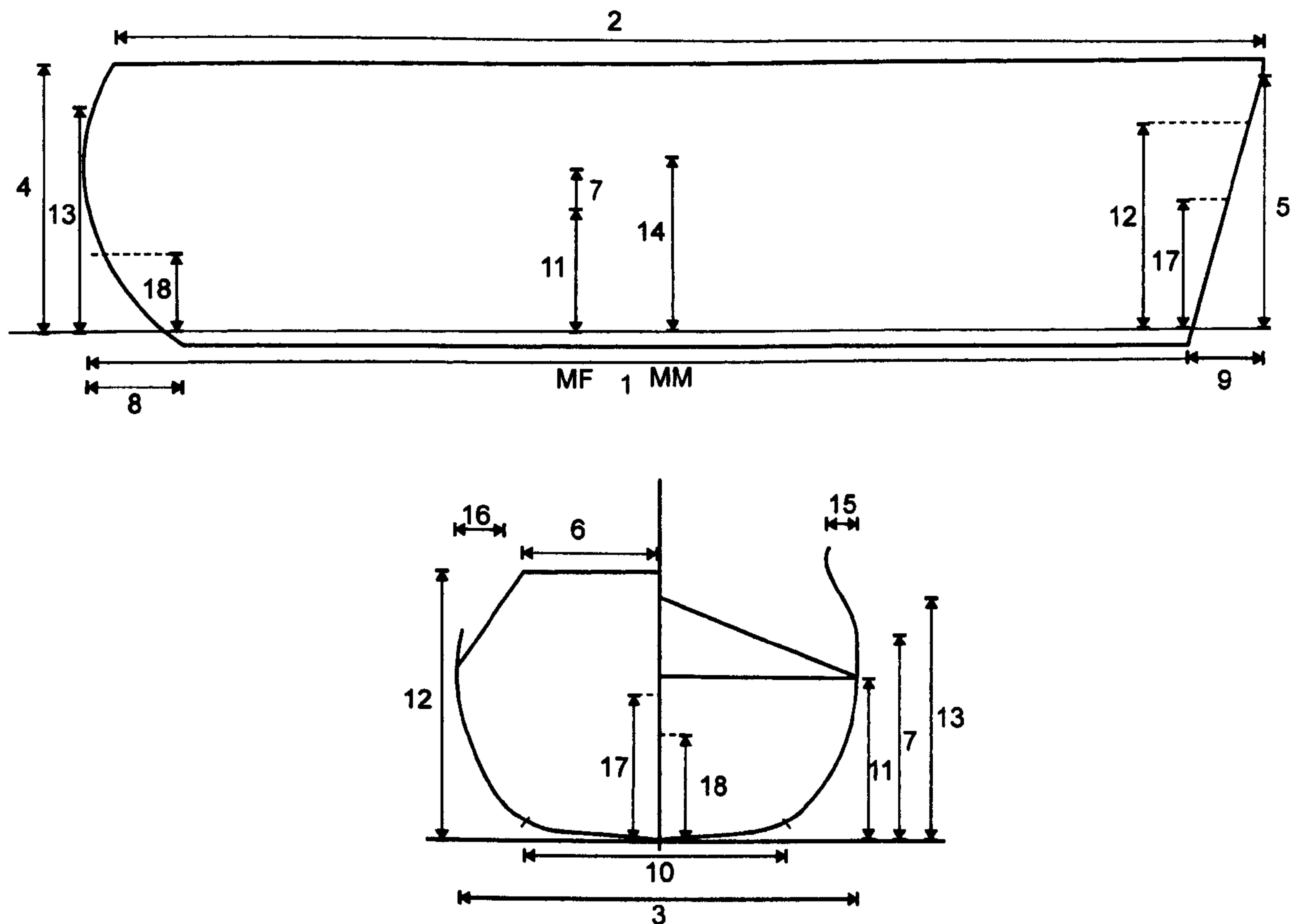
1. Longueur de la quille portent sur terre	45 Pieds
2. Longueur d'estraves a l'estambot	51 P. [pieds]
3. Larger de derre et dehors	14 P.
4. Haulteur d'estraves	12 P.
5. Haulteur d'estambot	11 P 1/2
6. La barre d'arcace a de long	9 P. 4 Pouces
7. Haulteur de fond de calle	7 P. 3 Pouces
8. Le lancement d'estraves	4 P. 6 Pouces
9. La queste de l'estambot	1 P. 6 Pouces
10. Le plat de la maîtresse varangue	9 P. 4 Pouces
11. Hauteur de la ligne du fort en son milieu	6 P. 3 Pouces
12. Hauteur de la ligne du fort derrière	9 P. 4 Pouces
13. Hauteur de la ligne du fort d'avant	13 P. 6 Pouces
14. Hauteur du Crans en droite ligne du maitre baus	7 P. 1/2
15. Cabannement en son milieu	12 Pouces
16. Cabannement en son trépau	3 Pied 2 Pouces
17. Hauteur de la fasson de derrière	5 Pied 6 Pouces
18. Hauteur de la fasson d'avant	3 P. 6 Pouces

In addition to the discussion of each measurement, a representational schematic is

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<sup>1</sup> Proportions of a barque named *La Belle* that was constructed at the port of Rochefort during the months of May and June 1684 of 40 to 45 tons.

provided (Figure 5-27). While many of the measurements are easily recognized, some take additional explanation, particularly in view of archaic useage or spellings. Each measurement is also compared to the archaeological remains. While only a few can be reconsidered in this manner, those that can have implications for the overall shape of the hull and for the reconstruction of the lines.



**Figure 5-27:** Schematic of *La Belle*'s dimensions from the proportions document. Drawing by Donald H. Keith.

**Measurement 1:** *Longueur de la quille portent sur terre ...45 Pieds*

Measurement number one literally translates as “length of the keel carrying on the earth,” or length of the keel touching the ground. This measurement does not include, therefore, the forward rake of the stem or the aft rake of the stern. The keel is measured

from the point where it begins its upward curve forward at the stem to its aft end.

Only a short section of the aft end of the keel is missing, most likely having broken off when the rudder finally separated from the ship. Because the aft face of the stern post is present, it was possible to accurately reconstruct the length of the keel from the angle of the forefoot to its end. This measures 14.77 m or approximately 45 *pieds 3 pouces*, which is only slightly more than indicated in the proportions document.

Measurement 2: *Longueur d'estraves a l'estambot ... 51 P.*

This translates as “length from stem to stern post,” *estraves* and *estambot* both being spelled in an archaic manner. This measurement is the length of the vessel from the outside of the stem to the outside of the stern at their uppermost point. Ollivier noted the following about this measurement:

... Recently many Builders have come to draw a distinction between the length from outside of stem to outside of post, the length from the rabbet of the stem to the rabbet of the post, and the length from the stem to post at the waterline. The length from outside of stem to outside of post is the same as is called simply the length from stem to post. The length from the rabbet of the stem to the rabbet of the sternpost is measured from the rabbet of the stem at the point of the greatest projection of this timber to the rabbet of the sternpost at the level of the wing transom, and this is also called the length from rabbet to rabbet. The length from stem to post on the waterline is measured from the rabbet of the stem to the rabbet of the post on the load waterline. This is the smallest of all the lengths from stem to post and recently some Builders have come to consider it as the principal dimension of ships in place of length from outside of the stem to outside of the post, which hitherto has been taken for the first dimension . . . (1736:230-231).

To confirm the measurement, the 9-*pied* arc of the stem was projected to the height provided in the document. This resulted in a slight inward arc, which is consistent with shipbuilding at this time. The distance was then measured from outside to outside.



The result was an insignificant discrepancy; the archaeological length of the ship measuring 51 *pieds 3 pouces* versus 51 *pieds* in the document. When the ship is measured from rabbet to rabbet at the height of the wing transom the result is 50 *pieds 10 pouces*, the difference from the 51-*pied* measurement in the document being negligible. However, this measurement was not written *longueur de rablure en rablure*, a distinctly different measurement that was clearly made by Ollivier (1737:231). He noted that the rabbet to rabbet measurement was a recent development and the older measurement from outside the stem to outside the stern post at their heads was more accepted (Ollivier 1736:231).

#### Measurement 3: *Larger de derre et dehors ... 14 P.*

This roughly translates as “breadth from outside to outside.” This measurement more frequently appears as *larger du vaisseau* or *larger dehors en dehors*, the latter being less common. Ollivier defined this as:

This is the distance from one side of the ship to the other to inside of plank at the place of the master mold (*maître-gabarit*) and at the height of [maximum] breadth. (1736:227).

He stressed that whether the measurement included the planks or was taken at the inside of the frames, both of which were less common, it was always taken at the *maître-gabarit*. Ollivier (1736:181, 183) also noted that the term *maître-gabarit* was used synonymously with *maître couple*, meaning the assembled pieces of timber rather than the mold from which these timbers took their shape, and with *maître varangue*, meaning the master floor timber. Therefore, this measurement was taken at the master couple, i.e., master frame, at the maximum breadth of the ship.

When the arcs of *La Belle*'s master frame and frames one forward and one aft are extended upward to the height of the maximum beam, the distance measures 15 *pieds*. This breadth differs markedly from the 14-*pieds* dimension provided in the document. Even accounting for the molded dimension of the frame and measuring to its inner face, the measurement is 14 *pieds 6 pouces*, one-half foot greater than the document. This is a significant difference that dramatically effects the lines and overall hull shape.

Measurement 4: *Hauteur d'estraves ... 12 P.*

Measurement 5: *Hauteur d'estambot ... 11 P. ½*

These are the heights of the stem and stern posts measured from the top of the keel on a perpendicular line from the point of the forefoot in the bow and the end of the keel in the stern. Interpretation of the forward measurement is problematic because it can be interpreted in two ways. As written it is “. . . 11 P ½..” In question is the interpretation of ½ . Other measurements in the document are quite specific, including those of only 2 *pouces*. In addition, in five other instances in the document when there was the intent to indicate one-half *pied* it was written as 6 *pouces*. It is common practice today when writing measurements to indicate one-half foot or one-half inch to use the ½ symbol, however that is usually followed by an indication of measure, for example 4 ½ feet, meaning 4 feet 6 inches. Despite the missing indication of *pouce*, it seems unlikely that the builders would have meant to indicate a measurement of only ½ *pouce*. i.e., 1.35 cm.

There is no question that the difference between one-half *pied*, i.e., 16 cm, and ½ *pouce* is considerable. However, an obsession with absolute accuracy is a modern construct resulting from the necessity to have interchangeable machined parts. In 17<sup>th</sup>-

century wooden shipbuilding an amount of 1.35 cm could easily be dubbed away or compensated for during construction. It seems reasonable, therefore, to assume that the measurement of 11 P ½ refers to 11 *pieds 6 pouces*, an interpretation that is also used elsewhere in this analysis. Unfortunately, there was insufficient preservation of the stern post to confirm this measurement. It should be noted here, however, when measuring the length of the ship from stem to stern a height of 11 *pieds 6 pouces* was used.

Measurement 6: *La barre d'arcace a de long ... 9 P. 4 Pouces*

Measurement six is somewhat less clear because of the spelling and archaic terminology. *Le barre d'arcace a de long* literally translates as “the wing transom length.” The more common spelling of *d'arcace* is *d'arcasse*, which itself is an older term that is more commonly written as *lisse de houri* or *lisse d'hourdi*.

No evidence of the wing transom survived so this measurement cannot be confirmed. It should be noted, however, that the wing transom was located at the height of the *ligne du fort*, i.e., the maximum breadth line, on the stern post.

Measurement 7: *Hauteur de fond de calle ... 7 P. 3 Pouces*

This literally translates as “height of the hold.” It also refers to the hold in general (Lescallier 1777:29). In the context of shipbuilding, this is more commonly called the depth of the hold and is measured from the top of the keel to the top of the beam on the first deck (Ollivier 1736:131). This measurement was taken, according to Ollivier, at the location of the *maître-gabarit*, i.e., master couple (Ollivier 1736:131).

The document indicated that the depth of the hold was 7 *pieds 3 pouces*. While the full height of the master frame to the level of the deck beams was not preserved, this

depth value is reasonable given other measurements on the ship. Furthermore, Ollivier noted that:

The depth of hold in the middle of vessels of the first, second, and third rank is equal to half their width and in others this depth is 1 foot and even 1 foot ½ less than half their width. All constructors give to the vessels of the fourth rank and frigates less depth of hold than half the width, on some 6 inches, on others 1 foot, 1 foot ½ and even 2 feet, especially in the frigates that don't have a first battery (1736:131).

Ollivier bases this on the assumption that physical middle of the vessel was also at the location of the master frame, which is not the case in *La Belle*. Furthermore, this measurement must be considered in combination with measurement 14, discussed below, and in that regard, a measurement of 7 *pieds 3 pouces* here is reasonable

Measurement 8: *Le lancement d'estraves ... 4 P. 6 Pouces*

This translates literally as “the throw of the stem” and refers to the overhang of this timber. The rake was measured from the angle of the forefoot forward on a horizontal projection to the outside of the stem (Ollivier 1736:152). Because only the lower portion of the stem was preserved, the outside edge was determined by projecting its arc upwards to its maximum radius, then dropping a perpendicular line to the keel.

