THE COROLLA WRECK EXPOSED: HISTORICAL ARCHAEOLOGICAL ANALYSIS OF NORTH CAROLINA'S OLDEST SHIPWRECK

by

Daniel Mark Brown

November 2013

Director of Thesis/Dissertation: Dr. Bradley Rodgers

Major Department: Maritime Studies

ABSTRACT

Because of the unexpected and spontaneous discovery of the Corolla Wreck in 2008, its relocation in 2009, and its dynamic six-month jaunt up and down the coast, all research questions posed by this thesis were formed in reaction to the wreck and what little information was available in the summer of 2010. Unaware of the extent or provenience of recovered material culture, the author set about utilizing the most relevant (mega) artifact at hand: the structural remains. Research questions seek to reveal the philosophical construction origin, function, and role of the ship these wreck remains represent, as well as what part the vessel played in the system of European-Atlantic commercial and territorial expansion (the systemic context). Identifying the ship is impossible, structural features and material culture, however, suggest three possible candidates for nations of origin: English, Dutch, or French. This required a survey of these nations' collective commercial and territorial expansion into North America in the 17th century. Alongside historical research on trade and settlement patterns by the leading colonial powers of the 17th century, research into 16th- and 17th-century ship construction treatises sought to elucidate contemporary historical sources that may reveal information regarding structurally specific cultural information locked in the mega-artifact that is the shipwreck. To compliment historical research of both the colonial systemic context and historical documents on

shape, form, and function for the wrecked vessel, a survey of 25 historic European shipwrecks dating from the 16th and 17th centuries provides the archaeological context for Wreck CKB0022. Material culture and structural features of the wreck provide the most definitive archaeological evidence for the vessel's origin, function, and role at the time of its wrecking event.

THE COROLLA WRECK EXPOSED: HISTORICAL ARCHAEOLOGICAL ANALYSIS OF NORTH CAROLINA'S OLDEST SHIPWRECK

A Thesis

Presented To the Faculty of the Department of History

East Carolina University

In Partial Fulfillment of the Requirements for the Degree

Master's of Arts

by

Daniel Mark Brown

November, 2013

THE COROLLA WRECK EXPOSED: HISTORICAL ARCHAEOLOGICAL ANALYSIS
OF NORTH CAROLINA'S OLDEST SHIPWRECK

by

Daniel Mark Brown

APPROVED BY:

DIRECTOR OF
THESIS: ______________________________
Bradley Rodgers, PhD

COMMITTEE MEMBER: ______________________________
Nathan Richards, PhD

COMMITTEE MEMBER: ______________________________
Carl Swanson, PhD

COMMITTEE MEMBER: ______________________________
Frederick Hocker, PhD

CHAIR OF THE DEPARTMENT
OF HISTORY: ______________________________
Gerald Prokopowicz, PhD

DEAN OF THE
GRADUATE SCHOOL: ______________________________
Paul J. Gemperline, PhD

DEDICATION

I dedicate this thesis and the degree to which it is a prerequisite to my darling wife, Ashley-Anne. Without her unwavering support over the past years, her diehard confidence in my abilities, her unflinching dedication to the improvement of our life and a greater fulfillment of happiness, none of this, or anything I've accomplished would have been possible. This degree was, after all, her idea.

ACKNOWLEDGEMENTS

No work of any significance is accomplished alone. I would like to thank my adviser Bradley Rodgers for allowing me to tackle this topic, despite never having me in the classroom before taking me on as a thesis student, for reading seven drafts of my prospectus, and countless chapters and revisions, always with an eye to detail, content, and structure. Brad was always in my corner. Next, I'd like to thank Nathan Richards for letting me barrage him with infinite queries over the years, thesis and otherwise. Nathan's open door and instant attention helped me through a myriad of puzzles and pitfalls. Nathan has been a mentor both in and out of the classroom. I'd like to thank Carl Swanson for his tireless dedication to his students' writing and the time and detail he took with my coursework and my thesis. Carl has helped make me a better writer. I'd also like to thank Fred Hocker for letting me pester him with thesis questions during each of the subsequent *Vasa* projects. Working hands-on on an intact 17th-century ship provided more insight to ship construction than any book or lecture. This list could go on forever: thank you to David Stewart for introducing me to ship construction, Lawrence Babits for numerous sources and suggestions, Mark Wilde-Ramsing and Nathan Henry for providing me open access to UAB records, and Megan Agresto at Currituck Lighthouse for tagging the wreck and providing photographs. Thanks also to Kroum Batchvarov for insightful suggestions and observations, Wendy Van Duivenvoorde for data on *Batavia's* frames, Tiago Fraga for Iberian ship construction sources, Jon Adams, Nigel Nayling, and Thijs Maarvlevelj for feedback and emails. The arduous translation of Witsen's chapter 8 would have been impossible if not for Katy Kavanagh at Joyner Library and Martin Bier for verifying the translation. North Carolina is indebted to George Browne for reporting the Corolla Wreck in 2008 and continuing to demonstrate concern for the fate of the vessel remains. Special thanks to Ray Midgett and Roger

Harris for allowing me to photograph their collection s of artifacts collected from the Corolla Wreck and providing original photographs, many diagnostic features would not have been observed if not for your combined interest and attention to the Corolla Wreck. Finally, thank you to Nathaniel Howe, Saxon Bisbee, and Daniel Bera for executing the secondary recording phase of the Corolla Wreck and its associated artifacts. One could not ask for a better crew.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE: Introduction

Introduction

In September 2008, after a typical North Carolina Outer Banks (OBX) nor'easter, George Browne noticed the remains of a vessel in the surf behind his summer home near Corolla, North Carolina. Browne and two local residents' curiosity, Ray Midgett and Roger Harris, no strangers to the seasonal uncovering and reburial of dozens of 19th-century shipwrecks, led them to observe the wreck was unlike any they had ever seen on the OBX.

FIGURE 1. Corolla Wreck in the surf, December 2009. (Photo by Roger Harris)

It would take 18 months for the proper authorities to respond and investigate Ray Midgett's suspicion—that this wreck hailed from the 17th century. After very little movement over 16 months, the wreck became buoyant in late 2009 and endured a tidal journey up and down the coastline of Corolla. In early 2010, North Carolina Department of Cultural Resources Underwater Archaeology Branch (NCDCR UAB) archaeologists Richard Lawrence and Nathan Henry confirmed Midgett's initial conclusion that this was the oldest known shipwreck ever encountered in North Carolina. This conclusion was based on their preliminary structural analysis—mainly the predominance of wooden fasteners used to assemble the vessel remains (as opposed to iron)—and Midgett and Harris's finds of 17th-century coins and other artifacts, in 2010.

Thus, the author formed all research questions posed by this thesis in reaction, post-deposition of the wreck, to what little information was available in the summer of 2010. Unaware of the extent or documentation of material culture, the author set about utilizing the most relevant (mega) artifact at hand: the wreck itself. Research questions seek to reveal the philosophical construction origin, function, and role of the vessel that these wreck remains represent, as well as what part it played in the system of European-Atlantic commercial and territorial expansion (the systemic context). Structural features suggest early to mid-17th century as the period of origin of the vessel's construction. Material culture provides a *terminus post quem* (earliest possible wrecking event date) of 1643. A survey of 16th and 17th-century ship construction treatises paired with analysis of contemporary archaeological wrecks will seek to answer whether the extent remains of the Corolla Wreck can offer evidence for its origins and function. Furthermore, analysis of the wreck's archaeological context includes examination and analysis of material culture collected by local residents that aids in identifying the possible socioeconomic role and use life of the vessel at the time of its wrecking event.

In 1994, in his cornerstone contribution to maritime archaeology, J. Richard Steffy proposed that one day scholars would be able to identify "sparsely preserved hulls according to nationality and period by interpreting their construction features and hull curvatures…" (Steffy 1994:11). Though not all scholars agreed with Steffy (then or now), this thesis seeks to test Steffy's proposal and try to identify the ship's probable origin and use based on construction features; the word *probable* is significant in that no typology by which to identify vessel remains by construction features yet exists. In order to understand this rare North Carolina cultural resource (only one known of its kind), this thesis will test the above comparative analytical model's potential for future application in maritime archaeology. Secondly, can analysis of 17th-century trade and settlement patterns reveal a statistical probability of where the Corolla Wreck originated and what was its function? Using archaeological and historical analysis, this thesis seeks to answer the question of whether the wreck is English, Dutch, French, Iberian, or North American in origin and function, to what probable degree, and if not, why? In doing so, this thesis seeks to provide broader application to future unrecorded wrecks. Though independent verification of such analysis is not possible at this time, the author hopes future archaeologists will validate Steffy's proposal and consider this approach as a step towards doing so. To provide the context to this systemic analysis, given the specific circumstances surrounding this rare and dynamic wreck (in its mobile nature caused by both natural and cultural forces) and its final deposition, a full account of the events that occurred from fall 2008 to summer 2010 are necessary. This description follows with a synopsis of previous research and explanation of thesis structure.

The Story of the Corolla Wreck

The waters of North Carolina, famously and appropriately termed the "Graveyard of the Atlantic," are home to approximately 5,000 historic shipwrecks (Babits 2002:119-126). Of these, NCDCR UAB has information on around 900 wrecks (Watkins-Kenny 2010:3). This includes over 150 wrecks buried (and often uncovered) in the surf and dunes of the Outer Banks (Nathan Henry 2010 elec. comm.). The tumultuous weather patterns of the mid-Atlantic occasionally unbury one of these wrecks, or in rare circumstances, cause an ocean wreck to beach. In September 2008, George Browne, a resident of New Jersey, was working in North Carolina and staying at his ocean side home in Corolla. One night a violent storm produced massive waves and in the morning, Browne noticed something along the water. It was a shipwreck (see FIGURE 2) (Watkins-Kenney and Henry 2010:1; George Browne elec. comm. 2012).

FIGURE 2. Wreck CKB0022 near Corolla, NC, in October 2008. (Photo by Roger Harris)

From Discovery to Removal

Most of the wooden wrecks scattered along the Banks hail from the 19th century, a period of massive traffic up and down the east coast. There was no reason to think this uncovered wreck was any different from the typical 19th-century wrecks seasonally exposed on the Banks. Browne examined the wreck at slack tide, noticing massive timbers held together with wooden nails, or “treenails.” No one in the area could identify the wreck. Browne photographed the wreck, recorded its GPS coordinates, and contacted the North Carolina’s Underwater Archaeology Branch (UAB, part of the Department of Cultural Resources) (Watkins-Kenney and Henry 2010:1; George Browne elec. comm. 2012). The ocean surf reburied the wreck within 48 hours. Photographs taken by Browne showed approximately 40 to 50 feet of wooden ship remains. Because of the close proximity of a known 19th-century wreck (The Ocean Hill Wreck, Site CKB0016), no attempt to investigate the wreck occurred that year. Proper authorities remained unaware that a 17th-century shipwreck had appeared near Corolla.

In September 2009, Browne returned to the Banks and noticed the wreck was again uncovered—and there was less of it. By December, it was fully exposed. Browne photographed it again. Curious visitors and residents began to scavenge artifacts from the wreck, so Browne contacted UAB again, voicing his concern over vandalism and continued exposure to winter storms (Watkins-Kenney and Henry 2010:5). UAB now suspected the wreck Browne reported was not the Ocean Hill wreck. Unfortunately, the wreck was beyond UAB's daily travel mileage limit (Watkins-Kenney and Henry 2010:15). Throughout the remainder of 2009, storms and pounding surf reburied and exposed the wreck several times. After one particularly violent storm, the wreck became buoyant. By 22 December 2009, the wreck was 280 yards (255 meters) north of its originally reported position, noted by local residents who marked its location based on beach mile-markers (driving on the beach is allowed with a permit) (Watkins-Kenney and Henry 2010:7). By the end of December, the wreck was even farther north by 0.7 miles (1.1 kilometers) (see FIGURE) (Watkins-Kenney and Henry 2010:13). Still concerned over the wreck, Browne contacted UAB again and was put in touch with NCDCR contacts at the Currituck Beach Lighthouse (Watkins-Kenney and Henry 2010:5,13). With Megan Agresto, Site Manager at the lighthouse, Browne tagged the wreck with UAB tags from the conservator at the Currituck Lighthouse (Watkins-Kenney and Henry 2010:1,10). The wreck remained in a dynamic state. Just days after it was tagged, the wreck was spotted 0.98 miles (1.570 kilometers) south (Watkins-Kenney and Henry 2010:16). By now, it was beginning to break apart even further (see FIGURE 5). Unfortunately, for the archaeological record, the wreck was not scientifically recorded before its disarticulation. A combination of factors contributed to the breaking up of the wreck; these are discussed in the results chapter.