When measured on the horizontal from the forefoot to outside the stem, there was a slight discrepancy. The document indicated the rake to be 4 *pieds 6 pouces* when in fact it is 4 *pieds 3 pouces*.

Measurement 9: *La queue de l'estambot ... 1 P. 6 Pouces*

This is the rake of the sternpost and according to Ollivier (1736:283), it was the “. . . projection of the sternpost beyond a perpendicular at the end of the keel, or the

horizontal distance between the end keel and the perpendicular of the sternpost.” Very little of the sternpost survived. However, enough is present to get an accurate measurement on the angle formed at its forward and aft edges at the keel. These angles were projected up to a height of 11 *pieds 6 pouces*, as indicated in the document. A perpendicular line was extended from the end of the keel to the head of the sternpost and the offset measured. This resulted in a significant difference from the 1 *pied 6 pouces* indicated in the document. If measured to the forward face of the sternpost, the rake was 2 *pieds 10 pouces*. When measured to the aft face of the sternpost the rake was 3 *pieds 4 pouces*. This difference in the rake has tremendous implications for any reconstruction of the hull.

Of interest is that the 1 *pied 6 pouces* rake offset intersects the aft face of the sternpost at the height of the run, i.e., *hauteur de la fasson*. However, a measurement at this location for the rake of the stern is not mentioned in any of the contemporary treatises and until confirmed otherwise, this should be considered a coincidence.

#### Measurement 10: *Le plat de la maîtresse varangue ... 9P. 4 Pouces*

Number ten is one of the key measurements in the construction of the ship. *Le plat de la maîtresse varangue* translates as “the flat of the master floor.” This measurement should not be confused with the length of the flat to the touch of the bilge arc. Rather, this is generally defined to be the length of the mold of the master floor timber on a straight line measured on a perpendicular from the centerline (Lescallier 1777:114; Ollivier 1736:269).

Coulomb (1683:19) suggested that the flat should be equal to half the master

beam, i.e., *maître bau*. Dassié (1695:19) stated that the flat should equal one-eighth of the length from stem to stern in war ships and equal to one-seventh of the keel for frigates. La Madeleine (Rieth 1996:53) stated that the length should be one half the width. Ollivier (1736:269) noted that this measurement was equal to 6 to 8 *pouces* less than half their width in warships and in frigates it was equal to 5 *pouces* plus 8 to 10 lines by foot of width. Du Monceau (1758:112) wrote that the flat should be half the maximum breadth, although some constructors make it 6 or 8 *pouces* less than that.

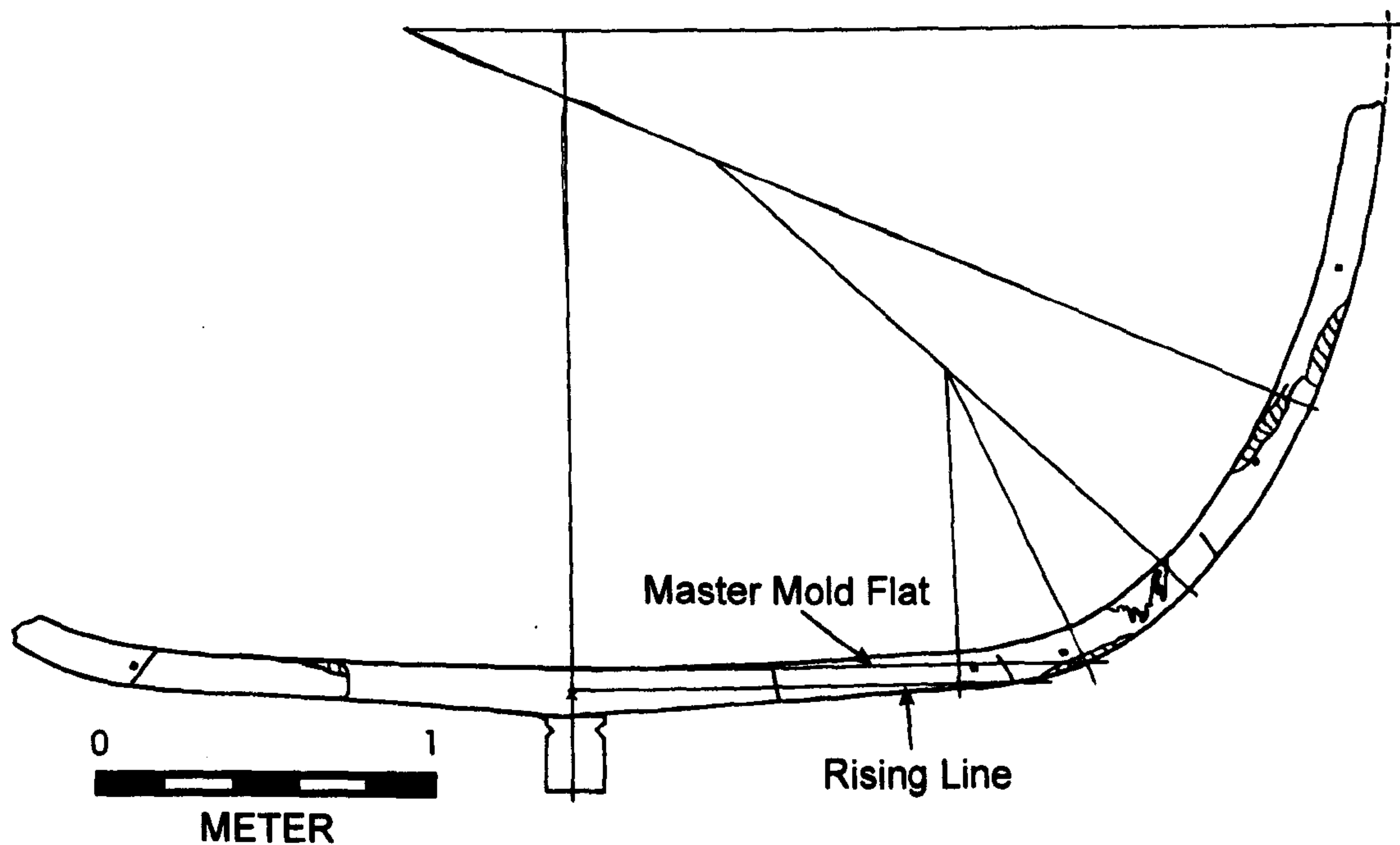
Fortunately, the master floor timber survived making it possible to check this measurement, which does not correspond to any of the proportions offered in contemporary treatises. Under those guidelines this should be equal to half of the maximum breadth, which from the document would result in 7 *pieds*, or half the actual breadth, which would result in 7 *pieds* 6 *pouces*. Instead the ship's 9 *pieds* 4 *pouces* from the document is 62% of the ship's actual breadth. Additionally, this measurement falls at the turn of the bilge and exactly bisects the 3-*pied* bilge arc (Figure 5-28). A precedent for this measurement falling at this location appears in 15<sup>th</sup>-century Venetian treatises wherein the flat, the *fondi*, also falls at the turn of the bilge, or *escoue* (Anderson 1925:135-163).

Measurement 11: *Hauteur de la ligne du fort en son milieu ... 6 P. 3 Pouces*

Measurement 12: *Hauteur de la ligne du fort derriere ... 9 P. 4 Pouces*

Measurement 13: *Hauteur de la ligne du fort d'avant ... 13 P. 6 Pouces*

Measurements 11, 12, and 13 are very similar. They are: height of the maximum breadth line in the middle, height of the maximum breadth line in the stern, and height of the maximum breadth line forward. These correspond to the *lisse du fort*, the ribband or

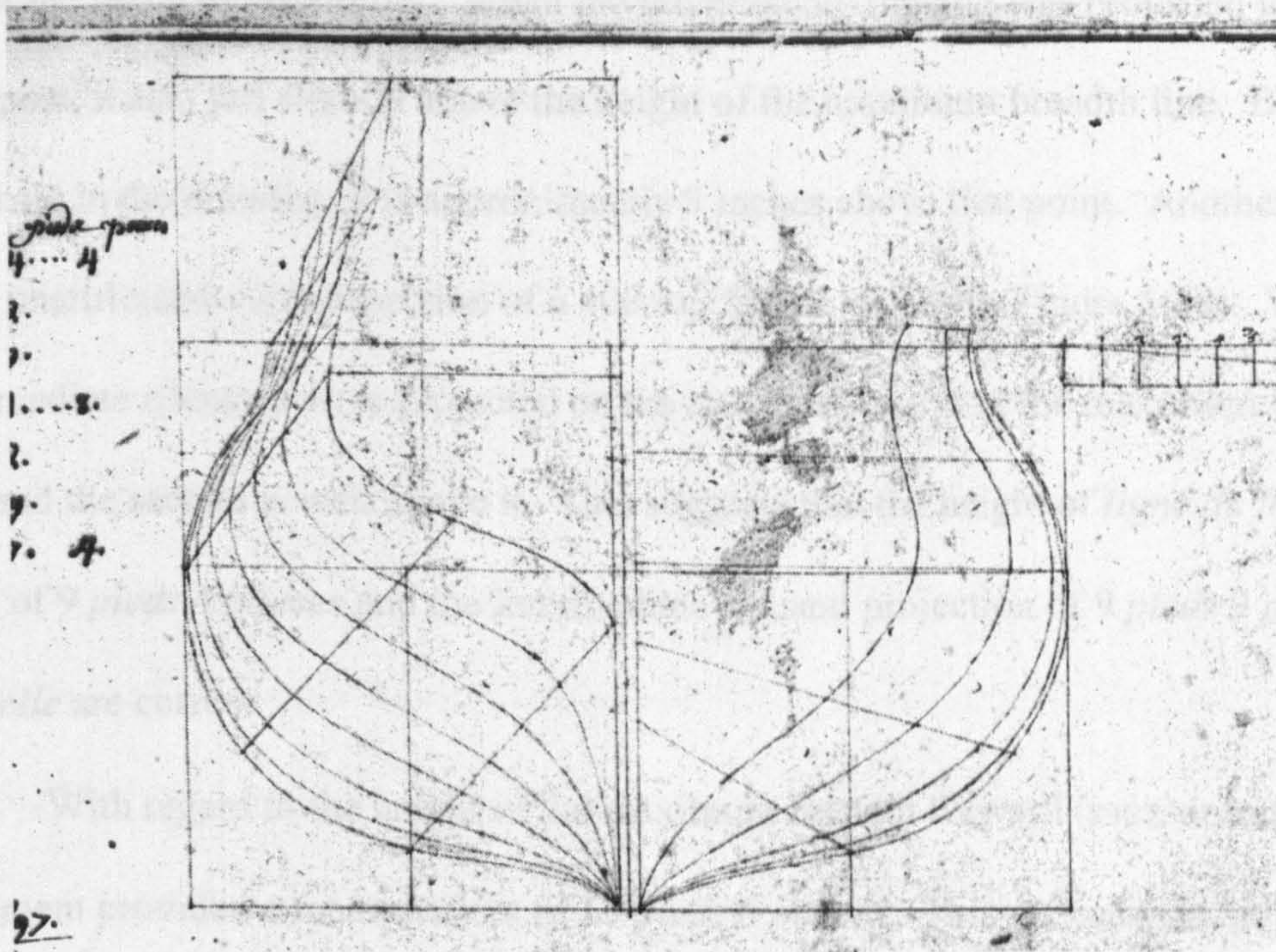


**Figure 5-28:** Relationship of arcs to flat and rising line. Drawing by Donald H. Keith.

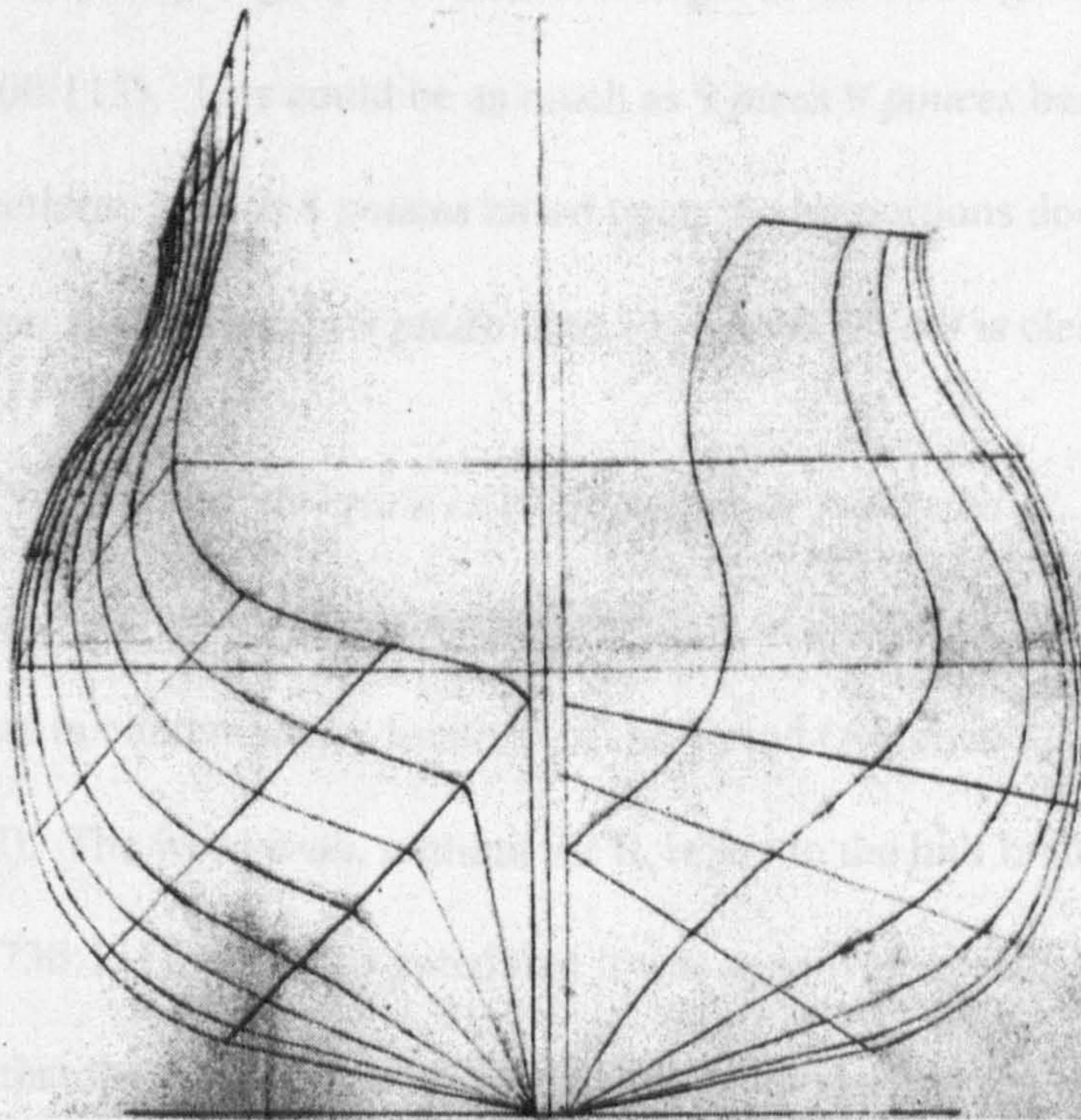
line at the maximum breadth. These measurements are, therefore, the height of this line at the stem and stern posts and at the master frame. Due to lack of preservation, it was not possible to confirm these measurements. However, they might be inferred through other means.

The surmarks on the timbers undoubtedly reflect the locations of at least two of the ribbands, the hull ribband and one intermediate ribband. These two sets of surmarks were projected on the lines plan vertical half sections (refer to Figure 5-21).

Measurement of those projected heights raised some questions. The projection of the intermediate surmark on the sternpost resulted in a height of 9 *pieds* 9 *pouces*. This is 5 *pouces* greater than the reported height of the maximum breadth line in the stern (measurement 12). At first consideration, this seems improbable. However, looking again at the vertical sections in the Cochois drawing of a frigate (Figure 5-29), this is not



**Figure 5-29:** Detail from the Cochois frigate with projected diagonals. Courtesy Musée de la Marine, Paris.



**Figure 5-30:** Unknown frigate ca. 1690 with projected diagonals. Courtesy Musée de la Marine, Paris.



out of the realm of possibility. When the intermediate ribband was projected to the sternpost, it also fell slightly above the height of the maximum breadth line. Based upon the scale in the drawing, it is approximately 9 inches above that point. Another example is an unattributed vertical section of a 400 ton frigate ca. 1690 (Figure 5-30). When the intermediate ribbands were projected on the sternpost, one is at the maximum breadth line and the second is well above it. This suggests that the height of *ligne du fort* in the stern of 9 *pieds 4 pouces* and the intermediate ribband projection of 9 *pieds 9 pouces* for *La Belle* are correct.

With regard to the height of the maximum breadth forward (measurement 13), the document provided a measurement of 13 *pieds 6 pouces*. This exceeds the height of the stem by 1 *ped 6 pouces*, which is clearly not realistic. Commonly this height was identical to or only very slightly less than the height at the hull's greatest width aft (Lemineur 2000:113). This could be as much as 9 *pieds 9 pouces* based upon the aft surmark projections, 9 *pieds 4 pouces* based upon the proportions document for the aft ribband, or even slightly less at 9 *pieds*. But 13 *pieds 6 pouces* is clearly an error.

Measurement 14: *Hauteur du crans en droite ligne du maître baus ... 7 P. ½*

This measurement was problematic because of the use of the word *crans*, which does not appear in contemporary treatises of the period (Anonymous 1691, Dassié 1695, Fournier 1667). The word *cran*, without the S, refers to the hull bottom in the dictionary by Ollivier (1736:131), who also noted that it was synonymous with the word *carene*. He further noted that the term *carene* was used to mean the keel in the Mediterranean. One can argue, therefore, that the term *cran* is an older version or variant of *crux*, meaning

bottom of the hull. The phrase could then be translated as the “height from the bottom of the hull in a straight line [perpendicular] from the master beam” or midship beam.

Because measurement seven already provides that information at the master frame, two other possibilities present themselves.

First, the literal translation of the phrase is: height of the notches in a straight line from the master beam. The term *cran* appears in modern dictionaries as notch or hole. Because this measurement is greater than the height of the hold at the top of the beam (but without the deck planking), it could be referring to the height at the bottom of the scuttles, or more likely, the gun port at the master frame. This measurement would provide a basis for establishing the run of the gun port sills forward and aft.

The second possibility relates to the position of the master beam. The *maître bau* was located at the position of the midship bend. That is, it was situated in the physical middle of the ship and near its center of gravity. This often coincided with the location of master frame, but not always. It would, however, be at the widest point on the ship. The physical center of *La Belle* falls at approximately 25 *pieds* 7 *pouces* 6 *lines* forward of the perpendicular of the stern post, while the ship's center of gravity falls approximately 9 *pouces* forward of that, below frame three aft. Based upon the archaeological reconstruction, the maximum breadth of *La Belle* continues to frame three aft. At that point there could be a slight increase in the depth of the hold due to the normal rake of the deck. Therefore, this measurement may refer to the depth of the hold at that location. Lastly, some treatises suggested that the depth of the hold at this location should be equal to one-half the breadth (Ollivier 1736:131). Because the maximum breadth of *La Belle* is 15 *pieds* and one-half that is 7 *pieds* 6 *pouces*, it is either serendipity or confirmation of

the archaeological findings and this second interpretation of this measurement. Due to lack of preservation, it was not possible to confirm this measurement.

Measurement 15: *Cabannement en son milieu ... 12 Pouces*

Measurement 16: *Cabannement en son trepau ... 3 P. 2 Pouces*

Measurements 15 and 16 also presented some problems of interpretation. The words *cabannement* and *trepau* do not appear in contemporary treatises and dictionaries of the period (Anonymous 1691, Dassié 1695, Fournier 1667, du Monceau 1758, Lescallier 1777 and 1791, Ollivier 1736). The word *caban* appeared in Lescallier (1777:27) and was described as having a Mediterranean root and referred to a thick woolen coat worn by sailors. In modern dictionaries *caban* is defined as a reefer, that is, a sailor who is charged with hauling or pulling in the sails (Harper-Collins 1993:106). It is reasonable to argue that the transition to a verb form of *caban* to *cabannement*, in the context of a proportions document, refers to the reefing in or pulling in of the hull, i.e., the tumblehome. The more common term for tumblehome in contemporary documents was *rentrement du maître gabarit* (Ollivier 1736:292) or *re'tricissement des gabarits* (Lescallier 1791:np). The use of a Mediterranean-based term in this linguistic context appears to reinforce the roots of *La Belle*'s builders. The term *trepau* is a variant of the word *trepot*, which is a little used term more commonly written as *cornier* (Ollivier 1736:340). This is the top of the fashion frame at the highest point in the deadworks at the stern.

Measurement 15, *cabannement en son milieu*, translates as the “tumblehome at the middle.” Further support for this interpretation is the measurement, which is only 12 *pouces* (32 cm). This amount of tumblehome is reasonable at midship. Measurement 16,

*cabannement en son trepau 3 pied 2 pouce* (102 cm), is the tumblehome in the stern.

Neither of these measurements could be confirmed.

Measurement 17: *Hauteur de la fasson de derriere ... 5 P. 6 Pouces*

Measurement 18: *Hauteur de la fasson d'avant ... 3 P. 6 Pouces*

These measurements are the “height of the runs aft” and the “height of the runs forward.” These were more commonly written as *lisse de façons derrier* and *lisse de façons d'avant*, quite literally meaning the height of the run or ribband of the hull aft or forward. These runs end at the stern and stem post and their height was determined at the same time as the general proportions of the ship.

As previously noted, the heights of the runs and their lengths were important measurements in the overall conception of the ship. Indeed, in the tablet and *trébuchement* they are critical. Each master constructor had his own method for making this determination. Coulomb (1683:22) based his recommendation on the stern post, using one-half that height for the run aft and one foot less than half for the run forward. Similarly Dassié (1695:22) stated that the run aft should be half the height of the stern post and the run forward should be one quarter of the height of the stem for frigates and smaller ships. Ollivier explained:

This is perpendicular height of the first ribband of the bottom over the keel forward and behind . . . . All constructors don't give same height to the runs of the vessels, but all agree to give less of them in proportion to the big vessels than to the small. The height of the runs of the forward is of about 2 inches by foot of depth of hold in the vessels of the first rank, 2 inches 6 lines in the ship of state of the second rank, 2 inches 9 lines in the vessels of the third rank, 3 inches in the vessels of the fourth rank and the frigates. The height of the runs of the aft is more or less equal in the vessels of the first rank at 2 1/2 times or at 2 times three quarters the height of the runs of the forward, and in the vessels lower in rank, twice and three quarters or at three times. The height of the runs of the flutes

and other structures of burden are adjusted more or less as in the vessels of the first rank. The galleys have about a quarter of the height of their depth of hold for height of the runs of the forward and once and half or once and two third this same hollow for the height of the runs of the rear. The height of the runs of the forward is adjusted in the shallops and rowboats as in the galleys, but the height of the runs of the rear only exceeds 3, 4 or at most 5 inches the height of the runs of the forward. One says that a vessel has a lot of runs when its first ribband of the bottom is raised strongly or that it has little roundness (1764:164).

Du Monceau (1758:118) suggested that the runs aft should be half the height of the stern post from its base to the wing transom for first, second and third rank ships, and for ships of 50 cannons or less, one half the full height of the stern post. He also noted that some builders divided the depth of the hold in three parts taking two-thirds for the height of the runs aft. For the height of the runs forward, these builders used 1/5 of the height of the wale, while others used 3/10 of the length of the master beam for the height aft and 1/3 of that for the run forward (du Monceau 1758:118). La Madeleine noted that the height of the runs aft for vessels of the first to third rank was equal to half the height of the stern post and the height forward was half the height of the run aft, i.e., one quarter the height of the sternpost (1712:16-17 in Rieth 1996:54-55). Once again, none of these formulae accurately reflect the height of the runs as provided in the proportion document, although Dassié was close at one-quarter for the height at the stem and du Monceau at half the full height of the stern post.

Due to lack of preservation, neither of these measurements could be confirmed. However, they might be inferred through measurement of the heights of the projected surmarks on the lines plan (refer to Figure 5-25). The projected height at the stem is 3 *pieds* 10 *pouces* and the projected height in the stern is 6 *pieds*, only slightly greater than those provided in the document. Given other discrepancies between the archeological

findings and the document, these differences are reasonable. Notably absent from this document is a measurement for the length of the runs, which would have provided the location of the forward and aft balancing frames. A discussion of the length of the runs, *longueur du façon d'avant* and *longueur de façon d'arriere* is provided elsewhere in the discussion of the balancing frames.

### **Inferences from Treatises and Other Documents**

Although there are discrepancies between the hull remains and the notarized registry, which is purportedly an accurate record of the ship, with the exception of the maximum breadth, most are minor. So it is worthwhile to consider what information can be gleaned and inferences made on other elements of the ship that are not addressed in the proportions document or that may be missing from the archaeological record. The validity of these sources of information and their usefulness in a fuller reconstruction of *La Belle*, whether on paper or in a model, has relevance for this study and for their broader implications in the study of ancient hulls.

### **Placement of the Master Frame**

There was a good deal of disagreement between the contemporary treatises on the correct placement of the master frame. Coulomb (1683:15) suggested dividing the keel into six equal parts, taking two of those for the runs of the rear, taking one for the runs forward, and then dividing the remainder in half. The anonymous author (1691:6) of a manuscript on galleys described dividing the length of the ship into four parts, using one for the run aft, then dividing the length by six parts and using one for the run forward, then dividing the remainder into two equal parts for the placement of the master frame.

Ollivier (1736:183) stated that builders did not place the master frame in the same place, some used 4, 5, 6 or 7 lines by foot of length overall and placed the master frame forward of the middle by that amount. Others, he said, divided the keel in five equal parts and placed the master two parts aft of the angle of the forefoot. He also noted that in the Mediterranean the master frame was placed at the middle between perpendiculars of the stem and tip of the keel, or 3 to 5 lines by foot of length from the stem to the stern forward of the middle (Ollivier 1736:183). Du Monceau stated:

The position of the master couple is a big question among the constructors . . . [and] how much to place it closer to the stem than the stern. There are the constructors who carry it in the front of the hull at its greatest width, pretending that a vessel bulged in this part had to be a better sailboat than another . . . . However, today's constructors bring it closer to the middle . . . . There are the constructors who divide the total length of the vessel in 8 equal parts . . . carrying one part to the front from outside the stem; then dividing one part by four and carrying one part of that from the perpendicular of the stern . . . the remaining . . . one divides by 6 . . . one adds one of these quantities in the front and two to the aft; [and] the remaining one divides in two to place the master couple . . . [more] to the forward than to the aft. Several constructors put the master couples at five twelfths of the keel from the forward (1758:115-16).