FIGURE 3. Wreck CKB0022 in the surf near Corolla, December 2009. (Photo by George Browne)

In mid-January 2010, UAB finally received permission to visit the wreck and conduct a scientific investigation. Head State Underwater Archaeologist Richard Lawrence, along with Nathan Henry, recorded the wreck's GPS coordinates, took photographs, measured wreck features , and created a scaled photographic profile and a rudimentary site plan (Nathan Henry 2011 personal comm.). They reported a 40 foot (12.192 meters) long forward portion of a large wooden vessel (see FIGURE 4 and FIGURE 5). Based on the size and type of material used in the construction, as well as the methods of construction, state archaeologists realized the shipwreck was much older than originally thought, most likely dating to the colonial period (Richard Lawrence 2010, in elec. comm. to Bruce Terrell). This, combined with the collection of coins dating from the mid-17th century, confirmed for Lawrence that the wreck was likely from the

17th century and was far older than any wreck previously recorded on the Banks (Watkins-Kenney and Henry 2010:37).

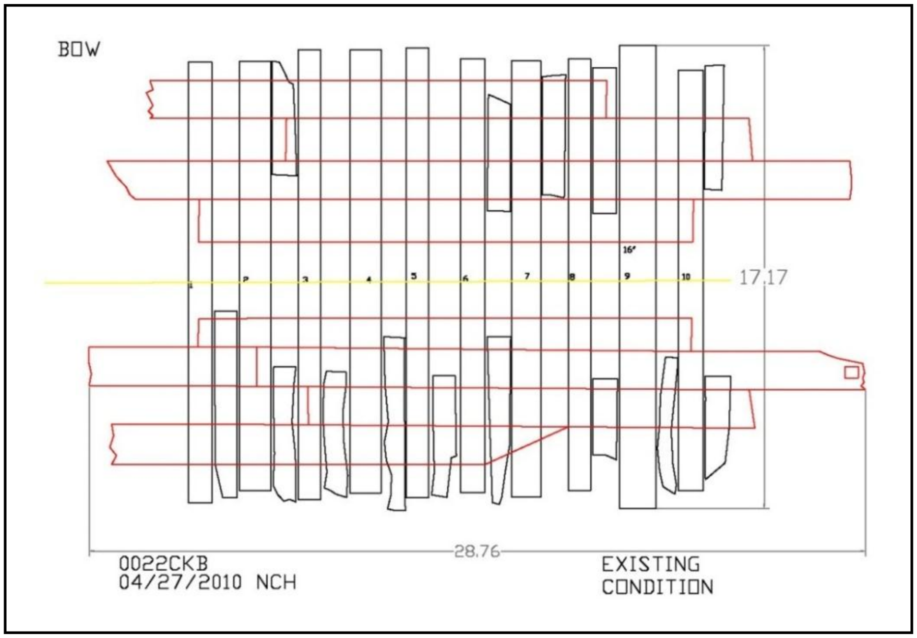

FIGURE 4. AutoCAD drawing created by NC UAB. (Courtesy Nathan Henry, 2010)

FIGURE 5. Wreck CKB0022 in early January 2010. (Photo by John Aylor)

A year of jostling by the surf and storms, along with souvenir and “treasure hunting” (as two collectors referred to themselves) activities of both local residents and vacationers, left very few artifacts on the wreck. Most of the artifacts recovered were not recorded *in situ* and remain in possession by Ray Midgett and Roger Harris. Local metal detectorists and artifact collectors, Midgett and Harris found English, Spanish, and French coins dating between 1610 and 1646 (Ray Midgett and Roger Harris 2012 personal comm.). Of the two collections, Harris’s had a much better established provenience—his artifacts having been removed from the wreck’s concretions, found in between frames, or within immediate proximity of the wreck. The author was later able to reconstruct a solid provenience for two French coins (discussed later) that helped to establish an estimated date for the wrecking event. This evidence, along with UAB observations of the wreck’s construction, made Site CKB0022 the oldest wreck found on the coast of North Carolina and one of the oldest on the Atlantic seaboard.

The overwhelming number of wrecks on the Outer Banks (277 wrecks are known just from Currituck County to the Virginia border) and the prohibitive cost of excavation and conservation meant the wreck was left to the elements (Watkins-Kenney and Henry 2010:15,17). Over the next three months, the fractured wreck traversed five miles up and down the coast. A portion of the keel, once lost, turned up 15 miles (24.140 kilometers) south (Watkins-Kenney and Henry 2010:31,52,71). UAB archaeologists returned to the wreck in March, noting its 4.26 mile (6.855 kilometer) change in location since their first visit (Nathan Henry 2012 elec. comm.). By the end of March 2010, local and state concern, newspaper coverage of the wreck, and its status as possibly the oldest wreck in the Carolinas, led to mounting political pressure to save the wreck from continued disintegration. Discussion on the logistics, permissions, and funding required began between various state entities (Watkins-Kenney and Henry 2010:38,47,51-56).

By April 2010, a plan was in place to remove the wreck from the surf. On 6 April, with all permissions granted, a massive multi-departmental state recovery team was assembled. The team consisted of the following entities: local government officers, the Corolla Fire Department, the North Carolina Wildlife Resources Commission (NCWRC), coastal managers with North Carolina Department Environment and Natural Resources (NCDENR), NCDCR UAB archaeologists, North Carolina Maritime Museum staff, and an additional 22 volunteers (Watkins-Kenney and Henry 2010:55; Watkins-Kenney 2010:4-5). The extraordinary bureaucratic cooperation produced a very enthusiastic atmosphere the day of the recovery. The team began work at dawn, using shovels to uncover the once again buried wreck. Senior UAB archaeologist Lawrence supervised as members of the Corolla fire department used fire hoses to remove sand from the wreck and carve a channel for the water to drain (see FIGURE 6). This rather unorthodox excavation technique severely damaged the surface layers of wood fibers. A telescopic forklift and airbags were used to raise the 12 ton (10.887 metric tons) wreck high enough to insert thick timbers and assemble a simple skid to tow the wreck. After lashing it securely with thick canvas straps, a front-end loader towed the wreck 1.95 miles (3.141 kilometers) to rest next to a boathouse close to the Currituck Beach Lighthouse.

FIGURE 6**.** Corolla Fire Department excavating Wreck CKB0022 6 April 2010 (Courtesy NC UAB).

Blasted free of most sand with the fire hoses, and exposed to the warming rays of the sun, the wreck quickly began to dry out. This process of desiccation led to a gradual warping and shrinking of the timbers. The saltwater that had impregnated the wood cells of the wreck's timbers for so long was evaporating. As it dried out, the cells collapsed, and wood shrank across the grain. The wreck looked very different by the time it was subjected to more thorough scientific recording (see FIGURE 7).

FIGURE 7. Wreck CKB0022 in June 2010. (Photo by Author)

The Wreck's Systemic Context

Before deposition in the archaeological record, the Corolla Wreck was employed in the complex behavioral system of 17th-century Europe. Ship production, Atlantic trade, colonial expansion, slavery, naval combat, military expansion, and commercial predation operated concurrent to one another. The 17th century was primarily a period of political expansion and technological innovation. Ship construction, traditionally a conservative industry, followed a diachronic trajectory, from drastic changes in northern Europe in the 16th century, to subtler changes around the middle of the 17th century (Shennan 1989:331; Adams 2003:99; Steffy 1994:142; Batchvarov 2002:27). Gradual changes and refined designs in the 16th century led to sleeker, more heavily armed, and maneuverable vessels in the form of the ubiquitous galleon (Adams 2003:104). By the early 17th century, galleons of several nations were similar in form and function, but the philosophical approach to their construction varied (Adams 2003:105) as much as the native tongues of their shipwrights. The greatest difference between competing nations in the construction of their ships was in framing, fasteners, and plank-on-frame order (Batchvarov 2002:iv,110; McCarthy 2005:64,80). Wars of the 17th century, in particular between England and the Netherlands, spurred unprecedented production of warships—and their destruction. Throughout the century, the number and sizes of ships' guns increased dramatically (Guilmartin 1994:150). Minor innovations in ship construction techniques also reflect the increased amount of commercial traffic on the Atlantic (Church 2008:59). These changes in the mid-17th century were more a matter of scale than principle—the greater demand for more heavily armed ships meant adapting construction methods to meet demands. Minor changes to internal structure were adopted to gain a similar, larger product: bigger and more powerful ships. In this militant background, the systems of Atlantic commerce and European colonialism of North America provide the systemic and broader historical context for this thesis (see Chapter Two).

Research Methodology

Archaeological research, historical research, and systematic analysis of 16th- and 17th-century wrecks and, in the context of contemporary treatises and European-Atlantic settlement and trade, form the methodology of this thesis. Archaeological research for this thesis was conducted in two parts. The first consists of data pertaining to Wreck CKB0022; the second consists of comparative analysis of other documented 16th- and 17th-century shipwrecks.

In May 2010, Wreck Site CKB0022 became the first littoral site recorded as part of East Carolina University's Program in Maritime Studies Summer Field Season. A team of graduate students under direction of professors Bradley Rodgers and Nathan Richards, recorded the wreck. Additional fieldwork in 2010 included more detailed recordings of further disarticulated timbers. In early 2012, students photographed artifacts reportedly from the wreck and investigated the wreck remains for further evidence, collecting multiple samples for analysis. Analyzing photographic evidence, the meteorological record, and UAB electronic correspondence revealed site formation processes from the time of the wreck's discovery in 2008 to its transportation to Hatteras in 2010. UAB sent five wood samples from different structural elements for wood species analysis to Lee Newsome of Pennsylvania State University. Sample 1, from the keel; Sample 2, from a floor timber; Sample 3, from the garboard strake; Sample 4, two treenails; and Sample 5, from a first-futtock (Watkins-Kenny Henry 2010:73).

The other half of the archaeological research comprised examining the dimensions and structural features of the Corolla Wreck and comparing these data to other 16th- and 17th-century wrecks of European origin. This includes composing a thorough report of these wrecks. Patterns in the features of wrecks over time from different nations make it possible to suggest a philosophical building tradition, and hopefully, a hypothetical nation of origin This analysis is intended to test Steffy's proposal.

Previous Research

Until recently, 17th-century shipbuilding had not received as much scholarship as centuries prior and after. As the 17th century has received more attention in the last few decades, in terms of ships and their construction, there are many categories of publications; several are comprehensive studies of shipbuilding that include the 17th century (see TABLE 1). More numerous are concentrated works with emphasis on the 17th century (see TABLE 2). Most common of all are site reports and articles on individual wreck sites (see TABLE 3). Seventeenth-century wrecks are also the focus of several theses and one dissertation (see TABLE 4). Rarest of all, are critical publications on specific shipwrecks or shipwreck sites such as Olof Cederlund's *Vasa Volume I* (2006) and Christian Lemée's (2006) *Renaissance Shipwrecks.* There are, of course, the volumes pending publication, vast amounts of unpublished research, and unpublished or untranslated historic manuscripts (see TABLE 1).

TABLE 1. 17TH-CENTURY MANUSCRIPTS AND PUBLICATIONS

Year	**Author**	**Title**
1586	Matthew Baker	*Fragments of English Shipwrightry*
1616	Fernandez	*Livro de Tracas de Carpintaria*
1623	Henry Mainwayring	*The Sea Man's Dictionary*
1627	John Smith	*A Sea Grammar*
1669	Edward Bushnell	*The Complete Shipwright*
1669	Samuel Sturmy	*The Mariner's Magazine*
1670	Anthony Deane	*Deane's Doctrine*
1670	Anonymous	*Album de Colbert*
1671	Nicolaas Witsen	*Ancient and Present-Day Shipbuilding*
1697	Cornelius Van Yk	*The Art of Dutch Shipbuilding*

TABLE 2. WORKS INCLUDING 17TH-CENTURY SHIPS AND THEIR CONSTRUCTION

Year	**Author(s) / Editor(s)**	**Title**
1988	Basil Greenhill	*Evolution of the Wooden Ship*
1991	Reinder Reinders and Kees Paul	*Carvel Construction Technique*
1994	Robert Gardiner	*Cogs, Caravels and Galleons*
1994	J. Richard Steffy	*Wooden Ship Building and Interpretations of Shipwrecks*
2003	Jonathan Adams	*Ships Innovation and Social Change*
2004	Fred Hocker and Cheryl Ward	*The Philosophy of Shipbuilding*

TABLE 3. ARTICLES AND WORKS WITH EMPHASIS ON THE 17TH CENTURY

Year	Author(s) / Editor(s)	Title
1972	Ralph Davis	*The Rise of the English Shipping Industry*
1978	Richard Unger	*Dutch Shipbuilding Before 1800*
1981	Brian Lavery	*Deane's Doctrine*
1984	J. Dodds & J. More	*Building the Wooden Fighting Ships*
1990	Peter Kirsch	*The Galleon*
1991	Brian Lavery	*Building the Wooden Wall*
2001	J. D. Davies	*Pepys's Navy*
2008	Robert Church	*Depletion of the Sylvan Sea*
2009	Richard Endsor	*The Restoration Warship*
2012	A. J. Hoving	*Nicolaes Witsen and Shipbuilding in the Dutch Golden Age*.