None of these formulae reflected the actual position of *La Belle's* master frame, which is at 17 *pieds* from the forward end of the keel. Du Monceau's two approaches shifted the master too far aft as did the anonymous author on galleys. Coulomb's method pulled it too far forward. Ollivier's various methods placed it too far aft, although dividing the keel in five parts provided the closest match. When various combinations of methods were employed, the position of the master frame was best reconciled by dividing the 45-foot 3-inch keel in eight parts. The result placed the master frame at 3/8ths from the forefoot.

## Placement of the Main Mast

On the position of the main mast there was little agreement among the treatises.

Fournier indicated that there was general and regional variation in its placement:

. . . some [builders] divide the gun deck in seven [parts], and take four parts toward the forward and three toward the aft and place the mast between the two. The Marseilloises share it [the gun deck] in five and put three parts of it forward and two to the rear; others share it in two and put it only two feet more aft than in the middle (1667:27).

Dassié (1695: 27) concurred with Fournier that the main mast should be placed two feet aft of the middle of the ship measured on the gun deck. Ollivier (1736:238) noted that the main mast was placed “. . . more or less in the middle of the length of the vessel . . .”.

According to du Monceau (1758:134), the main mast should be placed slightly aft of the middle of the ship by 7 ½ or 8 lines per foot of length overall. Although there was not a single formula for determining its position, most agreed that the main mast should be placed just aft of the middle of the ship. Once again, however, *La Belle* seems to be built with little regard for these treatises. The main mast is positioned squarely in the middle of the ship at frame three aft, i.e., 26 *pieds* 3 *pouces* from the perpendicular of the stem.

## Theoretical Reconstructions

One of the most difficult tasks in the interpretation of shipwreck remains is the accurate reconstruction of the hull, whether on paper or in a model. The notes, measurements, and drawings that constitute the evidence by which this effort is undertaken are often obtained under less than ideal circumstances and always with less than adequate time and resources. Only rarely is one afforded the luxury of extensive and thorough *in situ* documentation, rarer still is complete disassembly and recording of



individual timbers. Nonetheless, given relatively limited archaeological data, but access to historical documents and ship-building treatises, archaeologists make every effort to accurately recreate the shape of the hull. The nagging question that always lingers, however, is just how accurate is the result? Fortunately, there is an opportunity to address this question and perhaps quantify the result within the context of this study.

In 1999 Jean Boudriot, author and editor of numerous books on French naval architecture, undertook a theoretical reconstruction of *La Belle*. The results of the reconstruction and his analysis were published in the beautifully presented *Cavalier de La Salle l'expédition de 1684, La Belle* (Boudriot 2000). Included are Boudriot's trademark architectural renderings, illustrations of décornos on the bow and stern, armament, equipment, rigging, and photographs of highly detailed models. A volumetric estimate, a reconstruction of the master frame and remaining frames, along with vertical half sections, a lines plan and analysis, and a calculation of the tonnage were also included, these latter by Jean-Claude Lemineur (2000:106-121).

### **General Considerations**

The theoretical reconstruction, models, and other analyses were completed using as a basis the following: the proportions document previously discussed; a model of a lighter housed in the Musée de la Marine deemed a close match to *La Belle*; a drawing of a lighter in a treatise by Morineau (cited in Boudriot 2000:43); a treatise by La Madeleine (1712); and contemporary hull half-section drawings of *Profund* (1684), *Laurier* (1690), *Gaillard* (1683) and to a lesser degree *Fulminant* (1691). *Profund* is believed to have been designed by Pierre Mallet, although Boudriot ascribed it to his brother Pierre

Masson. The remaining three were built Pierre Masson, to whom Boudriot and Lemineur (2000:107) ascribed the design of *La Belle*. A discussion of design authorship of *La Belle* is provided elsewhere in this study. Lastly, the reconstructed theoretical lines of *La Belle* and the only known lines of a barque longue are compared. A discussion of barque longues in general and this example in particular are provided elsewhere in this study.

Only limited archaeological information was incorporated into the research: an uncorrected in situ field sketch of the master frame, similar field sketches at selected other stations, a measurement from the main mast to the sternpost, and a measurement from the master frame to the stern post. Often this is the full extent of the information that is available to the archaeologist and so a discussion of the results is enlightening.

As previously noted, Boudriot and Lemineur determined that the builder of *La Belle* was Pierre Masson (Lemineur 2000:106). They based this decision on the placement of *La Belle*'s master frame. At the time of the construction of *La Belle*, the regulation of 1673 called for the placement of the master frame equivalent to  $\frac{7}{12}$  the length of the keel measured from the stern post (Lemineur 2000:106). If the  $\frac{7}{12}$  formula had been used, it would have placed *La Belle*'s master frame at 26 *pieds* 3 *pouces* from the stern, or at 58%. However, its actual position is 28 *pieds* or at 62%. In his constructions of *Laurier* and *Galliard*, Pierre Masson placed their master frames at 61% of their lengths from the stern post. This placement, which slightly exceeds the  $\frac{7}{12}$  rule, is considered by Lemineur and Boudriot (2000:106) to be a signature trait of Masson.

Although required by regulation, and therefore presumably widely practiced, using twelfths as a basis for dividing the hull was also considered support for Masson by Boudriot and Lemineur. Lemineur (2000:106) noted that while *La Belle*'s master frame

was at 62% from the end of the keel, it was still possible to match the 7/12 regulation of 1673. He did this by measuring between the points at which the hull ribband intersects the stem and sternpost, rather than by using the length of the keel. This corresponds to the distance between the rabbets at the height of the hull ribband (*lisse du fond*), a hull measurement that was not mentioned in any of the contemporary treatises. As noted previously, according to Ollivier the rabet to rabet measurement was generally taken to be at the ribband of maximum breadth (*lisse du fort*), not at the hull ribband. However, by using the distance at the hull ribband as the basis, it was possible to accurately match the location of the master frame at 28 *pieds* from the stern to the 7/12 requirement (Lemineur 2000:106). Continuing on that basis of measurement and by dividing the hull in twelfths, which reflects Masson's use of twelfths in the construction of *Laurier* and upon which the reconstruction draws heavily, Lemineur created stations along the keel for further analysis (2000:106, 107 Figure 1).

These elements provide the foundation upon which Lemineur and Boudriot build their theoretical reconstruction. At this juncture, and all other considerations aside, it should be recalled that the archaeological remains differ from the proportion document. The primary difference, and the one with the greatest impact, is the width, which is one foot greater than recorded, i.e., 15 *pieds* vs. 14 (a 7% difference). From the outset this clearly impacts the basic working drawing of the hull and any reconstruction. Further, Lemineur and Boudriot did not have access to the results of the dendrochronological analysis, which might have influenced their reliance on certain archival documents.

In the larger scheme of things, these differences are minor. Of more importance is that a theoretical reconstruction, by its nature, requires and represents a difference in

approach weighted more heavily toward historical documents than toward archaeological remains. Both approaches can and do produce acceptable results, but they differ in their degree of precision.

### **Master Frame**

The first stage in the development of a hypothetical reconstruction is a consideration of the conception the master frame. Lemineur began with an examination of three ships built by Masson. However, the selection of those ships as a basis for analysis of *La Belle* introduced some problems of comparability. *Laurier* was a 2<sup>nd</sup> rank ship of 900 tons and so was a great deal larger and a different type than *La Belle*. Lemineur also drew upon *Gaillard*, a 5<sup>th</sup> rank of 350 tons, and *Fulminant*, a 1<sup>st</sup> rank of 1800 tons for guidance in shaping the master frame.

In order to combine information from the proportions document and the field sketches, Lemineur had to make certain assumptions. For example, he assumed a master floor of 17.5 cm molded by 12 cm sided at its centerline, when in reality the master is 14 cm molded by 16.5 cm sided. While the sided dimension is not relevant in this context, the molded dimension is quite important. Furthermore, the half-breadth of the master floor is actually 165 cm versus the 150 cm extrapolated from the field sketch, a difference of nearly 10% (Lemineur 2000:109, Figure 6).

These differences resulted in a determination that the master floor was conceived on the basis of 6 cm rising, instead of 8 cm. This latter led Lemineur (2000:106) to conclude that, “ A rising . . . [on the master frame] of 6 inches at the end of the floor is distinctly less than one presents on a ship of war.” This, in turn, led to a conclusion that

*La Belle* was more similar to a *barque de charge* or a *chatte*, which is a lighter (Boudriot 2000:43).

According to Boudriot (2000:43), a lighter was a common ship used in the harbors in support of the general operations of the marine. These ships were both decked and undecked to facilitate loading and unloading of equipment, ordnance, and supplies. They varied from 100 to 150 tons and their length varied from 56 to 74 feet. Their breadth was 3.6/10 of their length, ranging from 20 to 26.6 feet. This gave them a length-to-breadth ratio of 2.8:1. Their depth of hold was 45% of their width, ranging from 9 to 12 feet .

Furthermore,

. . . the relationship between the length of the master floor and the width outside of frame is of 65% and the rising limited to 1/18. The rake of the stem is equal to 1/15th of the length and the rake of the sternpost equals one quarter of the rake of the stem, the aft is round (Boudriot 2000:43).

A vertical section, from a treatise by Morineau, illustrates the hull shape of the typical lighter (Figure 5-31). Based upon the museum model, Boudriot observed that the mainmast was placed well aft of the middle of the length and that the ship had a small mizzen mast. He also suggested that the mainmast carried a square sail and the mizzen either a square or one or two jibs (Boudriot 2000:43). While lighters are clearly larger and heavier and these specifications bear little resemblance to *La Belle*, it is a reasonable conclusion given their limited archaeological data.

Working on the basis that *La Belle* was a lighter, Lemineur turned again to *Laurier* and the methods of Masson to conceive the master frame (2000:110-112). The result was a reconstructed master frame that is very like the Morineau illustration (Figure 5-32). While similar to *La Belle*'s master frame, this reconstruction is distinctly different

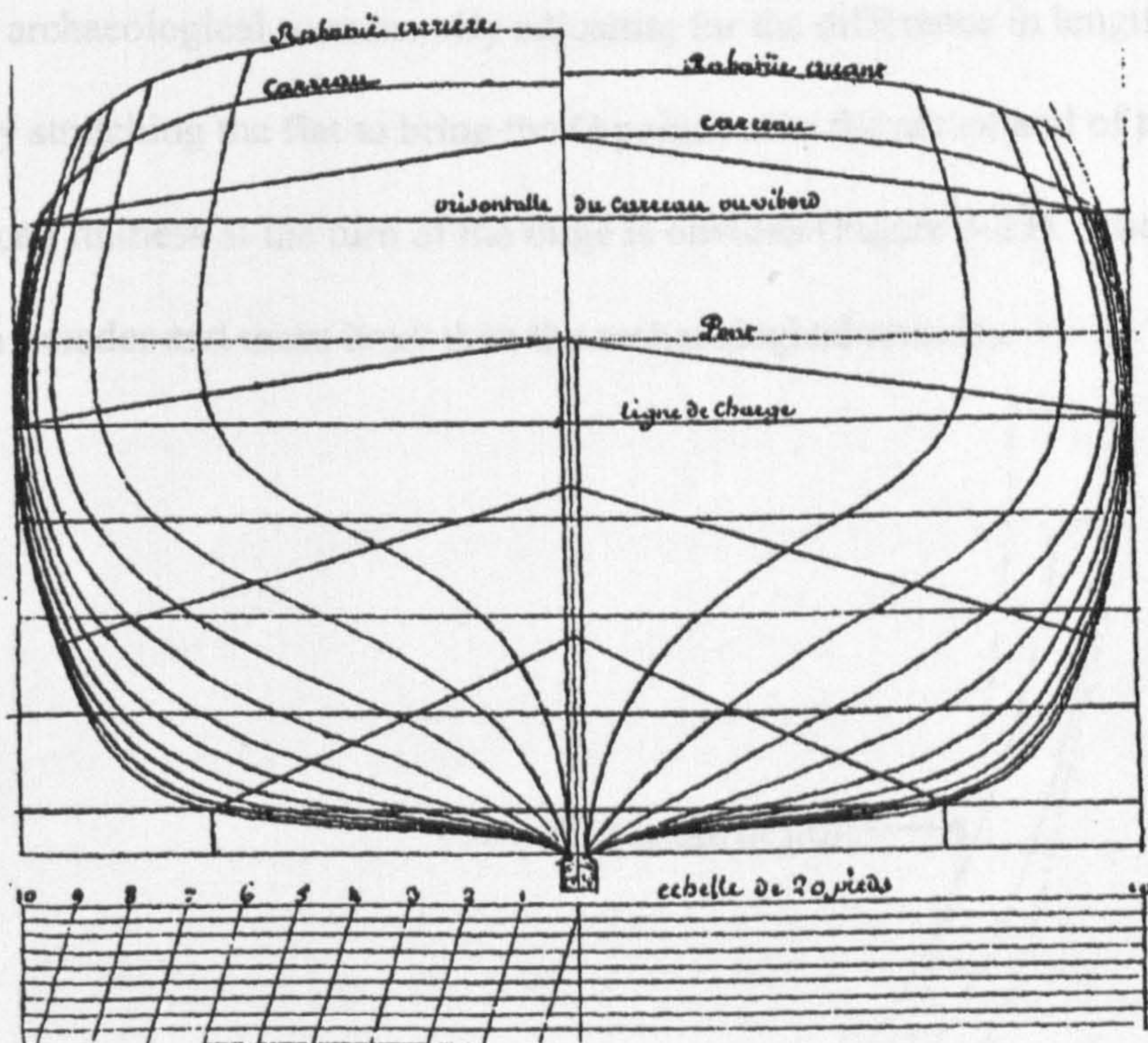


Figure 5-31: Half breadth plan after Morineau, in Boudriot 2000:43.