TABLE 4. SITE REPORTS, ARTICLES, AND WORKS ON INDIVIDUAL SHIPWRECKS (short title)

Year	Author(s) / Editor(s)	Title
1985	John Adams	*Sea Venture:* a second interim report--part 1
1977	Peter Marsden and David Lyon	A Wreck Believed to be the Warship *Anne*, 1690
1978	Colin Martin	The *Dartmouth*, A British Frigate Wrecked off Mull
1979	Ulysses Pernambucano de Mello	The Shipwreck of the Galleon Sacramento, 1668
1982	Allan J. Wingwood	*Sea Venture*, An Interim Report
1985	Richard Larn	Wreck of the Dutch East Indiaman Campen
1986	Allan J. Wingwood	*Sea Venture*, Second Interim Report--part 2
1988	A. J. Hoving	A 17th Century Dutch 134-foot Pinas, Part 1
1988	Norman C. Owen	HMS *Hazardous* Wrecked 1706
1989	A. J. Hoving	A 17th Century Dutch 134-foot Pinas, Part 2
1989	Thomas J. Oertling	The Molasses Reef Wreck Hull Analysis
1989	Thomas J. Oertling	The Highborn Cay Wreck
1991	Norman C. Owen	*Hazardous* 1990-1991 Interim Report
1996	J. Barto Arnold, III	Preliminary Report on the *Belle*, 1686
2006	Olof Cederlund	*Vasa: Volume I*
2006	Christian Lemée	*Renaissance Shipwrecks*
2007	Jens Auer and Atony Firth	The *Gresham* Ship
2007	Kroum N. Batchvarov	*Dartmouth* Revisited
2009	Wendy Van Duivenvoorde	*Batavia's* Archaeological Hull Remains
2010	Piotr and Katie Bojakowski	The *Warwick*
2012	Niklas Eriksson	The Lion Wreck

TABLE 5. THESES AND DISSERTATIONS

Year	**Author(s) / Editor(s)**	**Title**
1980	Warren Curtis Reiss	The Bristol Merchantman *Angel Gabriel* (M.A.)
1993	Sheila Clifford	Analysis of the Port Royal Shipwreck (M.A.)
1996	Jerome Lynn Hall	A 17th Century Shipwreck in Monte Christi Bay (M.A.)
2002	Kroum Batchvarov	The Framing of 17th Century Men of War (M.A.)
2003	Glen Greico	Modeling *la Belle* (M.A.)
2007	Miguel Fraga	Wreck of the *Santo Antonio de Tanná*, 1696 (M.A.)
2008	Wendy Van Duivenvoorde	The *Batavia* Shipwreck, an Archaeological Study (Ph.D.)

Conclusion

By examining 17th-century European-Atlantic expansion, systematically comparing the construction and features of 17th-century wrecks, and comparing these to contemporary ship treatises, this thesis seeks to provide broader application to undiscovered wrecks and those not yet examined. By these means, this thesis endeavors a greater understanding of the Corolla Wreck and its systemic context. A specific origin and exact function of the wreck may not be possible, but a hypothetical origin and probable function is. A practical application of this comparative analytical model to contribute a better understanding of future historic wrecks is the goal of this work.

Chapter Two establishes a systemic context for this thesis with a survey of European-Atlantic commercial territorial expansion. Chapter Three outlines research methodology, fieldwork, and post-processing. Chapter Four is a comparison of contemporary ship construction treatises and their potential use in dealing with problems and questions encountered in the archaeological and historical record. Chapter Five is a comparative study of wreck sites contemporary to the possible window of the Corolla Wreck. Chapter Six reports the results of archaeological analysis, the wreck's site formation, associated artifacts, and analysis of the wreck's structure. Chapter Seven finishes with conclusions and suggested routes of future research. Attached appendixes can be found in the table of contents and are occasionally referenced in the body of this thesis.

CHAPTER TWO: European Trade and Settlement in the 17th-Century Atlantic

Introduction

History is the study of past human activity. Archaeology is the study of remains left behind by past human activity. For archaeologists, history helps forms the *systemic context*: artifacts participating in a human behavioral system (Schiffer 1987:3). Sociologist Kenneth D. Bailey (1994:44) defines a system as, “a set of interacting units with interrelationship among them.” The term “set” implies the interrelated components, or units, have some common properties (Bailey 1994:45). The systemic context in turn helps archaeologists understand the *archaeological context*, that is, an event, or series of events, that has been preserved in the archaeological record (Spence 1995). The event in this case is the wreck of a 17th-century European merchant vessel. To better understand the context of this event, this chapter focusses on the European system of colonization as well as subsystems of transatlantic trade and territorial expansion, in which the Corolla Wreck was just one participant in these systems. Once established, colonies required resources in the form of labor and manufactured goods. In return, colonies supplied raw materials: for the Spanish silver and gold, the French and Dutch (initially) furs, and eventually for the English, cash crops, primarily tobacco and sugar, and later cotton, indigo, rice, lumber, exotic woods, and even rum. Transportation of resources to the colonies in return for commodities required ships capable of making the trans-Atlantic crossing. Concomitant with colonization efforts, countries like Portugal and the Netherlands established commercial entrepôts in the form of factories; for these countries, the emphasis was not on demographic expansion and increased production (Brazil being the exception), but acquiring and organizing the shipment of lucrative commodities for European markets and slaves for Spanish America.

Thousands of wooden ships carried out this commercial and territorial expansion. As a participant in the European exploitation of the New World, the Corolla Wreck is a representative example of the types of vessels used to carry out the dominant European powers' ambitions; it is symbolic of the massive increase of 17th-century Atlantic traffic. The remains of the unidentified vessel witnessed enormous and permanent change in social-economic systems on both sides of the Atlantic Ocean. It was an active participant European commerce; a vessel built for trade, it carried people and goods, going to or from the Americas before its wrecking event. Wreck CKB0022's timbers are heavy enough to be the remains of a warship; the lack of riders or any evidence of significant armament (virtually all merchant vessels carried some form of armament) other than ubiquitous lead shot suggest it was more likely a merchant vessel. Its location and structure initially suggest English origins. Structural evidence suggests its construction occurred in the earlier half of the 17th century; material culture associated with the wreck provides a *terminus post quem* of sometime in the 1640s.

This chapter explains the Corolla Wreck's historical significance and its systemic context, and postulates on the wreck's origin. In the order of least likely to most probable, this chapter presents historical reasons why the Corolla Wreck is not likely Iberian, conceivably but unlikely French, followed by a lengthier discussion of the possibility of it being Dutch, and finally, presents historical evidence that suggests it was an English-built vessel.

Iberian Empire, a Gradual Decline

Among colonial European powers, Spain was first to exploit New World resources. At the end of the 16th century, Spain and Portugal dominated the Atlantic. At first inspection, the sheer volume of Iberian shipping might suggest a decent probability that the Corolla Wreck was a Spanish or Portuguese vessel. With an entire century lead on its colonial rivals, Spain's possessions in the New World remained the largest throughout the 17th century (Skowronek 1992:110), thus, comprising a great percentage of Atlantic traffic. Despite decline beginning in the 17th century, exotic goods from the Pacific, silver from Mexico, and profitable New World commodities continued to flow from the *Carrera de Indias* (Route of the Indies) (Wilson 1961:412; Pérez-Mallaína 1998:1; Skowronek 1992:110). With tight control over its *asientos*, Portugal continued to monopolize the African slave trade as the main supplier of forced labor to Spanish America, despite English forays and Dutch incursions (Postma 1972:237; Morgan 1975:9). The New Spain Fleet, protected by the convoy and escort system first established in 1536, continued its regular annual departures until the middle of the 17th century. By the end of the 16th century, Spain claimed 300,000 tons of the 600,000 to 700,000 tons total European shipping (Phillips 1986:8-10). At the onset of the 17th century, Spain and Portugal continued to lead the way in economic expansion. In 1600, Spanish naval strength was greater than the Dutch and English combined; yet, by 1659, it was weaker than both. By the end of the first decade of the 17th century, the empire was already in decline (Cooper 1970:227; Wallerstein 1982:117). Much of the strain on Spain resulted from the previous century's expansion. The cost of building a ship went from 4,000 *ducados* in 1550, to 15,000 after 1600 (Phillips 1986:3,23; Hart 2008:97). In addition, the rising cost in freight and a decline in the Spanish shipbuilding industry had a detrimental impact on the empire's economy, resulting in a decline in Spanish-built Atlantic traffic

The earliest Iberian shipping centers developed in Lagos on the Algarve coast and in Lisbon on the Tagus River. In Spain, shipbuilding developed along the Catalan coast of the Mediterranean and along the north coast on the Bay of Biscay. Northern proto- industrial towns like Viscaya supplied shipyards with the timber and iron required by shipwrights who used more iron than their English or Dutch counterparts. Depletion of native resources in the 16th century (mostly timber, resulting in imported materials) and the demand for larger ships raised prices in shipbuilding centers like Bilbao, unsurpassed in Europe for more than a century (Aritinaño 1917:67-68; Clayton 1976:243-244; Boorstin 1985:164; Smith 1983:51). Royal shipyards produced both merchant vessels and warships, and the crown often subsidized and contracted the construction of ships over 600 tons in private shipyards. Early Spanish naval architect Tomé Cano estimated in 1583 that 1,000 ships, averaging 250 toneladas, existed in Spain, all them native owned (1611:96; in Phillips 1986:23) (a *tonelada* was the measure of a ship's carrying capacity in Andalusia and the Indies trade (Phillips 1986:228), essentially tons burthen). Within this average were many vessels between 400 and 600 toneladas. By the 1665, the size increased to 735 toneladas for galleons and 650 toneladas for naos (Phillips 1986:46). Using local timber stores, Havana and Cartagena built ships for the Carrera de Indias, the Portuguese used Indian teak for the spice trade, and Guayaquil (Ecuador) and Manila supplied galleons for the Pacific trade (Veitia Linaje 1702:273; Usher:194; Clayton 1976:246; Scammell 1989:135; Smith 1993:52). Thanks to effective conservation policy Spanish timber resources eventually recouped by the mid-17th century (Goodman 1996).

Unlike its neighbors, Spain was well settled in the Caribbean and the American continents at the opening of the 17th century. By 1600, the lesser Antilles were of little importance to Spain, compared with Mexico or Peru. The only islands occupied by the Spanish in the early 17th century were the Greater Antilles, Cuba, Hispaniola, Jamaica, and Puerto Rico, along with Trinidad (Dunn 1972:15). Early cattle ranches in Florida, like in much of the Caribbean, were abandoned by the 17th century, and only St. Augustine remained as a powerful Spanish fort and garrison, left to protect the northern route of the Carrera (Arnade 1961:118), which was largely determined by the trade winds and Atlantic currents (see FIGURE 8 and FIGURE 9). Spanish colonists in the Antilles were just as happy to trade tobacco or silver with Dutch or English vessels for slaves, textiles, tools, guns, or other finished products.