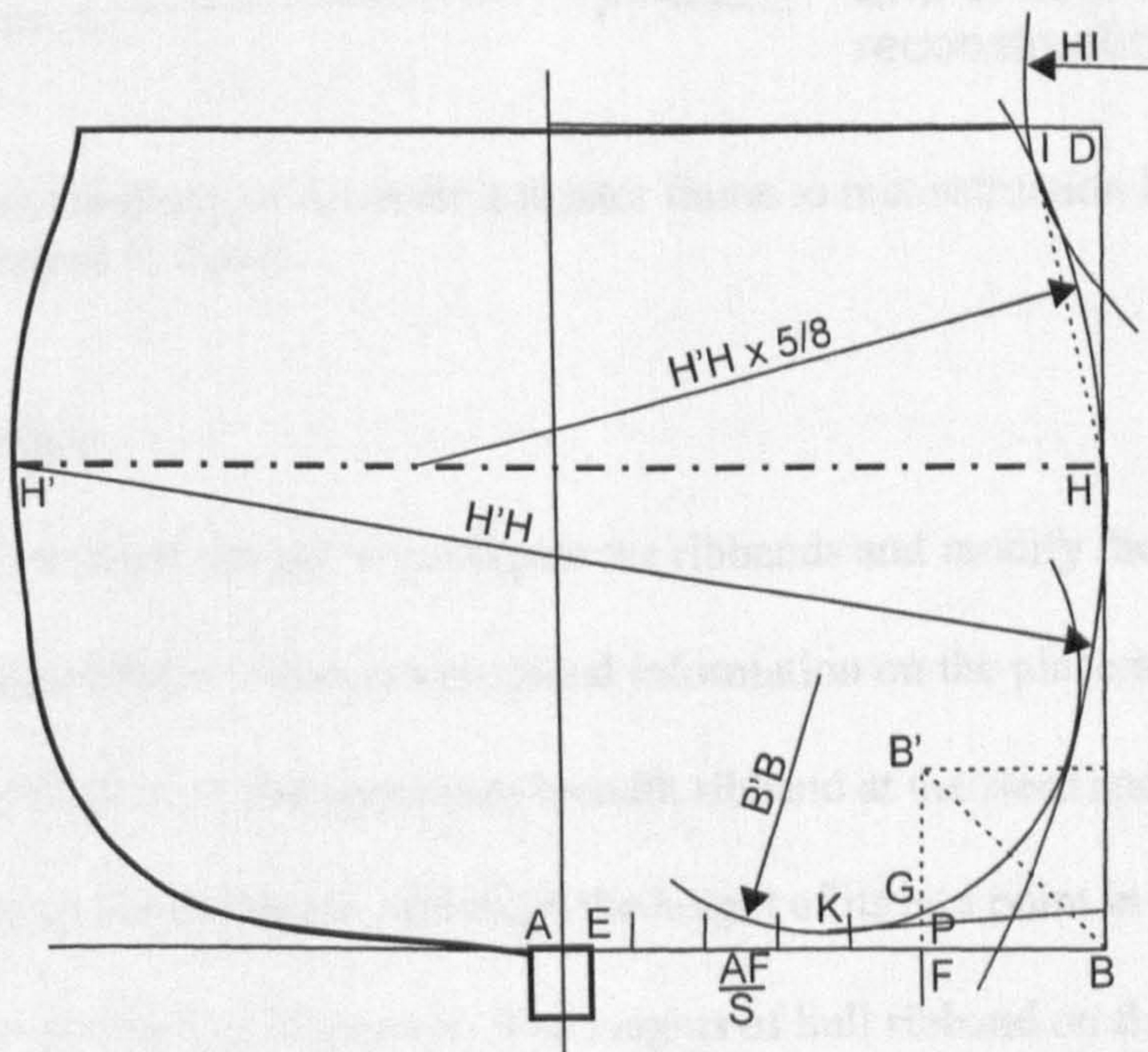
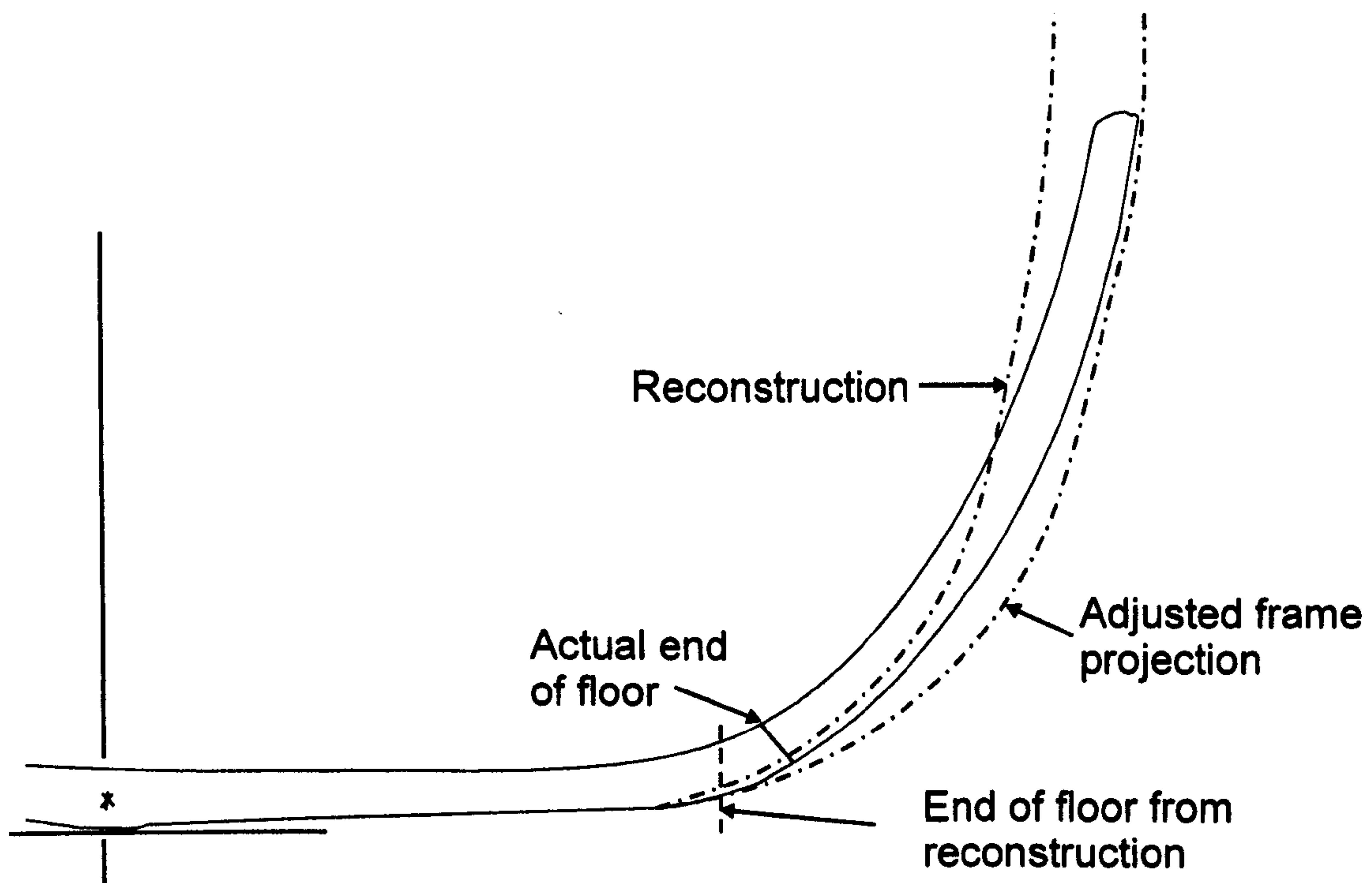


Figure 5-32: Reconstructed master frame after Lemineur Fig 11, in Boudriot 2000:112.

from the archaeological remains. By adjusting for the difference in length of the floor, that is, by stretching the flat to bring the G point out to the actual end of the floor, the pronounced fullness at the turn of the bilge is obvious (Figure 5-33). The shape clearly becomes rounder and more boxy than the archaeological remains.



**Figure 5-33:** Comparison of *La Belle*'s master frame to reconstruction by Lemineur. Drawing by Donald H. Keith.

### Shape of the Hull

Next, Lemineur sought to configure the ribbands and modify the forward and aft frames. The proportions document provided information on the placement of two ribbands. The heights on the maximum breadth ribband at the stern and at the middle is straightforward in the document, although the height of its end point in the bow is problematic, as previously discussed. The heights of hull ribband on the stem and sternpost are given and at its lowest point it passes the end of the master frame floor

timber at the point of the horizontal projection of the floor rising.

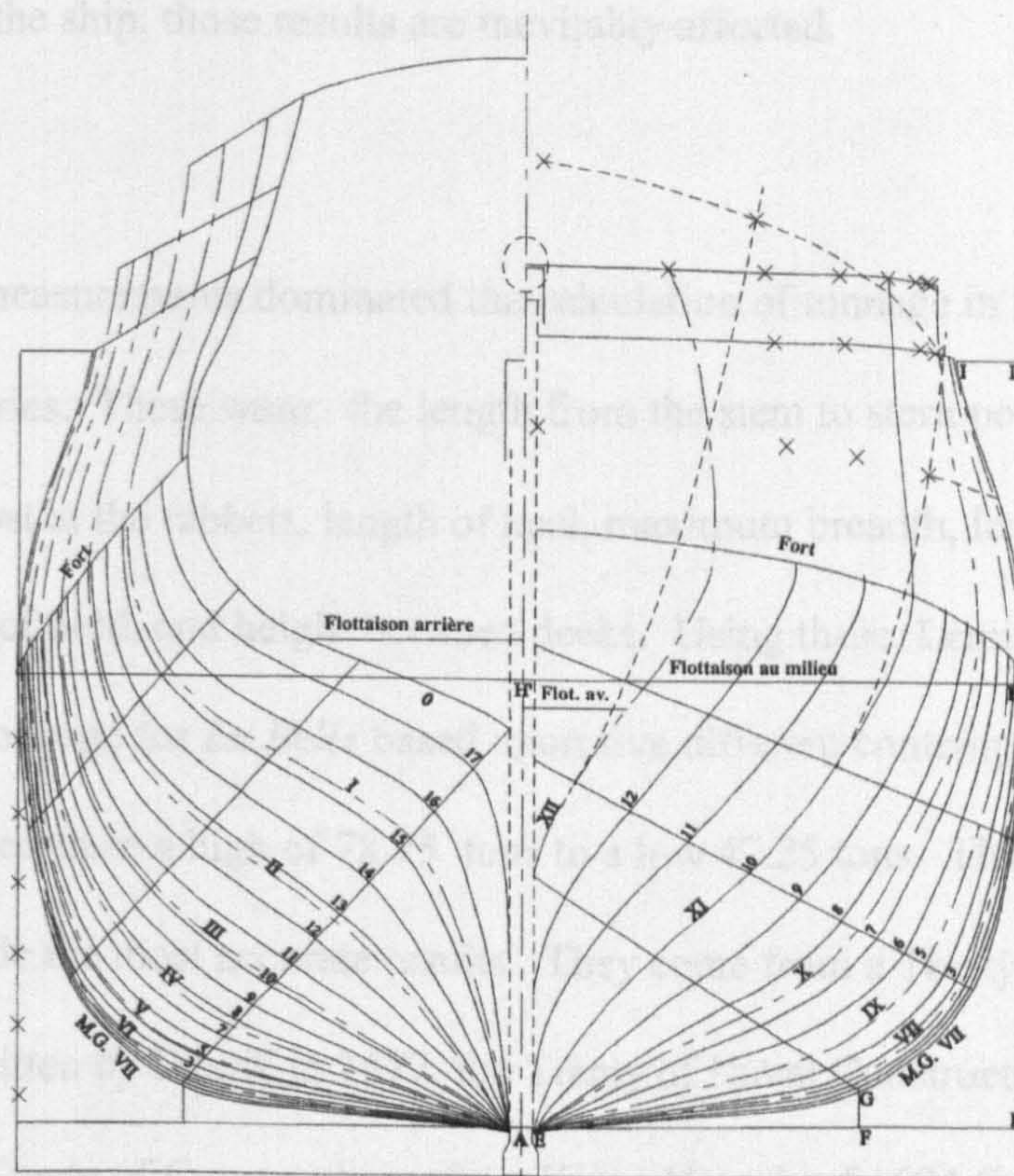
With these two ribbands known from the document, Lemineur determined the placement of two intermediate ribbands. To do so, he looked to the flute *Profund* for guidance (refer to Figure 5-22). In that drawing both lower ribbands are projected as straight lines, however the line of maximum breadth is shown as a slight curve. Also following the *Profund* example, the two intermediate ribbands are projected as averages between the ribband for maximum breadth and the hull.

In order to check his conclusions on the ribbands and therefore the shape of the frames, Lemineur (2000:116) first plotted the hull ribband on a graph and compared that to the ships *Laurier*, *Gaillard*, *Profund*, and *Fulminant*. Because there was a similarity with *Laurier*, he then plotted the ribband for the maximum breadth and two intermediate hypothesized ribbands for *La Belle* based on *Laurier* (Lemineur 2000:120-121). In doing so, he encountered a problem of fairness with the theoretical reconstruction of the maximum breadth at certain frames.

Through a series of calculations Lemineur (2000:119) ultimately came to the conclusion that the tablet and trébuchet were used in *La Belle*. Because of the difficulties he encountered in resolving the arithmetical progression in the trébuchement, and applying that to the ribbands, Lemineur found it necessary to make a series of adjustments to the trajectory of the maximum breadth ribband. The adjustments were unavoidable in order to keep the shape of the bow from becoming too pinched (Lemineur 2000:121). He ultimately resolved the problem by adjusting the fullness of the breadth ribband forward, and adopting the shapes of the intermediate ribbands, albeit with “. . . one or two harmonious fictional lines in the extension of the floor timber and the crotches” from



*Laurier vis a vis Masson* (Lemineur 2000:119-121). The resulting reconstruction incorporates a curved maximum breadth line from *Profund*, two averaged intermediate ribbands whose shapes are based upon *Laurier*, and a maximum breadth ribband from *Laurier* that was primarily modified forward (Figure 5-34).



**Figure 5-34:** Reconstruction half breadth plan after Lemineur Fig. 13, in Boudriot 2000:114.

Although the foundation upon which this effort was undertaken, i.e., the shape of the master frame, was incorrect, the methodology used is impressive and would have likely produced excellent results had it been combined with more extensive archaeological data. As it is, when the theoretically-reconstructed ribbands are compared to the archaeologically-projected lines from the surmarks on *La Belle*, there are clear differences (refer to Figure 5-21). The surmarks also suggest that *La Belle* would not

have had two intermediate ribbands between the hull and maximum breadth, but only one. Both *Profund* (1684) and the flute built by Cochois (1697) exhibit a single ribband here (refer to Figures 5-22 and 5-23). Lastly, because the placement of the ribbands and therefore the shape of the frames is an important consideration in determining the tonnage and volume of the ship, those results are inevitably affected.

## Tonnage

Seven measurements dominated the calculation of tonnage in the late 17<sup>th</sup> and early 18<sup>th</sup> centuries. These were: the length from the stem to stern post, the length from stem to stern post at the rabbets, length of keel, maximum breadth, length of the wing transom, depth of hold, and height between decks. Using these, Lemineur (2000:133) calculated the tonnage for *La Belle* based upon five different contemporary formulae. The results varied from a high of 78.75 tons to a low 47.25 tons. Three of formulae appear to provide the most accurate results. They come from a Treaty of Naval Architecture written by Dassié in 1677, the Treaty of Naval Construction (Document J355), and the Treaty of Construction of the Kings Vessels of 1694 (Lemineur 2000:133).

Because there are some discrepancies between the proportions document and the archaeology, the measurements used by Lemineur are provided first, followed by the archaeological measurements in brackets.

### Figure 5-35: Key Measurements from Proportions Document for Tonnage Calculations

Length from the stem to stern post	51 pieds [51 P 3 p]
Length from stem to stern at the rabbets	49 pieds 5 pouces 21 lines <sup>2</sup> [50 P 10 p]

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<sup>2</sup> Extrapolated from the reconstruction.

Length of keel	45 pieds [45 P 3 p]
Maximum breadth	14 pieds [15]
Length of the wing transom	9 pieds 4 pouces <sup>3</sup>
Depth of hold	7 pieds 6 pouces <sup>4</sup>
Height between decks	0

**Figure 5-36: Comparison of Tonnage Calculations**  
(After Lemineur 2000:113)

According to Dassié:  $\frac{(51 + 45)}{2} \times \frac{(14 + 9P4p)}{2} \times 7P\ 6p + 0 = \frac{4200}{80} = 52.50$  tons

According to an anonymous formula Document J355:  $\frac{45 \times 14 \times (7P\ 6p + 0)}{100} = 47.25$  tons

According to the Treaty published in 1694:  $\frac{51 \times 14 \times 7\ P\ 6p}{100} = 53.65$  tons

When these same formulae are recalculated with the archaeologically-obtained measurements, the results are significantly different. The Dassié formula results in a tonnage of 55.41 tons, a difference of 5 %. The anonymous formula results in 50.90 tons, a difference of 7%; and the 1694 Treaty formula results in 57.66 tons, a difference of 7%. In figuring tonnage, these differences are substantial. Furthermore, none of the calculations match the proportions document, which lists the tonnage as “. . . 40 to 45 tonneaux,” although the anonymous formula comes the closest to the document.

As importantly, these formulae demonstrate the difficulty in calculating tonnage at this time and, perhaps, the futility of doing so for archaeological confirmation other than as an intellectual exercise. It also demonstrates how critically important the

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<sup>3</sup> Lemineur inadvertently used the height of the maximum breadth line instead of the width of the wing transom, which is 9 *pieds 6 pouces*. For purposes of this discussion and comparability, his measurement is used.

<sup>4</sup> Refer to the discussion of the proportions document, measurement number 14.

archaeological measurements are because the greatest impact in figuring the tonnages came from the difference in the maximum breadth, not the minor differences in the length of the keel or the length from stem to stern.

### **Hull Volume**

Lemineur (2000:126-127) did an excellent job of determining the volume of *La Belle*. The results of the volumetric calculations forward and aft, 1,078.91 cubic *pieds* and 1,575.48 cubic *pieds* respectively, for a total volume of 2,654.39 cubic feet without hull planks, is methodologically sound. He struggled with the calculated center of gravity for the hull at 26 *pieds* 3 *pouces* 6 *lines*, slightly forward of the actual middle of the hull, which he calculated at 25 *pieds* 6 *pouces* based upon the 51 *pieds* in the document. This placed the center of gravity at 51.56% of the length rather than at 50%, the latter of which is closer to that of the lighters (Lemineur 2000:126).

In an effort to bring this center of gravity back toward the midpoint, Lemineur first adjusts the fullness of the middle ribbands, without success. He then looks at the maximum breadth ribband forward and attempts to adjust those frames. But those adjustments proved unsatisfactory, noting:

The modification of the line of maximum breadth would have permitted one to preserve the middle ribband shape borrowed from the *Laurier*, but the reduction in volume forward [of the master frame] would have decreased the total volume by a good one hundred cubic feet, bringing the displacement volume to less than 95 tons. . . . Historically, a volume of 2,800 cubic feet is possible. The documents of the time mention ships of the harbor of 45 tons with a displacement of 2,520 cubic feet. However this second solution also had unacceptable consequences. This volume . . . would make *La Belle* a ship of sharpness close to the small vessels, an unimaginable thing because of the configuration of the master frame. [Additionally] . . . constricting the forward ribbands resulted in difficulties for the installation of the cables and other furniture notably the windlass.

In the end only the very rounded part of the line of maximum breadth between the forward lof frames<sup>5</sup> and the stem can be modified slightly to compensate. . . (2000:126).

In the end, Lemineur (2000:128-129) was still bothered by the forward position of the center of gravity vis-a-vis the actual middle of the ship and his inability to bring it more in line with the lighters through various modifications.

While correcting Lemineur's calculations to account for the greater maximum breadth of the hull would change the numerical result, it would not change the overall analysis. In sum, while the shape of *La Belle's* master frame under this theoretical reconstruction was weighted toward a lighter, other analyses provided only minimal support for this conclusion.

### **Analysis**

There is no question that theoretical reconstructions are useful tools. They allow exploration of various hypotheses that benefit research into the conception and design of ancient hulls. They also encourage creative and innovative approaches to analysis of data and the documents. However, because they rely so heavily on historical documentation and, therefore, represent a distinct difference in research emphasis, they should be viewed as intellectual explorations not archaeological fact. While the result may be close to archaeological reality, as shown by this review, it can never match the degree of accuracy or precision that good archaeological research provides.

In this instance, the belief that *La Belle* was built and conceived by Pierre Masson, and that his methods should be applied to the analysis of the hull, heavily influenced all

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<sup>5</sup> Lemineur places these in the first three frames forward of the master frame (2000:128).

aspects of the theoretical reconstruction. This was borne out by the decision at the outset, influenced in part by limited archaeological information, that *La Belle* could not possibly be a barque longue and was instead a lighter. The difficulties encountered in attempting to accommodate the minimal archaeological information to the historical documents in order to confirm these conclusions are a clear indication of the risks inherent in a heavily document-dependent approach.

At the outset, the purpose of the research should dictate which method is appropriate, bearing in mind the trade offs. If the purpose is the broad brush, and there is little or no need for the investment of time, money, and effort required of complete archaeological investigation, then minimal, but accurate archaeological data combined with careful use of historical documents can result in a perfectly acceptable theoretical reconstruction and good general concepts. If, on the other hand, the purpose is to advance knowledge of hull design, to create accurate museum displays and models, or to build reproductions, then nothing but extensive and thorough archaeological investigation will do.

Realistically, one is most often faced with less than the optimum in the amount of archaeological research that is possible. What then, are the 10, 20, or even 30 most important pieces of information to obtain? As the preceding discussion makes clear, it is not so much the number of measurements, it is their accuracy that is important. Poorly executed drawings and inaccurate measurements have little value. At worse, they can send the researcher off in a direction that bears little fruit or, at best, result in inaccuracies that are hard to correct once in print. On the other hand, a few carefully gathered and documented measurements or photographs are priceless. They can be the basis for future

research, provide a useful archaeological comparison, or perhaps even contribute to the study of hull design.

## **Conclusion**

The surprising discovery of the ancient Mediterranean method of the tablet and trébuchement in *La Belle* is an archaeological first that demonstrates the primacy of archaeology in such studies. It clearly establishes the difference between the Atlantic and the Mediterranean methods of hull design in the 16th and 17th centuries. As such, it is a benchmark for comparison with other sites in the study of hull design. This study is also a milestone in the greater scholarly endeavor in which manuscript-based knowledge of Renaissance hull design is coupled with the analysis of wrecks.

*La Belle* demonstrates the fusion of Mediterranean and Atlantic design elements and the active nature of technology transfer among the Mediterranean and Atlantic shipyards of the French marine. Shipwrights not only took with them their intrinsic skills as craftsmen, they took their ideas about ship design, adapting and sharing them with their contemporaries.

*La Belle* is also a ship that demonstrates the nature of transition, from the old methods to the new. The presence of surmarks, which are ancient tools used as aids in construction, is not surprising. However, when projected onto a drawing *La Belle's* surmarks appear as diagonals for the placement of the ribbands and so clearly served a second purpose. On the cusp of the era when architectural methods were beginning to be applied to ship design, *La Belle's* projected surmarks represent a transitional step in the development of the lines plan. This ship, therefore, fills an important gap in our

understanding of the evolution from the ancient methods where no lines plans were used to the graphic depiction of the hull using the lines plan.

Although the study of *La Belle* answers some questions about design, it clearly poses others. Not the least of which is, why is *La Belle* different from the proportions document? Why is its construction, beyond general conception, not more clearly reflected in contemporary treatises that include such detailed instructions for the placement of masts, length of keel, and general ratios? With regard to the proportions document the major differences, other than a possible error by the copyist and the demonstrated difference in the maximum breadth, may have more to do with our modern preoccupation with precision than anything else. It was simply not important from a record-keeping standpoint or realistic from a construction standpoint to spend the time and effort to double check each record and each measurement. The construction methods of the time were those of the craftsman, not of the bureaucrat.

With regard to the detailed shipbuilding instructions in contemporary treatises, for the most part these focused on the ranked ships of state, the frigates, the galleys, and similar. Although *La Belle* was built during a period where ship treatises were being written in ever-increasing numbers, their authors looked toward the future not toward the past. *La Belle* represents a ship type never built in great numbers, was clearly on the decline, and was rapidly being replaced by newer, better, faster types. It is not surprising, therefore, that so little was written about the barque longue and its variants.

Archaeologists tend to favor the material record, something that can be touched, analyzed, dated, and measured. Historians tend to favor the written record, something that is read and discussed. Both avenues of research are necessary. It is the latter,



however, that most often influences theoretical reconstructions. Theoretical reconstructions are, by their nature, heavily dependant upon historical documents. As such both their development and presentation must be carefully considered. To be useful in an archaeological context, the documents upon which they are based must be subject to the greatest possible scrutiny for the information they contain and the context within which they were written. As often as not, the archaeological record reveals that the historical record is not only inaccurate, but incomplete and filled with the biases and misconceptions of their creators.