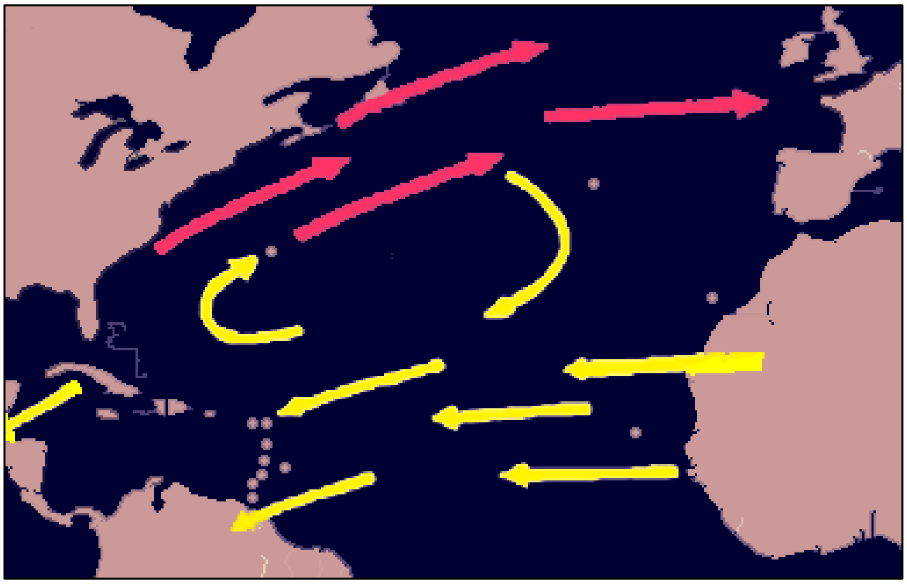

FIGURE 8. Atlantic Trade Winds (*westerlies pink, easterlies yellow*). (Image by author, 2013)

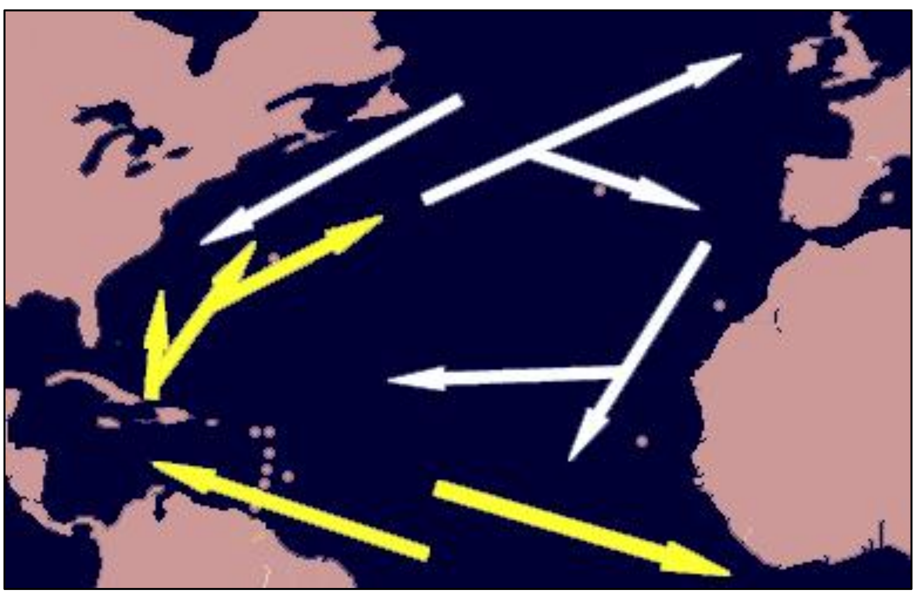

FIGURE 9. Atlantic currents (*Labrador, N. Atlantic, & Canary Currents white, Gulf Stream and Equatorial Currents yellow)* dictated early trade routes along with trade winds. (Image by author, 2013)

Each year a fleet departed Seville, splitting into two after reaching the Caribbean; one sailed to New Spain (Mexico), the other to *Tierra Firme* and then Panama (FIGURE 10). These vessels averaged 250 toneladas, a viable tonnage for the Corolla Wreck based on its timbers and Spanish ship construction codes (Phillips 1986:52-55,62,228-232). Departing from Seville, the convoys carried cloth, dyestuffs, glassware, paper, munitions, metals, wood, cable, and all kinds of foodstuffs to the New World. From the onset of empire, this trade flowed from Seville, Spain's only Atlantic entrepôt (see FIGURE 11). The most important trade was silver from Mexico and Potosí (modern day Bolivia), and gold from the islands and the mainland. Gold, in fact, only comprised a minority of Spanish cargoes. An estimated 300 tons of gold made its way to Spain from the Americas before 1660. The lifeline of the Spanish crown's revenue was silver; an estimated 25,000 tons were mined from Potosí alone between 1500 and 1660 (Phillips 1986:9; Scammell 1989:133; Skowronek 1992:110).

FIGURE 10. Spanish (*grey*) and Portuguese (*blue*) 16th- and 17th-century trade routes. (Image by author, 2013)

FIGURE 11. View of 16th-century Seville, by Alonso Sánchez Coello. (Courtesy Museo de América)

Slaves from Portuguese slave forts on the west coast of Africa worked the sugar fields of the Atlantic islands, the Caribbean, and South America (Scammell 1989:108). Spain relied on the Portuguese to supply their slave labor force; with the *asiento* (a Papal approved monopoly), the Portuguese enjoyed control of the African slave trade despite Dutch incursions in the early 17th century. The Corolla Wreck's deposition on the mid-Atlantic east coast of North America could make it a candidate as a slaver, but its construction does not reflect Portuguese traditions (see Chapter Five). That the Dutch usurped the African slave trade from the Portuguese, however, leaves the possibility of the Corolla Wreck's potential involvement in slavery. Portugal's split from Spain in 1640 left Spanish possessions without their traditional supply of forced labor. Hence, Spain relaxed its mercantilist policy on the slave trade allowing for first Dutch, and later, English and French merchants to expand into that trade whereas previously they were seen as interlopers (Scammell 1989:108,119). The increase in Dutch, French, and English slaving and the success of Spanish-Caribbean plantations ultimately led to the above nations developing

Caribbean colonies of their own, colonies that increased the demand and supply of slave labor from slavers of all nations.

Hampered French Colonial Efforts

The earliest French activity across the Atlantic occurred in the form of piracy on Spanish shipping. Following on the heels of the Spanish, French excursions in Atlantic exploration and settlement began in 1534, earlier than most English or Dutch attempts. After Giovanni da Verrazano mapped the northern American coastline from Florida to Nova Scotia, King Francis I of France took interest in the New World's economic potential, while French Catholics envisioned missionary opportunities (Jaenen 2001:155). Despite early interest, French efforts along the Gulf of St. Lawrence were "hesitant and inconsistent," distracted by wars with Spain and territorial ambitions in Italy (Fiset and Samson 2009:48). Jacques Cartier and Jean-François de La Rocque de Roberval convinced Francis to finance an attempt to find a northwest passage to Asia in an effort to access the wealth of trade that filled Spain and Portugal's royal coffers (Fiset and Samson 2009:48). Once Cartier and Roberval abandoned the idea of a northwest passage, they refocused on settlement. By 1537, a few pioneer families occupied the banks of the St. Lawrence River (see TABLE 6).

TABLE 6. DATES OF FRENCH COLONIES AND MAJOR 17TH-CENTURY EVENTS

Year	**Name**	**Year**	**Name**
1537	St Lawrence River settlements	1635	Guadeloupe, Martinique, St. Christopher
1543	Cape Rouge Colony (lost)		
1560	Charlesfort (destroyed)	1640	Tortuga, French Hispaniola
1564	Fort Caroline (destroyed)	1648	Thirty Years' War ends
1604	Acadia	1664	Fort Louis (abandoned 1688)
1608	Quebec	1672	Franco-Dutch War begins
1611	Montreal	1678	Franco-Dutch War ends
1618	Thirty Years' War begins	1688	Nine Years' War begins
1632	French Guiana (Cayenne)	1697	Nine Years' War ends

Continued efforts in the 1540s failed to achieve permanency in North America; the Cape Rouge colony, consisting of just 30 settlers vanished and became a French version of the Lost Colony (Fiset and Samson 2009:48-49). Prominent French Protestant leader Admiral Coligny supported two Huguenot efforts: René de Laudonnière led the founding of Fort Carolina in Florida in 1556, and Jean Ribaut led the founding of Charlesfort in 1560, in present day South Carolina, (Jaenen 2001:156). Having already attempted to thwart French efforts in 1541 (their armada failed to intercept the French fleet), Spain succeeded in the 1560s, brutally massacring the inhabitants of both settlements (Jaenen 2001:156; Fiset and Samson 2009:49). Later efforts by Samuel de Champlain led to the settlement of Acadia (New Brunswick) in 1604-1605, Quebec in 1608, and Montreal in 1611 (Fiset and Samson 2009:49).

The death of Henry IV stalled further colonial efforts as Marie de Medici, under the influence of her foreign advisors, refused to adopt Henry's state-building policies, maintaining a week non-nationalistic policy (Palm 1924:653).With the crowning of child king Louis XIII, Cardinal Richelieu continued his predecessor's consolidation of the nation-state, emphasizing the development of trade, industry, and colonies (Montchrétien 1889:207-208; Palm 1924:654). Despite distraction by the Thirty Years' War, under Cardinal Richelieu's encouragement, successful, permanent settlement efforts on the St. Lawrence occurred again in 1632 (see FIGURE 12).

A trickle of French settlers continued at an average of 300 a year throughout the 1600s, though an average of two-thirds of them returned to France (Moogk 1989:464). If emigration was discouraged, trade was not. A merchant association financed these successful settlements (Jaenen 2001:156). The demand for furs, especially beaver pelts, outmatched cod, whalebone, walrus oil, and ivory (Jaenen 2001:156). By the 1630s, French traders exported 15,000 furs annually, selling at ten times their purchase price in Europe, undercutting Russian and Baltic fur markets. Competing with English fishermen, in the 1650s upwards of 400 French fishing vessels and whalers plied the frigid waters off Newfoundland; French whalers also operated off the coast of Brazil (Scammell 1989:95-96,132). New World goods arrived in France’s principal ports along the Atlantic: Dieppe, Caen, Granville, St. Malo, Brest, Dieppe, Rouen, Bordeaux, and La Rochelle (Moogk 1989:471).

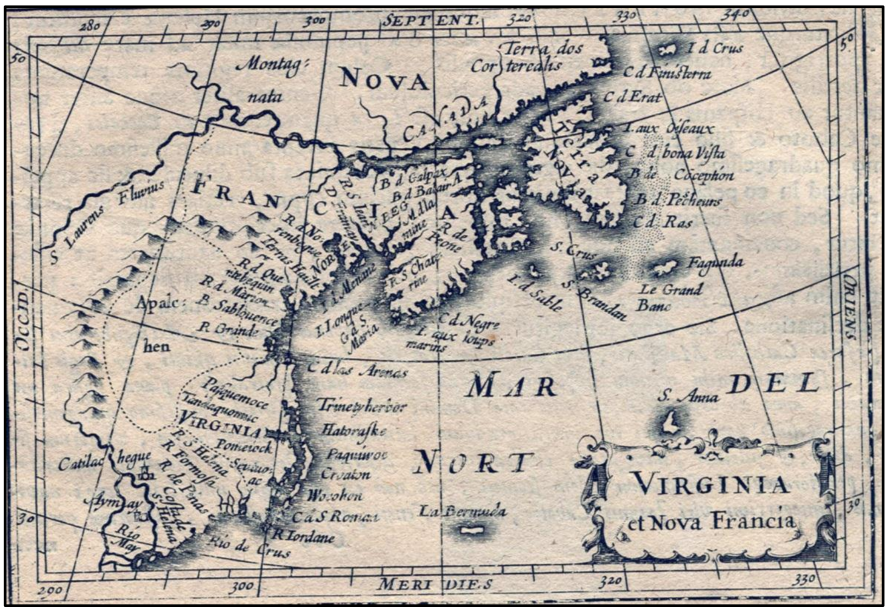

FIGURE 12. Virginia and New France, 1616 by Petrus Bertius (Courtesy MapsofPA.com).

The West Indies also attracted the French for the same reasons as the Dutch and the English, namely the lucrative European sugar market and privateering ventures against Spanish ships (see FIGURE 13). French refugees occupied Tortuga and western Hispaniola early in the 17th century; some planted tobacco and became the first Gallic occupants of that island; others turned to preying on Spanish commerce becoming the famed buccaneers (Exquemelin 1678:32). After Caribbean tobacco prices dropped, French planters resorted to cacao, cotton, indigo, and later, sugar (Garrigus 1993:238-239). This led to greater and continued French involvement in the

African slave trade. In the Gulf of Mexico, René-Robert Cavelier Sieur de La Salle led several efforts, briefly establishing Fort Lois at Matagorda Bay in 1684. The English, French, and Dutch often cooperated against the Spanish in the Caribbean; these alliances were tenuous at best (Dunn 1972:16).

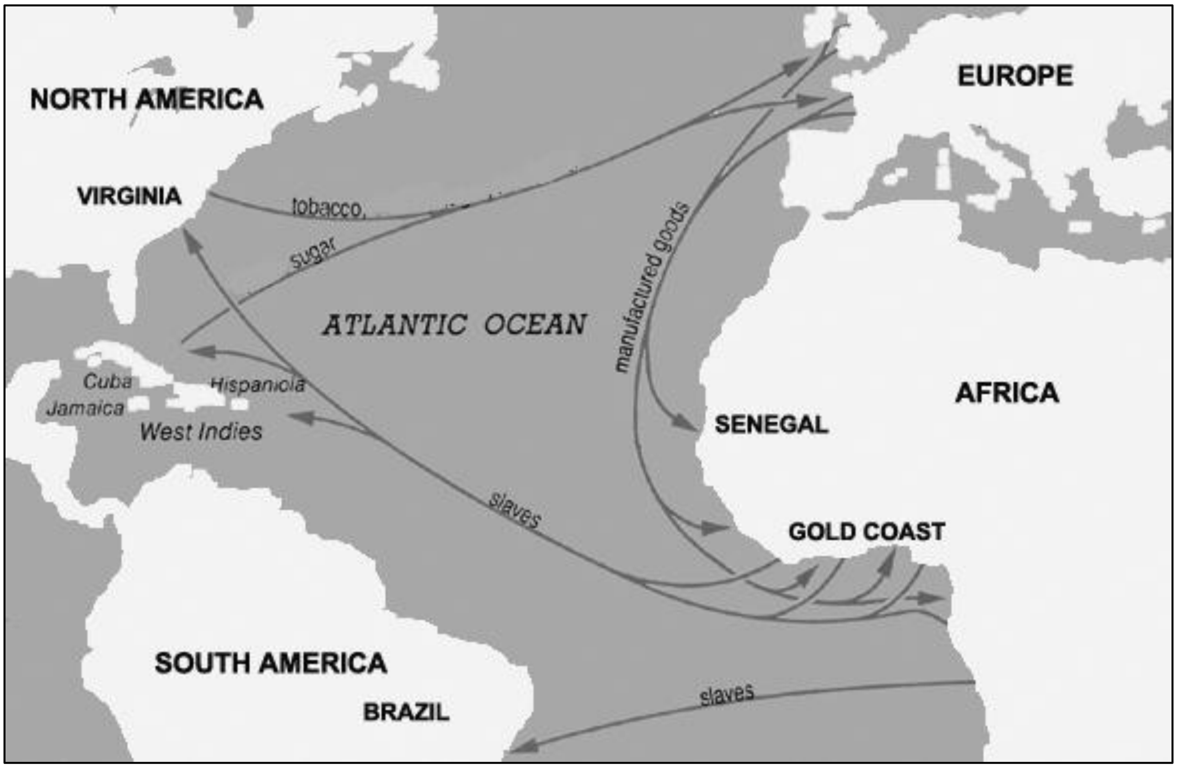

FIGURE 13. 17th-century trade routes and goods exchanged. (Image by author, 2013)

Netherlanders in the New World

Despite their own struggle for independence (in part as a means to continue it), the Dutch challenged Spanish and Portuguese dominance in trade across the globe. During the various colonial wars, the Dutch captured almost as many colonies as they settled. Despite the Eighty Years' War (1568–1648) for independence from Spain, steady Dutch expansion occurred in both trade and settlement throughout the 17th century. The Dutch, however, had an inclination to focus more on trade than establishing colonial infrastructure for production, preferring hostile takeovers of rival factories and plantations in the most literal sense. Like the English, some motives were political and religious in nature, but it was a strong and established commercial foundation and the potential for profit that drove the Dutch to brave the Atlantic.

Early Dutch Expansion

The success of Dutch merchants lay largely in organized business skills and an advantageous geographic position that allowed them to develop a vast merchant fleet, which by the end of the 16th century outnumbered the English in the Baltic by three to one (Bang 1906; Davis 1972:1). Historian J. H. Parry (1967:211) lists six cost advantages utilized by the Dutch in overseas expansion: (1) the skill of Dutch shipwrights, (2) the parsimonious use of resources, (3) labor saving devices, (4) large-scale standardized production, (5) bulk purchasing of materials, and (6) cheap transportation of construction materials used in Dutch ships (Wallerstein 1982:109). Most Dutch merchantmen were engaged in trade between western and northern Europe; only a minority were employed in Atlantic crossings. Their size ranged from 300 to 500 tons, likely the upper limits of the Corolla Wreck's tonnage. The lighter construction (the use of pine, smaller frames, and fewer guns) and simpler rig gave the Dutch an average tonnage-to-man ratio of 20:1, as opposed to the English ratio of 7:1. From the flyboat and herringbus, the Dutch developed the *fluyt*, a lighter built cargo vessel with simplified rig and length to beam ratios between 5:1 and 6:1. Their design meant the ability to carry great bulk with more efficient use of energy per ton of cargo with fewer crew, and with more efficient loading and unloading, reduced time spent at dock, all of which reduced freight rates.

Dutch merchants exploited their commercial advantages throughout the 16th century. They shipped Mediterranean wine and salt, Baltic timber and goods, and of course, herring from their near monopolistic fishery from the Skaw (Scandinavia) to Gibraltar, Norway, and England

(Davis 1972:2). By the 1590s, Dutch merchants expanded their markets to include goods such as spices, sugar, silks, dyestuffs, Mediterranean fruit and wine, and Spanish American silver from the Caribbean. At the same time, Baltic trade continued to grow beyond timber and grains (rye and wheat), salt, and herring, to expand into high-value goods from the Mediterranean (Unger 1980:267; Israel 1995:312;Emmer 2003:6).

The *Vereenigde Oost-Indische Compagnie* (VOC), the United East-Indian Company, formed in 1602 from remnants of several East India companies in Holland and Zeeland that operated between 1597 and 1602 (Israel 1995:322; Emmer 2003:6). The VOC's success spurred further interest in the New World. Amsterdam merchants bought exotic Caribbean goods and silver from Spanish settlers (Israel 1995:325).The earliest Dutch attempts at colonization occurred in 1600 with two settlements along the Amazon (see TABLE 7) (Emmer 2003:9). Dutch colonial ambitions in the Caribbean and North America never matched their rivals. Most Dutch expansion occurred in Asia, and to a lesser degree in Africa, usually at the expense of Portugal (Emmer 2003:10-11). Widespread backing for a West Indies company in 1607 stalled during peace negotiations with Spain. The Dutch fight for independence and the emphasis on European trade stymied Dutch expansion even after the truce of 1609. A consequence was an English foothold in the Chesapeake. In 1621, Amsterdam merchants finally formed the *West-Indische Compagnie*, (WIC) (Israel 1995:325-326,404-405).

Dutch Expansion 1609 to 1655

Mired in near continuous military struggle for independence from Spain since 1568, with the Twelve Years' Truce from 1609 to 1621, Dutch commercial and territorial expansion followed a sporadic, opportunistic pattern. The first outpost established in New Netherlands along the Hudson River in 1614 was Fort Nassau, strictly for buying furs from Native Americans

(Condon 1968:28). It is conceivable but impossible to know if the Corolla Wreck was involved in that trade. Initially attracted by the Native American fur trade, Dutch merchants quickly realized the profitability of Chesapeake tobacco, while that struggling colony barely survived, let alone turned a profit (Kupp 1973:653; Billings 1975:5; Pagan 1982:485; Rink 1986:19).

TABLE 7. DATES OF DUTCH COLONIES AND MAJOR 17TH CENTURY-EVENTS

Year	**Event**	**Year**	**Event**
1600	Amazon (fails)	1648	Thirty Years' War ends
	Banda (recaptured by Portuguese)		Dutch Independence
1605	Ternate, Tidore, Amboina	1650	St. Martin, Aruba, Bonaire
1609	12 Years Truce with Spain		Masca (captured)
1610	Banda	1652	First Anglo-Dutch War begins
1611	Fort Nassau (African Gold Coast)		Cape Town
1614	New Netherlands,	1654	First Anglo-Dutch War ends
	Fort Nassau (Hudson River)	1655	New Sweden (Delaware)
1615	Dutch Guiana (Cayenne, lost 1632)	1656	Colombo (captured)
1618	Thirty Years' War begins	1658	Ceylon (captured)
1619	Batavia (Jakarta)		Cayenne (re-captured, lost 1664)
1621	War resumes with Spain	1662	Nagappattinam (captured)
1622	Hormuz (captured)		Cranagore & Cochin (captured)
1624	Bahia (captured)	1665	Second Anglo-Dutch War begins
1625	New Amsterdam (lost 1664)	1667	Second Anglo-Dutch War ends
1630	Recife (captured, lost 1654)	1672	Third Anglo-Dutch War begins
	Pernambuco (captured, lost 1654)		Franco-Dutch War begins
1634	Curaçao	1673	New Amsterdam recovered
1635	Cayenne (re-captured for 1 year)	1674	Third Anglo-Dutch War ends
1638	Mauritius (abandoned)		New Netherlands ceded to English
1639	Hirado	1678	Franco-Dutch War ends
1641	Malacca (captured)	1688	Glorious Revolution,
	Angola (captured, lost 1648)		Nine Years' War begins
	Deshima & Horadio	1697	Nine Years' War ends
1642	Axim (captured)		

The Dutch also brought the first African slaves to Virginia, demonstrating early interest in that trade (Postma 1972:237). Under the tutelage of the WIC, Dutch expansion in the New World continued, much to English agitation. New Holland was followed by further settlement along the Hudson River with the purchase of Manhattan Island and the founding of New Amsterdam (Boxer 1965:150; Rink 1986:69). Like Batavia in the East, New Amsterdam became the entrepôt of Dutch commerce in North America. New Amsterdam and the founding of Fort Orange (Albany) secured Dutch access to the North American fur trade; FIGURE 14 illustrates the territory claimed by the Dutch, not necessarily controlled (Israel 1995:934). Contrary to the highly profitable VOC, the limited success and eventual decline of the WIC following the Anglo- Dutch Wars led to a limited presence of the fast and defensible pinnace in the New World (Unger 1980:46-47).

FIGURE 14. New Netherlands 1650, by Adriaen van der Donck. (Courtesy New Castle, Delaware)

New Netherlands also gave Dutch merchants better access to the Chesapeake tobacco markets. Recognizing the value of tobacco, and with well developed markets, Dutch merchants began purchasing Virginia tobacco in 1619; some Netherlanders even settled their own Virginia plantations to maintain access to the tobacco market. Pre-existing markets meant Dutch buyers could offer a better price, outbidding London merchants for their own colonial product (Kupp 1973:654; Pagan 1982:485). The early adoption of smoking tobacco in the Netherlands led to the earliest mass production of clay pipes; among other commodities, Dutch merchantmen delivered pipes to the English colony. The Dutch privateers and pirates, known as "Capers," also recognized the profit in tobacco. Taking advantage of English distractions during the Civil War and rise of the Puritans, the Capers plagued English merchant vessels, prowling outside the Chesapeake or near Land's End (Middleton 1946:183-185).

In 1648, Phillip IV of Spain formally recognized Dutch independence with the Treaty of Munster, marking the peak of the United Provinces (see FIGURE 15) as the most powerful European trade power with factories and colonies all over the globe (Goslinga 1971:27). The North American Dutch presence in the mid-Atlantic grew when in 1655, the Dutch conquered the fledgling Swedish colony in parts of what is now Delaware, Pennsylvania, and New Jersey, absorbing it into New Netherlands (Munroe 1978:13,37-40). In less than a decade, the region became a prosperous agricultural colony with over a hundred plantations raising cows, oxen, horses, sheep, and producing a variety of grains. Even a few breweries opened, supplying Maryland with beer in exchange for Chesapeake tobacco. Like their Manhattan brethren, the Delaware colony also shipped thousands of furs to Amsterdam (Munroe 1978:56). As the Netherland's influence grew and the Dutch achieved hegemony, rivals both marveled and resented their success.

Anglo-Dutch Rivalry

The open seas grew smaller as Dutch and English traffic continued to grow and compete with Spain for global trade. The English Navigation Act of 1651 prohibited the import of English colonial products by Dutch ships, prevented shipment of Mediterranean goods from Dutch ports to England, and banned all Dutch commerce with English territories in the Caribbean.