Lastly, is there a broader lesson that can be learned from the design analysis of *La Belle*? The archival documentation comprising treatises, proportions document, registries, accounts, drawings and lines plans, and modern theoretical reconstructions all represent degrees of distance and variance from the archaeological reality. How heavily each of these tools should be relied upon must be weighed against the purpose of the research. There is no disputing, however, that the only immutable evidence is the archaeological record. The archaeologist may not understand all that is unearthed, but the physical remains is the yardstick to which all of these other sources must be compared, evaluated and, in some cases, cast aside.

## VI. Conclusion

The analysis of *La Belle*'s hull was undertaken with five aims in mind. In their pursuit, several unanticipated discoveries were made.

The first aim of this study was to reconstruct the conception and design of *La Belle*'s hull. Because *La Belle* was built on France's Atlantic coast, it was expected that the ship would fit into the Atlantic construction scheme, reflecting shipbuilding techniques associated with that area. Instead, *La Belle* exhibits an ancient Mediterranean design concept using the tablet and trébuchet, known only from Renaissance manuscripts and modern ethnology. This makes *La Belle* an archaeological first. Until its discovery and analysis no archaeological example that can be associated with this design procedure had been identified. As such, it is a benchmark for comparison with other sites and a milestone in the study of hull design.

This finding is all the more surprising because *La Belle* was built at a time of a dramatic change in ship construction. The burgeoning shipbuilding industry in the newly-created Royal shipyard at Rochefort was undergoing a transformation from the work of highly skilled craftsmen, working by traditional rules-of-thumb, to the nascent science of the naval architect. Schools for the education of master shipwrights were teaching new methods and ship design was beginning a transition from a largely empirical approach to the development of the architecturally-based ship plan. Despite *La*

*Belle's* ancient design method, the application of these new techniques appeared archaeologically in the position of the surmarks on the frames. When the surmarks were projected onto the half breadth plan, it revealed that they did not correspond to the locations of the contiguous arcs used to design its shape. Rather, the projected surmarks created parallel diagonal lines that graphically represent the placement of hull ribbands and serve as control point for the shape of the hull. The use of diagonals in this manner was the first step in the shift toward the modern ship plan. Their appearance in *La Belle* and their implications for ship analysis is another demonstration of archaeology as a primary and unimpeachable source.

The second goal was the documentation of a previously unstudied ship type through an analysis and description of the hull's assembly and its comparison with contemporary shipbuilding practices. *La Belle* was described in French marine rosters as a *barque longue*, a largely ignored ship type poorly documented in contemporary illustrations and treatises. Despite this relative obscurity, many elements of *La Belle's* hull reflect prevalent construction methods found in larger classes of ships. For example, the dimensions of the keel are very similar to those found on warships and the configuration of the main mast assembly is identical to that found on a French flute of 400 tons. Uniquely French were the use of the forefoot rather than a stepped stem, the placement of frames perpendicular to the keel rather than canted, and the use of iron fasteners only in the assembly of the frames. The absence of limber holes was surprising as they were regularly used by the French, while the built-up floors, or crotches, were typical of both the French and English yards. *La Belle's* notched ceiling planks at the turn of the bilge and at the end of the ceiling also served as longitudinal stringers. In combination with

two other higher stringers below the level of the deck, they formed a belt around the ship adding strength to the hull. In short, while *La Belle* may have been a member of a class of ship that was not recorded in great detail, in almost all respects it was very typical of French construction of the period. It is the expression of these constructional elements, however, that a picture of *La Belle* as a so-called *barque longue* emerges. As such, this ship represents an archaeological resource that can contribute to future research into historic ships and their construction.

Whether it was typical of the *barque longue* or related to the distinctiveness of *La Belle*'s conception, an unusual fastening pattern was found when the assembly of the frames was carefully examined. Forward of the master frame the prevalent pattern was two fasteners from the floor to the futtocks and thereafter, while aft of the master it was three fasteners from the floor to the first futtock then two fasteners thereafter. Within these patterns were clear anomalies both forward and aft. This discovery raised unanticipated questions and led to a more detailed examination of the sided dimensions of each of the frame sets. These also exhibited anomalies that only became understandable when combined with information from dendrochronological analyses.

Archival research unearthed a remarkably rich source of registries, letters, and documents specific to *La Belle*. Examination of these documents raised fundamental questions regarding the ship's genesis and typological identification. The third goal was an evaluation and analysis of these documents to resolve these issues. Was *La Belle* the same 'good barque' referred to in a memorandum from the King? That ship was to be sent to the Gulf dismantled onboard *Le Joly*. The documents revealed, however, that the disassembled ship would not fit as cargo and would instead have to be sailed to the New

World. If *La Belle* was the one in the king's memorandum, the construction, disassembly, then reassembly should have left some physical evidence on the hull timbers. Because no such evidence emerged, what was this ship and where did it come from? While contemporary journal accounts suggested that *La Belle* was a gift from the King to La Salle, registries and a letter written by La Salle made it clear that the ship was not his personal property. Furthermore, *La Belle* was not the dismantled ship described in the memorandum from the King. Instead, it was a ship already under construction in the yard that was destined for the use of Rochefort Intendant Pierre Arnoul and was pressed into service for the expedition.

*La Belle* was referred to as a frigate, barque, and barque longue in contemporary accounts and registries. This conflicting typological identification was a key issue for the hull analysis. The disparity among contemporary journals and letters likely reflected the knowledge of their authors and the circumstances of the correspondence. It is not surprising that the ship was referred to in many different manners, the use of the generic and colloquial being as common then as it is today. Of more use in the typological identification were the official naval lists that were forwarded to Versailles. In each of these official documents, the ship was classified as a barque longue and so should be considered that type.

Because only two illustrations of the barque longue are known, it was against these that *La Belle* was initially compared. These illustrations immediately presented problems, the most notable of which was the absence of a mizzen mast. Based upon archival documents, *La Belle* is known to have been configured with a mizzen. This led to several questions about the illustrated ships and barque longues in general. When were

these ships drawn and how typical were they? Both were depictions of ships in northern yards 26 and 36 years after the construction of *La Belle* and so were temporally and regionally different than *La Belle*. How many ships of this type were built and where? The barque longue was never built in great numbers and the vast majority were built in Dunkerque by one shipwright. Only *La Belle* and a handful of others were built in southern or Mediterranean yards and so those would not necessarily share all characteristics with the northern barque longues.

How do the illustrated ships and *La Belle* compare to all known barque longues? Only one of the illustrations, drawn by Danish naval officers, is a technical drawing from which dimensions could be obtained. When comparing the dimensions of this ship to all others for which there is information, both *La Belle* and the Danish ship generally fall within the normative ranges for all members of the class. However, when comparing the Danish ship to all others built only at Dunkerque, it fell below the normative ranges for the length to breadth ratio, length, and breadth of those ships. As such, the Danish example is not a good comparative model for the barque longue type. Furthermore, it was drawn when the barque longue was on the decline and its successor, the sleeker corvette, was in ascendency.

When comparing the masting configuration found on *La Belle* with other similarly-sized ships built in the region at the same time, the presence of a mizzen mast was common. It was also common for the corvette to be configured with two or three masts, one of which was a mizzen. Given other differences in shipbuilding traditions between northern and southern and Mediterranean coasts of France, it is likely that there were regional differences in hull form and masting in the barque longue as well. Today,

as in the past, classification of naval ships was not based solely on masting configurations, but on size, armaments, and purpose. While not built at Dunkerque, in all important respects *La Belle* was a barque longue.

The fourth goal was to obtain species identification of the timbers used in *La Belle*. Analysis of a comprehensive sample revealed that oak from central France was used in all of the major construction elements. Pine from the Pyrenees was used for the main mast, small interior planking, and bulkheads. Fir, probably from the higher elevations of central France, was used for the stanchion posts in the forward hold and the pumpwell. Elm from the nearby area of Champagne was used for the pump tube. One sample of Holm oak, from the Mediterranean, was discovered used as a filler board at the top of the ceiling. No New World species were found to be used in the several repairs noted in the hull. The species identifications demonstrated a comprehensive use of domestic trees and an extensive timber supply network.

When the result of the species analysis was compared to 63 timber contracts for the period 1670-1700, the percentages of wood types represented in *La Belle*'s hull and the percentage of contracts by type were remarkably similar. As such it is another indicator that this ship was built in a shipyard that was part of a national organizational milieu geared toward an increased production of ships.

The fifth goal of the research was to obtain information on the origin of the wood used in the ship's construction. In combination with the identification of species, this analysis confirmed that the wood logged for shipbuilding at Rochefort extended beyond local exploitation well into the nearby Angoumois and Aunis regions. In addition, the dendrochronological analysis revealed unexpected results regarding the dating of the

timbers and the possibility of re-use of whole frame sets. The oldest timbers, those with final ring dates in the 15<sup>th</sup> century, are highly suspect and should not be relied upon without additional sample analysis. Those with dates in the first half of the 16<sup>th</sup> century can be used with a degree of caution, but are internally statistically viable. The remainder, with final ring dates after 1550 can be used with confidence. This means that at least some of the trees used in *La Belle*'s construction were felled more than 125 years before its construction. This is a remarkable finding that has broader implications for understanding the nature of shipbuilding and the recycling of timbers. In *La Belle*, when combined with the information from the study of its fastening patterns and the physical dimensions of the frames, it clearly indicated the reuse of complete frame sets. Further, if *La Belle* was a completely new ship, rather than a ship incorporating used timbers, then nearly all of the samples should have dated to the few years just prior to its construction.

The dendrochronology also showed that there was a clear preference for trees in the 60-80 year range for the floors through the second futtocks, with a strong secondary preference for trees from 30-50 years. This trend was reversed in the third futtocks, where younger trees were preferred. Also reflecting these preferences were the low numbers of trees from the 90-160 category. Overall, the pattern is one that favors mature trees between 30 and 80 years, a finding that is reasonable but not widely documented in the literature.

Climatologically, the dendrochronological results along with an examination of the grain of the tree from the timbers supports a finding that the timbers came from a natural, rather than a plantation environment. The range of environments from very closely spaced stands with strong competition to open woodlands with little or no



competition reflects the environment of central France's oak forests. This also supports the finding of timber reuse from an older ship.

The importance of dendrochronological analysis of shipwreck remains is strongly supported by these results and should be encouraged. These findings place *La Belle* in a singular position to contribute to an understanding of 17<sup>th</sup>-century shipbuilding because there are no other investigated sites from the Rochefort region that have species use and dendrochronological data available. Thus, *La Belle* provides a benchmark that can contribute to broader historical research.

Although not an expressed goal of this research, a fortunate set of circumstances allowed a comparison of the archaeological remains to a theoretical reconstruction of the hull undertaken by Jean Boudriot (2000). In so doing, it was possible to answer a question that often plagues archaeologists working with limited data while attempting to accurately recreate the shape of a hull: How accurate is the result?

In the case of *La Belle* the basic information relied upon by Boudriot and Lemineur was inappropriate for the use to which it was placed. Further, due to the lack of extensive archaeological data, certain assumptions and conclusions were reached that proved flawed. The results, while beautifully presented, were not an accurate reflection of the archaeological reality. With more information, the results would likely have been quite different. Of more importance is that a theoretical reconstruction, by its nature, requires and represents a difference in approach weighted more heavily toward historical documents than toward archaeological remains. Both approaches can and do produce acceptable results, but they differ in their degree of precision.

Archaeologists tend to favor the material record, something that can be touched,

analyzed, dated, and measured. Historians tend to favor the written record, something that is read and discussed. Both avenues of research are necessary. It is the latter, however, that most often influences theoretical reconstructions. As such, the development and presentation of theoretical reconstructions must be carefully considered. To be useful in an archaeological context, the documents upon which they are based must be subject to the greatest possible scrutiny for the information they contain and the context within which they were written. As often as not, the archaeological record reveals that the historical record is not only misleading, but incomplete and filled with the biases and misconceptions of their creators.

Lastly, is there a broader lesson that can be learned from the design analysis of *La Belle*? Archival documentation including treatises, proportions document, registries, accounts, drawings and lines plans, and modern theoretical reconstructions all represent degrees of distance and variance from the archaeological remains. How heavily each of these tools should be relied upon must be weighed against the purpose of the research. There is no disputing, however, that the only immutable evidence is the archaeological record. The archaeologist may not understand all that is unearthed, but the physical remains are the yardstick to which all other sources must be compared, evaluated and, in some cases, cast aside.

The five research foci in this study provide a unique picture of late 17<sup>th</sup>-century shipbuilding in the Atlantic arsenals of France. The study shed light on the study of hull design and conception, ship typology, ship construction and assembly, wood species use and origin, dendrochronological dating of shipwreck remains, timber exploitation for shipbuilding, forest environments, and timber reuse. In many of these, *La Belle* is an archaeological first.