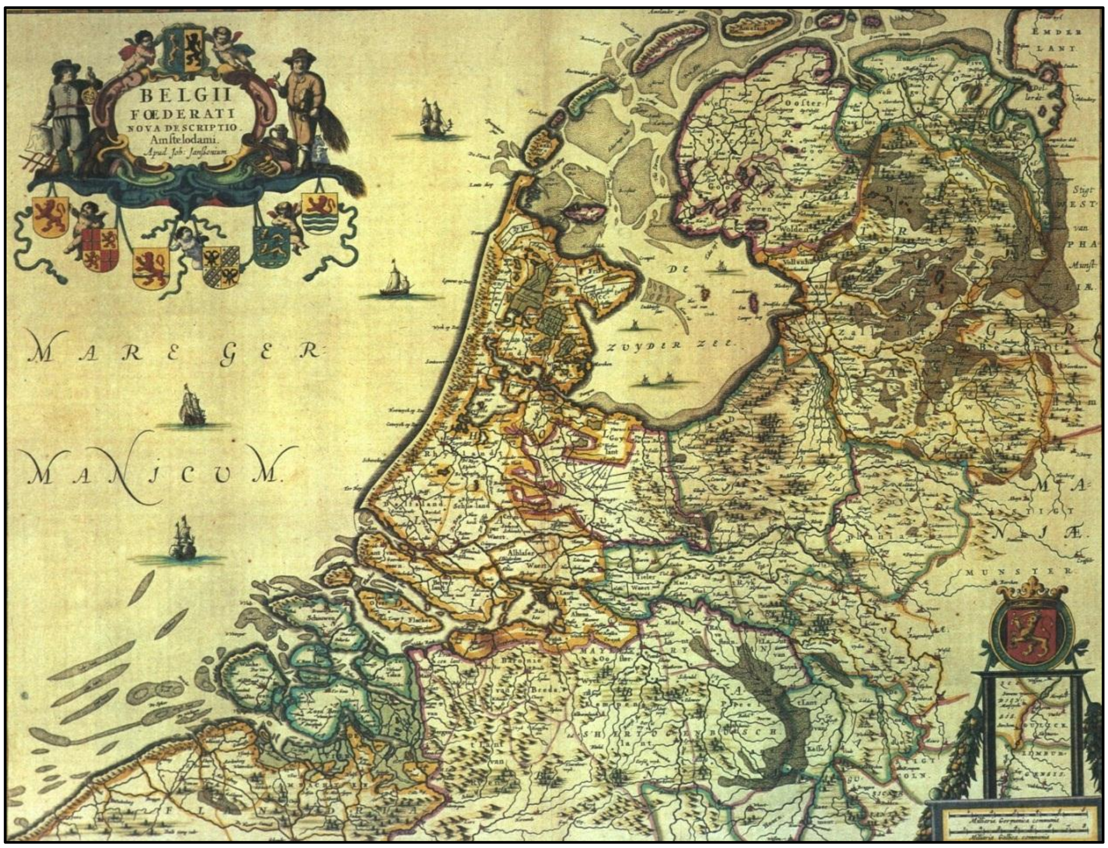

FIGURE 15**.** The Republic of the United Netherlands, 1658, by Joannes Janssonius (Courtesy LensonLeeuwenhoek.net).

The act proved ineffective, merely exacerbating rising tensions. Both nations increased the harassment and capture of each other's shipping. Competition continued in English fishing grounds, and Dutch merchant vessels increased harassment of English vessels in the tobacco rich Chesapeake. The Anglo-Dutch Wars and the Franco-Dutch War checked the growth of the Netherlands' overseas territories. The Dutch lost an estimated 1,200 to 1,600 vessels, most of them merchant ships captured or sunk. Distracted by war with England, the Dutch lost their holdings in Brazil to the Portuguese, along with several West African slave forts (Pagan 982:499-500; Wallerstein 1982:106; Israel 1995:715). Though Dutch commerce continued to thrive, the result of the Anglo-Dutch Wars was the rise of England as a global maritime power.

English Expansion

Before disappearing at sea, English adventurer Sir Humphrey Gilbert offered some advice to his fellow “Gentlemen Adventurers” in his published account of Newfoundland:

> Who seeks, by gain and wealth, t’advance his house and blood:
> Whose care is great, whose toil no less, who hope is all for good;
> If anyone there be, that covets such a trade:
> Lo, here the plot for common wealth, and private gain is made.
> (Gilbert 1583 page before fol. 1).

Gilbert’s statement foreshadowed the 17th-century expansion of English shipping and increase in European markets. This expansion originated in the growth of England’s fisheries and coal trade in the 16th century (Gentleman 1614; Davis 1972:3). The union of Spain with Portugal in 1580 opened up the Pacific and Indian oceans as areas of opportune predation for English privateers, exemplified by Francis Drake’s predatory circumnavigation of the globe, 1577-1580 (Davis 1972:6). English privateering in the 16th century was the beginning of English interest in American markets, and the success of the Levant Company (1581) established an English presence in the eastern Mediterranean. (Oppenheim 1913; Davis 1972:4-7).

In the 1590s, the English economy experienced a boom following the repulse of the Spanish Armada in 1588, expanding England’s merchant fleet with additional ships. From the 1580s onward, the number of new venture companies increased. The expansion of mining, coal, iron production, and shipbuilding occurred under the early reign of James I (Loades 2000:39). Chartered in 1600, the East India Company (EIC) struggled throughout the 17th century, achieving profits in the following century. That same year, the number of members in companies went from 43 to 197, an increase of 458% (Rabb 1967:72,74). By 1607, four EIC fleets competed with Dutch merchants in Asian waters (Davis 1972:8). Profits earned by the EIC spurred further investment in foreign ventures

With the founding of Jamestown, the number of new members to all companies in a single year peaked in 1609, growing from 183 to 1,294, an increase of 707%. EIC voyages between 1601 and 1617 reaped 100% profits of £500,000. English exports of cloth to Middleburg and Hamburg from 1604 to 1614 brought in £125,000-£144,000 (Loades 2000:140). Members reinvested profits and diversified, as it was common for company members to own shares in numerous companies, many of whom served in Parliament (Rabb 1967:73,154).

English ships carried this growing commerce, departing from London and Bristol primarily, but also from smaller and mid-sized English ports. This shift and increase in trade meant more work for Thames shipbuilders. Between 1591 and 1619, more than 300 ships over 100 tons, were built at a total tonnage over 90,000 tons (Dietz 1986:127-129). The long Spanish War had drained Queen Elizabeth's resources but produced a merchant class that was tougher, richer, and more ambitious than its predecessors. English merchants and sailors no longer looked in awe upon the Spanish, but sought to emulate or surpass their old foe (Kirsch 1990:335; Loades 2000:131).

In doing so, the English continuously vied with, their former ally, the Dutch. The eruption of the Thirty Years' War led to a general decline in European trade, but where there was decline, English merchants were happy to pick up the slack (Loades 2000:141,146).

TABLE 8. ENGLISH MERCHANT COMPANIES FORMED IN THE 16TH AND EARLY 17TH CENTURY

Compiled from Rabb 1967:146-165. From archives of the British Museum, British Public Record Office, House of Lords, India Office Library, London Livery Companies, Nottingham University, Huntington Library, the Folger Library, Institute of Early American History, and the Hakluyt Society Publications first and second series.

Charter	**Name**	**Notes**
1551	*Merchant Adventurers*	early focus on a NE passage to China
1555	*Muscovy Company*	evolved from the above company
1565	*Company of Mineral and Battery Works*	Industrial, economic expansion of internal infrastructure
1568	*Company of Mines*	
1576	Frobisher and Fenton	operated until 1582
1577	*Spanish Company*	overtaken by Phillip II 1585
1578	Gilbert Voyages	operated until 1583
1579	*Eastland Company*	involved in Baltic trade
1581	*Levant Company*	
1581	Privateering Expeditions	official date is 1585, renewed in 1625
1583	*Venice Company*	competed with *Levant Compnay*
1584	*North-West Passage Company*	reformed in 1612 to little success
1585	*Barbary Company*	
1586	Cavendish Voyages	repeated in 1591
1586	Irish Settlements	consisted of two interests in Munster and Ulster
1587	Drake Voyages	executed strategic and profitable expeditions
1588	*Senegal Company*	
1594	*Guiana* and Amazon	began with Raleigh's South American voyages
1600	*East India Company*	most successful company
1602	Gosnold Voyage	very small, five members
1605	Weymouth Voyage	
1606	*Virginia Company*	originally part of the New England ventures
1610	*Hudson Company*	similar but separate from the NW Passage Co.
1610	*Newfoundland Company*	
1611	*French Company*	short-lived
1612	*Bermuda Company*	
1615	*New Merchant Adventurers*	
1618	*Africa Company*	lasted only 2 years
1619	*New River Company*	
1624	*Massachusetts Bay Company*	
1625	*Plymouth Company*	
1629	*Providence Island Company*	short-lived Puritan privateering base

Like Amsterdam, London benefitted from Antwerp's decline. In 1602, 70% of England's imports came from northwestern Europe, and 75% of its exports went there in exchange. By 1635, 35% of London's imports came from northwestern Europe, 44% from the Mediterranean, 11% from East Indies, and 5% from North America (see FIGURE 16) (Loades 2000:147-148). North American trade, the smallest portion of the pie, grew exponentially throughout the rest of the century, especially after English settlement of the Caribbean. The first successful English colony was, of course, Jamestown, Virginia.

FIGURE 16. Virginia and New Netherlands, inset from *Nova et accurata totius Americae tabula*, 1660 by Frederik de Wit (Courtesy Boston Public Library).

A Fragile Beginning

The first successful attempt to establish an English foothold in the New World departed on 20 December 1606. Samuel Purchas, along with 104 men and boys, set out from London on three vessels (Brown 1891:152). The Virginia Company's charter was an adaptation of the successful system of 16th-century Irish plantation grants used in Munster and Ulster (Quinn and Ryan 1983:167-170; Loades 2000:138). The idea was English gentlemen would oversee transplanted Englishmen who would till the soil, and produce goods from resources, aided by a friendly native population; economic success in Ireland, however, was plagued with political violence and turmoil. Purchas, Christopher Newport, John Smith, and company eventually came to Virginia, 26 April 1607 (Brown 1891:156). After a fortnight of exploring, the ambitious group of Englishmen chose an isthmus on the James River and broke ground on a fort 14 May 1607 (Brown 1891:161).

In Pursuit of Profit and Economic Independence

Virginia Company's founding investors' motivation was the lure of gold and possible undiscovered passages to Asia, as well as a renewed attempt to fulfill the profitable visions of the two Richard Hakluyts (Morgan 1975:19; Billings 1975:4). Unlike Raleigh's previous attempts at establishing a privateering base, the Virginia Company's plan officially excluded preying on foreign trade and did not include the sowing and harvest of a single cash crop (Hening 1823:65). Under the Hakluyts' influence, the Gentlemen Adventurers of 1607 intended to bring the "True Christian faith" to the indigenous population, then teach natives the ways and benefits of English civilization, and with the aid of Indian labor, produce commodities for English consumption (Alison and Quinn 1973:49). This could allfeviate their mother country's dependence on foreign imports for most commodities other than wool (Alison and Quinn 1973:49; Morgan 1975:45-47).

Despite abysmal progress, the Crown renewed the Virginia Company charter in 1609. Under the new leadership of Governor Thomas Gates and Lieutenant-General Thomas Dale, Virginia finally attained viability (see FIGURE 17). Tobacco became the economic mainstay and most important cash crop and commodity produced by the Chesapeake colonies in the 17th century. As late as 1620, food remained in great scarcity despite regulations put in place by Governor Dale requiring planters to devote one month a year to produce private food stores (Morgan 1975:86-87; Billings 1996:10).

FIGURE 17. JAMESTOWN, 1624 by John Smith (Courtesy National Park Service).

Historians credit John Rolfe’s success with introducing more marketable tobacco with saving the colony. His 1612 to 1614 experiments with West Indian tobacco, *nicotiana tobacum*, resulted in a strain that replaced the harsher native Virginian tobacco, *nicotiana rustica* (Billings 1975:9). Historical sources put the first significant shipment of tobacco to England between 1614 and 1616 (Billings 1975:9; Kupperman 2007:280). By 1614, the contracts of the few surviving servants of 1607 expired, and men planted for themselves. Ignoring Dale's order to plant food, they planted tobacco instead (Billings 1975:10). By the end of the 1620s, both merchants and planters recognized the tobacco trade as highly profitable and Jamestown, continued to grow (see FIGURE 18). The general decline in prices paralleled the monumental increase in tobacco production. Planters produced 400,000 pounds in 1630 and 15,000,000 pounds in 1660 (Horn 1994:142).

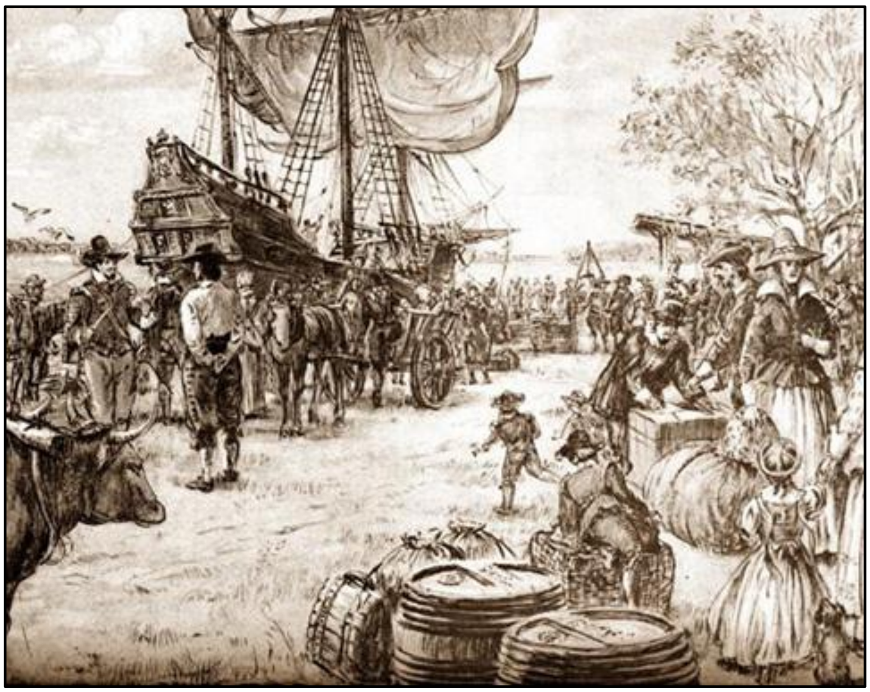

FIGURE 18. Jamestown Wharf, by Sydney King (Courtesy National Park Service)

As Virginia earned profits from tobacco, interest in American settlement grew. Sir George Calvert, Lord Baltimore of Ireland, received a royal charter granting him Maryland as a proprietary colony in 1632. Maryland farmers primarily planted tobacco, though some grew wheat and rye (Horn 1994:54,144). All of these crops found their way to London and Bristol, England's major ports; both grew rapidly with the re-export of American cash crops, tobacco, and later sugar (Loades 2000:175). Mid-to-late 17th-century Dutch rivalry and predation (discussed above) led to the adoption of convoys by English merchant fleets to stave off financial losses (Middleton 1946:183).

England’s population doubled during the 16th and 17th centuries (Wrightson 1982:130). This massive population growth fueled the estimated 500,000 people who migrated to new overseas possessions (Horn 1994:24). Formed in 1620, the New England Company established New Plymouth (later absorbed by Massachusetts) that same year, and Boston was founded in 1630 (Loades 2000:143-144). Ambitious merchants established trade networks in southern Europe, the Wine Islands, and the Caribbean, exporting New England fish, timber, livestock, and produce. This in turn, led to a flourishing maritime industry by the end of the 17th century (Anderson 1991:132-133). New England’s shipping routes included the Caribbean and Bermuda, England’s second permanent colony.

During Governor Dale’s 1609 voyage to Virginia, a hurricane separated his flagship, *Sea Venture,* from the rest of the fleet, and its companion ship, *Ketch,* was lost (see Chapter Three). *Sea Venture* wrecked on a reef in Bermuda; a handful of the ship’s company comprised the earliest settlers (Strachey 1610, in Stansby 1625:1735-1746). The official charter for the colony came four years later in 1612; like Virginia, the charter was modeled after Irish plantation grants. (Quinn and Ryan 1983:167-170). English settlement elsewhere continue at a dogged pace over the next few decades (see TABLE 9).

Barbados fared much better than other Caribbean efforts. Founded in 1625, it became the principal English holding in the Caribbean for the next several decades; after introducing sugar, it also became the principle 17th-century producer of rum (Dunn 1972:18; Smith 2005:40). By 1629, English shipping reached 115,000 tons, compared to 50,000 tons in 1572. The boom of 1629 followed with a slump then a steady increase and another boom in 1636 to 1637 (Davis

1972:1,11-15). English expansion into the Caribbean halted until William Penn and Robert Venables's successful capture of Jamaica in 1655 (see FIGURE 19). It grew to become England's most lucrative Caribbean possession; sugar and plunder made Jamaica wealthy (Dunn 1972:151).

TABLE 9. DATES OF ENGLISH COLONIES AND MAJOR 17TH-CENTURY EVENTS

Year	Colony or Event	Year	Colony or Event
1607	Jamestown	1647	Bahamas
1612	Bermuda	1649	Commonwealth of England founded
1620	New Plymouth	1650	Anguilla
1624	St. Christopher	1651	English Civil War ends
1625	Barbados	1652	First Anglo-Dutch War begins
1628	St. Kitts	1653	Protectorate replaces Commonwealth
1628	Nevis	1654	First Anglo-Dutch War ends
1629	Tortuga (failed)	1655	Jamaica
	New Providence (failed)	1659	End of the Protectorate
1630	Massachusetts Bay	1660	Restoration
1632	Maryland	1665	Second Anglo-Dutch War begins
	Antigua	1666	English Virgin Islands
	Barbuda	1667	Second Anglo-Dutch War ends
	Montserrat	1670	Cayman Islands
1636	Connecticut	1672	Third Anglo-Dutch War begins
	Rhode Island	1674	Third Anglo-Dutch War ends
1642	English Civil War begins	1688	Glorious Revolution, King William's War begins

Early agricultural efforts by English settlers in the Caribbean consisted of attempts to replicate the Virginia model of profitable tobacco plantations along with cotton (Dunn 1972:6,49). The poor quality of English grown Caribbean tobacco, competing with Spain's century long cultivation of the crop, made English planters little money (though it thoroughly succeeded in the Chesapeake). Hence, between 1640 and 1660, English planters abandoned tobacco and cotton and adopted sugar as the islands' main cash crop (Dunn 1972:59). Caribbean rum, marketed locally for decades, found its way into the English maritime community, eventually reaching markets along the margins of the Atlantic, including Boston and the Chesapeake (Smith 2005:40).

FIGURE 19. The 17th-Century Caribbean, inset from *Nova et accurata totius Americae tabula*, 1660 by Frederik de Wit (Courtesy Boston Public Library).

Mid-Century Tensions, Crisis, & Change

The outbreak of the English Civil War disrupted trade and though records during that period are scant, total available tonnage is estimated as twice that available during the Armada crisis (Davis 1972:11). A sharp increase in shipbuilding occurred in 1646, and then declined again in 1649, after the shocking execution of Charles I, making European monarchies hesitant to trade with England (Davis 1972:11). Dutch independence in 1648 led to a resurgence of competition with English trade, edging out English progress in the Baltic and even re-exporting Chesapeake tobacco from the Chesapeake back to England (Davis 1972:12). The English built heavier ships designed for strength, maneuverability, and most of all, defensibility; this meant a larger crew and a more expensive vessel, requiring higher freight. The Dutch maintained fierce competition with their remarkably productive shipbuilding industry and efficient merchant marine (Davis 1972:12).

First mentioned in admiralty records in 1630, the Royal Navy formally established the rating of ships in 1649 (Loades 2000:168). The specialization of ships-of-the-line and frigates led to the abandonment of the age old English tradition of using merchant auxiliaries as it proved ineffective early on in the First Dutch War. The practice was abandoned in 1652. The Corolla Wreck may be the remains of a merchant auxiliary; the lack of material evidence is inconclusive in this regard. This departure from English tradition was a marked change from less than a century before; in 1588 only 20% of the Navy Royal were Elizabeth I's ships (Loades 2000:167). Following peace in 1654, foreign built vessels comprised at least half the English merchant marine. At least 1,000 of them were Dutch ships seized during the war (Davis 1972:13). Following Restoration, Charles II's Navigation Act of 1660 created more demand than English shipwrights could produce. Production steadily increased, just not enough to meet merchants' needs. By 1660, total shipping reached 180,000 tons, compared to 110,000 tons in 1625 (Loades 2000:168). Also in the 1660s, English slavers began operating in Madagascar, meeting labor demands along the Dutch African Cape. They soon transported slaves to their own colonies on Bermuda, Barbados, Virginia, and later Caribbean settlements (Scammell 1989:108). The Second Anglo-Dutch War (1665-1667) met some merchants' demand for tonnage in prizes, and regulations were relaxed after the London fire of 1666 to meet the need for timber to rebuild the city (Davis 1972:14).

Conclusion

The 17th century was a test of unity for the nation states of Spain, France, and England. For Portugal, it was a struggle to maintain a national identity in the face of Spanish consolidation. In the Netherlands' case, the Dutch struggled to attain unity in the form of independence from Spain. The 17th century was also a period of major colonial expansion for northern Europe. Adventurers, soldiers, and sailors, far from pusillanimous, flexed their respective nations' consolidated might. Violence, on land or at sea, was a perfectly acceptable means to an end. It is debatable whether the Corolla Wreck originated from England, Holland, France, Spain, or Portugal.

Among these candidates, Iberian is the easiest to eliminate. The Spanish use of local timber in the Americas and the Philippines (documented in the archaeological record) for colonial built vessels eliminates those territories for Corolla's origins, based on its European wood species (see Chapter Six). Though the Spanish use of vessels built in their southern Dutch provinces does not mean it could not have sailed under a Spanish flag. The Portuguese employed teak in East India merchantmen built from local Indo-Asian sources. French origins are debatable. The French purchased many of their vessels from the Dutch and employed a style of construction strongly influenced by their suppliers (Bactchvarov 2002:127). Early French attempts at settlement in modern day Florida and South Carolina in the 16th century might suggest the Corolla Wreck as a link to those failed colonies (records for both are scant). Minimal French contribution to early 17th-century transatlantic traffic make it highly unlikely the Corolla Wreck was a French vessel.

Could the vessel have been Dutch? Revenues from Holland's North American trade amounted to a minimal contribution compared to Baltic, Mediterranean, and East Indian commerce. Dutch assisted Swedish attempts at New World colonization resulted in 12 voyages in efforts to establish a colonial presence along the Delaware Bay. The vessels were either purchased or built in the Dutch style; one ship never returned to Sweden (see Chapter 3). The Corolla Wreck's deposition south of the Chesapeake may suggest its involvement in the tobacco trade, whether a Dutch interloper or English merchant vessel remains will be clarified in subsequent chapters.

It is also possible the Corolla Wreck was a victim of pirate or privateer; rival powers commonly captured and re-captured vessels throughout 17th-century European conflicts, the Anglo-Dutch Wars were not exceptions. The rapid 17th-century growth of the English merchant marine leaves the British Isles as a very viable candidate of origin; the Corolla Wreck might be a relic of England's seafaring commercial expansion. Early in the 17th century, Virginia remained England's most valuable overseas possession. If the Corolla Wreck was lost en route from the Chesapeake, it would most certainly have been carrying tobacco; if its final voyage was to the New World, it would have been carrying finished goods, commodities, supplies, and laborers. Regardless of its origin, the Corolla Wreck represents mid-17th-century continued northern European expansion and is a macro-artifact from this period of increased Atlantic traffic. Taking the wreck's deposition on the Outer Banks of North Carolina into account, it was most likely English or Dutch, given the historical trends of trade and settlement in North America and the Caribbean. The French were not really in the game before 1650, the Spanish were in decline about the same time, and Portuguese vessels rarely visited the mid-Atlantic.

If population figures correspond with maritime traffic in the early 17th century, then English is again the most likely candidate. In 1630, New England and Virginia combined had 4,300 colonists. In 1650, that number reached 46,000. This gives the English an average of 85.6% of North American colonial population between 1630 and 1650 (Famighetti 1997:378). A safe estimate would then be 80% to 85% likelihood the vessel was English, a 6% to 9% possibility it was Dutch, and a 5% to 7% chance it was French. The Dutch emphasis on trade versus settlement, however, could easily skew the Dutch probability to a much higher degree. Within this context, the Corolla Wreck is symbolic of the massive numbers of 17th-century Atlantic traffic. The remains of the unidentified vessel bore witness to enormous and permanent change in social systems on both sides of the Atlantic Ocean. It was an active participant in the Atlantic community. It carried people and goods going to or from the Americas; where it was built and under what flag it sailed remain inconclusive.