**Appendix A**  
**Barque Longues Constructed 1671-1708**  
 (after Le Conte 1935 and Boudriot 1990)

Name	Date of		Builder	Length	Depth of		Length
	Construction	Place of Construction			Hold	Breadth Ratio	
L' Active	1703	Brest	Blaise	50.00	9.10	4.60	5.49
L' Adroite	1671	Brest					
L' Agathe	1675	Dunkerque	Hendrick	54.00	13.60	5.60	3.97
L' Agathe	1708	Rocheport	Le Masson	66.00	16.00	8.00	4.13
L' Agile	1707	Dunkerque	Le Vasseur	64.00	17.60	7.00	3.63
L' Allumette	1693	Dunkerque	Hendrick/Houvens	57/47 <sup>1</sup>	14/11.6	5.6/6	4.97/4.05
L' Assurée	1671	Brest					
L' Assurée II	1677	Dunkerque	Hendrick				
L' Assurée	1679	Dunkerque					
L' Assurée	1690	Dunkerque	Houvens				
La Bayonnaise	1689	Brest					
La Belle	1684	Rocheport	Mallet	51.00	14.00		3.64
La Belle II	1689	Rocheport	P. Mallet				
La Biche	1691	Dunkerque	Houvens	60.00	14.60	5.60	4.10
La Blonde	1689	Le Havre	B. Chaille	65.00	14.00	5.00	4.64
La Bonne	1690	Dunkerque	Houvens				
La Boussole	1691	Dunkerque	Cochois	60.00	14.00	7.00	4.28
La Brune	1690	Dunkerque	Houvens				
La Choquante	1690	Dunkerque	Hendrick	70.00	17.00	7.60	4.11

<sup>1</sup> Discrepancies noted by Boudriot in length, breadth, or depth. Only *L'Allumette* had a discrepancy in the name of the builder.

Name	Date of		Builder	Length	Depth of		Length
	Construction	Construction			Hold	Breadth Ratio	
La Cigale	1707	Dunkerque	Le Vasseur	64.00	17.60	7.00	3.63
La Commode	1691	Dunkerque	Houvens	62.00	16.60	5.30	3.73
La Corvette (Folle)	1674	Rochefort	B. Chaille				
La Curieuse	1701	Le Havre	P. Cochois	52.00	13.00	6.20	4.00
La Diligente	1703	Dieppe	P. Cochois	56.20	15.00	6.60	3.74
La Discrète	1693	Dunkerque	Guillou	57/49	14/16	5.6/6	4.07/3.06
La Dorade	1691	Dunkerque	Houvens	66.00	16.60	5.60	3.97
L' Effrontée	1677	Dunkerque	Hendrick				
L' Émeraude	1691	Dunkerque	Cochois	70.00	17.00	7.60	4.11
L' Entendue	1689	Le Havre	E. Salicon				
L' Entreprenante (Bayonnaise)	1671	Brest					
L' Espérance	1675						
L' Étoile	1708	Rochefort	Le Masson	66.00	16.00	8.00	4.13
La Ferme (Lutine)	1672	Dunkerque	Hendrick				
La Fidèle (Méchant)	1672	Dunkerque	Hendrick				
La Fine	1671	Dunkerque	Hendrick				
La Fine	1674	Dunkerque	Hendrick				
La Fine II	1689	Brest	Brun	56.00	15.00		3.73
La Fine III	1693	Dunkerque	J. Houvens	60.00	15.00	7.00	4.00
La Fine	1702	Dieppe	Blondel	56.00	15.00	5.40	3.73
La Flatteuse	1690	Dieppe	Blondel	48.00	12.00	5.00	4.10
La Flèche	1691	Dunkerque	Cochois	60.00	14.00	7.00	4.28
La Fortune	1693	Dunkerque					
La Fouine	1693	Dunkerque	Guillou	62/60	14.6/16	5.6/7.6	4.24/3.75
La Gentille	1701						

Name	Date of		Place of Construction	Builder	Length	Breadth	Depth of		Length Breadth Ratio
	Construction	Construction					Hold	Hold	
La Gracieuse	1703	Dieppe	Drouillard						
L' Hardie (Belle)	1671	Brest							
L' Hautaine	1693	Dunkerque	Hendrick		61.00	18.00	6.00		3.38
L' Inconnu	1671	Dunkerque	Hendrick						
L' Inconnue	1674	Dunkerque	Hendrick						
L' Insenée	1703	Brest	Blaise		50.00	9.10	4.60		5.49
La Joyeuse	1691	Le Havre	G. Salicon						
La Levrette	1689	Le Havre	B. Chaille						
La Levrette	1707	Dunkerque	Le Vasseur		64.00	17.60	7.00		3.63
La Lunette	1691	Le Havre							
La Marie-Françoise	1703	Le Havre	P. Cochois		52/61	16/17.6	7.0/6		3.25/3/46
La Méchante II	1689	Brest	Brun						
La Mignonne (Rochelaise)	1675	Le Havre	Hendrick						
La Moqueuse	1676	Brest							
La Nympe	1692	Dunkerque	Guillou		60.00	16.60	5.60		3.97
La Pouponne	1671	Dunkerque	Hendrick						
La Pouponne II	1690	Dunkerque	Houvens						
La Prompte	1689	Le Havre	E. Salicon		60.00	16.60	5.60		3.97
La Prompte	1692	Dunkerque	Guillou						
La Rieuse	1678	Dunkerque	Hendrick						
La Rochelaise V	1689	Dunkerque	Hendrick						
La Rusée	1691	Dunkerque	Houvens						
La Rusée	1695	Calais			47.00	12.00			3.92
La Sans Peur	1689	Dunkerque	Hendrick						
La Sibylle	1689	Dunkerque	Hendrick						



## Appendix B: *La Belle* Wood Species

Timber No.	Timber Description	Wood Species	Outside ID
3	Bulkhead 3 Plank	Red Pine ( <i>Pinus resinosa</i> )	
10	Bulkhead 3 Nailer	Red Pine	
16	Bulkhead 3 Nailer	Red Pine	
18	Bulkhead 2 Plank, part of pump	Red Pine	
20	Bulkhead 2 Plank	Red Pine	
24	Forward Hold Deck Beam	White Oak ( <i>Quercus</i> spp.)	
28	Goats Foot	White Oak	
30	Pumpwell Stanchion	Red Pine	
31	Pumpwell Stanchion	Fir ( <i>Abies</i> spp.)	
35	Pumpwell Plank	Red Pine	
40	Pumpwell Nailer	Red Pine	
44	Forward Hold Deck Plank	Red Pine	
49	Forward Hold Deck Plank	Red Pine	
51	Forward Hold Deck Plank	Red Pine	
54	Bulkhead 1 Plank	Red Pine	FPL
56	Bulkhead 1 Plank	Red Pine	
59	Bulkhead 1 Stanchion	White Oak	
61	Bulkhead 1 Nailer	Red Pine	
63	Bulkhead 1 Nailer	Red Pine	
64	Forward Hold Deck Stanchion	White Oak	
67	Main Mast Step Filler Piece	White Oak	
68	Main Mast Step Partner	White Oak	
69	Main Mast Step Chock	Fir	
70	Main Mast	Red Pine	
73	Main Mast Step Rider	White Oak	ESF
76	Pumpwell Plank	Red Pine	
77	Pumpwell Plank	Red Pine	
78	Bulkhead 2 Stanchion	Fir	FPL
79	Pump Tube	Elm ( <i>Ulmus</i> spp.)	
80	Pumpwell Stanchion	Red Pine	
83	Pumpwell Stanchion Nailer	Red Pine	
89	Stringer Piece	White Oak	
90	Stringer Piece	White Oak	
93	Filler Plank/Covering Board	Live Oak ( <i>Quercus ilex</i> )	ESF/FPL
98	Filler Plank	White Oak	
108	Ceiling, Starboard	White Oak	
109	Ceiling, Starboard	White Oak	
112	Repair	White Oak	
115	Limber Board, Starboard	Red Pine	
117	Limber Board, Starboard	Red Pine	
119	Keelson	White Oak	

## Appendix B: *La Belle* Wood Species

Timber No.	Timber Description	Wood Species	Outside ID
121	Tailpiece	Spruce ( <i>Picea</i> spp.)	ESF
128	Ceiling, Port	White Oak	
134	Foremast Lock Timber	White Oak	
136	Foremast Heel Base	White Oak	
143	Stringer Chock	Fir	
147	Futtock, Starboard Bow	White Oak	
150	Futtock, Starboard Bow	White Oak	
153	Futtock, Starboard Bow	White Oak	
158	Futtock, Starboard Main 1	White Oak	
163	Futtock, Starboard Main 1	White Oak	
169	Futtock, Starboard Master Couple	White Oak	
171	Futtock, Starboard Master Couple	White Oak	
172	Futtock, Starboard Bow	White Oak	
174	Wedge, Between Ceiling, Starboard	Red Pine	
176	Main Mast Nailer	Red Pine	
178	Main Mast Step Buttress	White Oak	
180	Limber Board, Port	Red Pine	
182	Ceiling, Port	White Oak	
183	Repair	White Oak	
188	Futtock, Starboard Main 1	White Oak	FPL
190	Futtock, Starboard Main 1	White Oak	
194	Futtock, Starboard Main 2	White Oak	
196	Futtock, Starboard Main 2	White Oak	
200	Futtock, Starboard Main 2	White Oak	
202	Futtock, Starboard Main 2	White Oak	
210	Futtock, Starboard Stern	White Oak	
213	Futtock, Starboard Stern	White Oak	
216	Futtock, Starboard Stern	White Oak	
218	Floor, Stern	White Oak	
219	Stern Knee	White Oak	
220	Stern Cant Frame	White Oak	
221	Stempost	White Oak	
222	Limber Board, Port	White Oak	
227	Futtock, Starboard Main 1	White Oak	
236	Foremast Filler Piece	Red Pine	
238	Foremast Filler Piece	Red Pine	
242	Floor, Bow	White Oak	
243	Futtock Port Stern	White Oak	
245	Futtock, Port, Bow	White Oak	
249	Futtock, Port, Bow	White Oak	
250	Floor, Bow	White Oak	



## Appendix B: *La Belle* Wood Species

Timber No.	Timber Description	Wood Species	Outside ID
251	Futtock, Port, Bow	White Oak	
257	Floor, Main 1	White Oak	
258	Futtock, Port Main 1	White Oak	
262	Futtock, Port Main 1	White Oak	
268	Futtock, Port Master Couple	White Oak	
274	Futtock, Port Master Couple	White Oak	
275	Floor, Main 1	White Oak	
276	Futtock, Port Master Couple	White Oak	
277	Floor, Main 2	White Oak	
279	Floor, Main 2	White Oak	
282	Futtock, Port Main 2	White Oak	
288	Futtock, Port Main 2	White Oak	
290	Ceiling, Port	White Oak	
292	Foremast Chock	White Oak	
293	Ceiling, Starboard	White Oak	
295	Wedge, Between Ceiling and Frame	Red Pine	
296	Futtock, Port Stern	White Oak	FPL
299	Wedge, Between Ceiling and Frame	White Oak	
302	Floor, Stern	White Oak	
304	Floor, Bow	White Oak	
306	Filler, Between Ceiling and Frames	Red Pine	
313	Stem Deadwood	White Oak	
314	Stern Deadwood	White Oak	
315	Stem Shim	White Oak	
319	Starboard Garboard	White Oak	
321	Starboard Garboard	White Oak	
322	Outerhull, Port, Aft	White Oak	
326	Knee and Deadwood Wedge	White Oak	
329	Outerhull, Starboard, Aft	White Oak	
333	Repair	White Oak	
338	Outerhull, Port, Aft	White Oak	
339	Repair	White Oak	
341	Outerhull, Starboard, Forward	White Oak	
342	Outerhull, Port, Midships	White Oak	
343	Repair	White Oak	
346	Outerhull, Port, Forward	White Oak	
348	Port Garboard	White Oak	
352	Outerhull, Port, Forward	White Oak	
354	Keel	White Oak	
357	Outerhull, Starboard, Forward	White Oak	
361	Outerhull, Starboard, Midships	White Oak	

## Appendix B: *La Belle* Wood Species

Timber No.	Timber Description	Wood Species	Outside ID
362	Keel	White Oak	
363	Outerhull, Starboard, Forward	White Oak	
367	Repair	White Oak	
368	Stem Cutwater	White Oak	
369	Repair	White Oak	
375	Outerhull, Starboard, Midships	White Oak	
379	Outerhull, Starboard, Aft	White Oak	
381	Outerhull, Starboard, Forward	White Oak	
389	Repair	White Oak	
	Treenail Sample	White Oak	
	Treenail Sample	White Oak	

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Series B, Service Général

Marine B<sup>2</sup>, Dépêches de Seignelay, Ministre de la Marine

Marine B<sup>2</sup>, Ordres du Roi concernant la Marine

Marine B<sup>3</sup>, Correspondance concernant la Marine

Series D, Matériel

Marine D<sup>1</sup>, Construction Naval

Marine D<sup>3</sup>, Approvisionements et Subsistances

Series G, Documents Divers

Marine 3, Hydrographie

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Fonds des Colonies Series C, Correspondance à l'Arrivée

Colonies C<sup>11</sup>, Correspondance Général

Colonies C<sup>13</sup>, Correspondance à l'Arrivée, Louisiane

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Section des Manuscrits Nouvelles Acquisitions Français (NAF)

Volumes 21306 to 21444, Correspondance Général, 1683-1687

Papiers de Nicoalas et Pierre Arnoul, Intendants de la Marine

Mélanges Colbert (MC)

Letters and Instructions given to Seignelay containing 84 files

Service Historique de la Marine (SHMR), Rochefort

Series 1L<sup>3</sup>

12 to 17, Construction Navales 1675 to 1710

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