CHAPTER THREE: Methodology

Introduction

The author formed research questions as a response to Wreck CKB0022's discovery near Corolla, and preliminary investigation by professors from the Program in Maritime Studies at East Carolina University. The unexpected discovery of ship remains and the delayed response by the scientific community resulted in a rare 17th-century shipwreck washing up and down the shore for 18 months. Initial research questions and more developed research design follow below with an explanation of archaeological fieldwork undertaken from 2010 to 2012, a description of the approach and execution of historical research, and finally, a discussion of post-procession work and preliminary results.

Research Design

After UAB contacted Professor Bradley Rodgers regarding the potential age of Site CKB0022, he developed research questions to recover as much data from the wreck remains as possible, incorporating it into the 2010 Program in Maritime Studies Summer Field School. Since the Corolla Wreck has never been sheltered from the environment and no conservation efforts undertaken, the primary task was to record the wreck in detail, creating a scaled site plan to preserve knowledge of its structure in the archaeological record. Dr. Rodgers instructed graduate students to create a detailed and accurate pencil drawing. The same students later copied and inked all plans onto Mylar™ (archive quality polyester film). Dr. Nathan Richards later scanned the plans to create a digital record, edited and improved to publishable quality. Following recording, the author researched other 16th- and 17th-century Atlantic-European shipwrecks to compare the Corolla Wreck to contemporary sites. This occurred alongside research on 16th- and 17th-century ship construction treatises to identify the construction tradition that produced the wreck and its possible age based on its structural details. Research on Atlantic trade and settlement in the same period sought to establish a systemic context for Wreck CKB0022.

To understand the site's formation processes, the author created a chronological photographic archive from the hundreds of photographs taken of the wreck between 2008 and 2010. The author recreated the path of the dynamic wreck's journey up and down the coast of Corolla using GPS coordinates and verifiable eyewitness descriptions of the wreck's location on various dates, coinciding with the photographic record. Conducting further research into formation processes, the author needed to analyze natural (environmental, geographic, meteorological) and cultural factors (human interaction, site contamination, looting) that may have influenced the site formation and the wreck's change in structural integrity. After observing artifacts in the photographic record, the author photographed material culture removed from the wreck (unprovenienced) and analyzed it to extract additional information about the wreck's age and its possible origins. Using this multilateral, systematic approach to investigating the wreck, the author hoped to determine a probable nation of origin, estimated age, and at the very least, the construction philosophy behind the building of the original vessel that the remains represent. The first phase of research occurred in May 2010.

Field Research: Summer 2010 to Spring 2012

In May 2010, East Carolina University's Program in Maritime Studies incorporated the recording of the wreck as part of the terrestrial component of its 2010 Summer Field Season, allowing students firsthand interaction with an artifact possibly four centuries old. Under direction of Dr. Rodgers and Dr. Richards, students created a scaled 1:10 site plan of the wreck including a plan view drawing, frame profiles, and drawings of an apron and a keel section all in feet and tenths (see FIGURE 20).

FIGURE 20. ECU graduate students mapping Wreck CKB0022 (Photo by Author, 2010).

Students observed structural features, sketched the wreck, and discussed the wreck's orientation. Dr. Rodgers's initial observation confirmed that the wreck was certainly far older than any wreck previously located in the Carolinas; its construction features suggested origins in the early 17th century. Students set up a baseline along the wreck's center with the zero end at what was suspected as the forward terminus. The wreck consists of 10 frames; the keel was missing; frames are attached to eight strakes of planking by treenails. The team noted some iron fasteners and concretions along the centerline of several floor timbers. Three pre-assembled frames were longitudinally fastened with treenails; longitudinal fastener holes indicated one missing paired futtock and one lost associated floor. Evidence of another missing floor found in the impressions of the inside surface of planking indicated 12 frames beforebefore disarticulation in January 2010. Initial photographic evidence provided by Roger Harris confirmed this. This led to the first frame to be numbered “Frame 3.” Students tagged the frames respectively and divided the wreck into eight equal sections, four 10-foot sections on either side of the baseline. Using baseline-offset methods, students recorded the dimensions of all timbers, noting the position of iron fasteners, and treenails, and whether they were shorn, wedged, or missing.

On the second day of recording, Dr. Richards joined the site with staff archaeologist Calvin Mires and crew chief Stephen Dilk. They conducted a digital laser survey of the wreck’s basic dimensions using a TopCon total station (see FIGURE 21). Students completed the pencil draft of the site plan along with floor profiles. On this second day, Dr. Rodgers determined that the initial orientation of the wreck was wrong, and what was considered at first to be the forward end was actually the wreck’s after end. This means that the frames were numbered from the aft to forward, making Frame 3 its after-most surviving frame, and Frame 12 is the forward-most surviving frame element. On the third day, a smaller team recorded a portion of forward timber, that was part of the disarticulated bow assemblage, likely an apron. The team also traveled to the Graveyard of the Atlantic Museum (GOAM) to record the keel piece recovered months earlier. Following the recording, the ECU team purchased a tarp and lashed it to the wreck to provide protection from the elements as the wreck continued to dry and warp.

FIGURE 21. Dr. Richards instructing ECU graduate students in digital recording of frames (Courtesy ECU 2010).

As discussed in the introduction, the wreck was relocated to the Graveyard of the Atlantic Museum (GOAM) in July 2010. No conservation plan actually existed beyond brief electronic communications between UAB and GOAM. In October 2010, the author, along with three other graduate students enrolled in the Program in Maritime Studies, traveled to GOAM to record in detail surviving timbers of the wreck using a TopCon total station. Upon arrival to the sight, it was apparent that no new information could be extracted from the wreck's main structure, because the timbers were badly desiccated and warped since the May documentation. For this reason, the author focused on the apron and keel section (see FIGURE 22). The team sketched the site and shot in datums on fixed positions around the wreck, marking and numbering them with chalk, eliminating the time consuming process of shooting in a backsight (known point of spatial orientation). The team completed this second recording the following day.

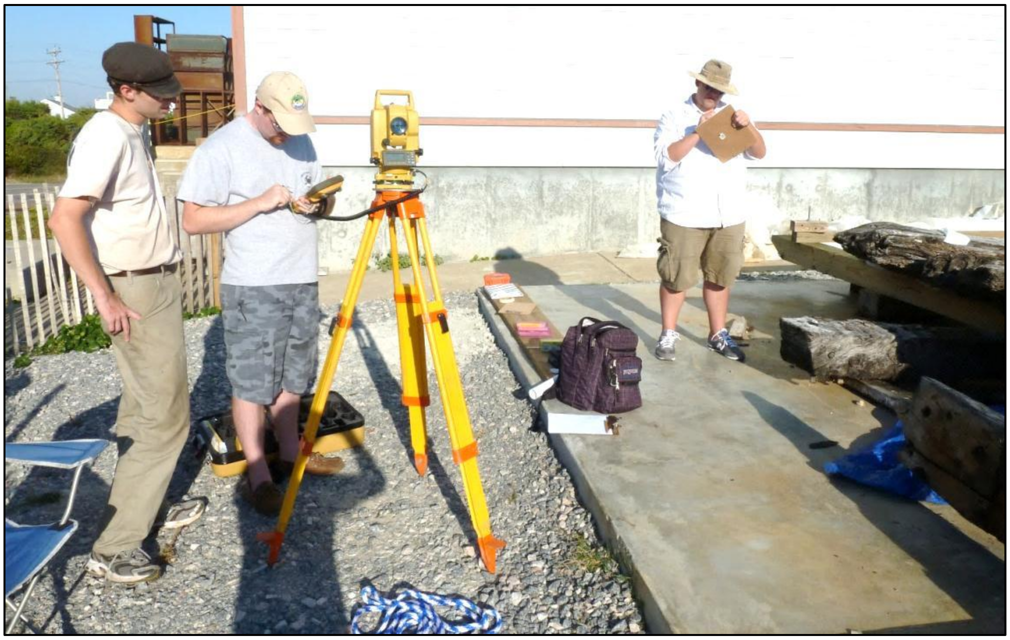

FIGURE 22. ECU graduate students (Nat Howe, Saxon Bisbee, and Daniel Bera) recording the keel section in October 2010. (Photo by Author).

In fall 2011, the author visited UAB headquarters in Kure Beach, North Carolina, to collect more data on Site CKB0022. All existing records were made available, including internal documents, electronic correspondence, the photographic archive, and a few artifacts, some of them donated by collectors. With access to a plethora of photographs taken before May 2010, the author began unraveling the confusing mystery of the wreck's arrival and disarticulation. Even more important, photos of previously unseen structural features no longer extent provided more clues as to how the vessel was built.

In the spring of 2012, the author and same team of graduate students met Ray Midgett and Roger Harris at Midgett's house in Southern Shores to examine and photograph their collections of material culture (see FIGURE 23). Midgett's collection was more extensive, though its provenience was harder to verify; several coins dated between the 1590s and the 1640s. Harris's collection included concretions similar to those found on the wreck with lead shot, brass pins, and nails, both embedded and loose, two coins dating between 1610 and 1643, and a deadeye dating between 1610 and 1640 (Fred Hocker 2013, elec. comm.) Harris's concretion and the only two artifacts documented *in situ* before removal from the wreck underwent conservation at ECU.

FIGURE 23. ECU graduate students recording artifacts collected by Ray Midgett and Roger Harris (Photo by Roger Harris, 2012).

Historical and Archaeological Research

To narrow the wreck's window of historical origin, the author conducted a survey of 16th- and 17th-century wreck site reports, articles, and comprehensive works on ship construction of the period. The author catalogued a systematic, critical list of 16th- and 17th-century wrecks, ethnic origin (if known), and their construction features. By utilizing contemporary sites and ship construction treatises, the author scrutinized the Corolla Wreck to extract as much analysis from its remaining and photographed structural elements.

Concomitantly, the author established a systemic context for the wreck site. This process, as a whole, sought to create a comparative analytical model to test Steffy's proposal.

Throughout the process, while improbable, the author sought the identification's of ships known to be lost off the mid-Atlantic eastern seaboard from the later 16th and to middle 17th century. This was before the author had access to either Harris or Midgett's artifacts. Thus, the author considered viable candidates, and if possible, eliminated them from the list of possibilities. Among these were *Fogel Grip*, the only Swedish vessel lost during the 17th-century New Sweden colonial voyages; *Ketch*, a pinnace lost in the same storm that wrecked *Sea Venture* on Bermuda in 1609; HMS *John*, a Royal Navy 4th rate lost in 1652 off the coast of Virginia; and HMS *Swift*, an advice boat lost off the coast of Virginia in 1698. While the identity remains a mystery, it is clear the Corolla Wreck is not the remains of any of these four vessels. While investigating *Fogel Grip*, the author viewed photos of metal squares found on the Corolla Wreck that looked strikingly like 17th century square-cut Swedish coins, or *klippingar.* These turned out to be iron dice for hail-shot; later the author learned the ill-fated vessel wrecked in the Baltic. The *Ketch* happened to wreck too early; two coins dated to no earlier than 1610 and found on the wreck eliminates *Ketch* since it was lost in 1609. The wreck remains are also too large to be the remains of *Swift*, a 154 ton, six-gun, 76-foot vessel looted, scuttled, and burned by local inhabitants of North Carolina. HMS *John*, a 367-ton vessel purchased in 1646, of 28 guns, remains a viable candidate (Hepper 1994:1).

Post Processing

North Carolina's Outer Banks are a popular vacation destination for an estimated five million tourists each year (LearnNC.org 2013). That the wreck featured as a cover story for *The Virginian-Pilot* in March 2010 only brought it even greater attention as it continued to meander up and down a five-mile stretch of beach near Corolla. The result is a photographic record of the wreck comprising over 1,700 photographs from 2008 to its removal to Hatteras in 2010. A great deal of time was spent sorting, identifying authorship, dating accurately, and eliminating duplicate pictures or photos with erroneous labels regarding the date taken and by whom. The product is a carefully sifted photo-archive with accurate dates and authorship. When viewed chronologically, a visual record of the wreck and its continued interaction with natural and cultural factors is apparent. At times, discovering the authorship or date of a photograph proved challenging as metadata (information electronically stored within the digital file) was often lost through the process of duplication and electronic communication. Among the last information to survive in the metadata was the camera make and model. The author created a matrix in an Excel spreadsheet listing the camera makes, models, and confirmed authorship. In this way, many unidentified photographs received proper authorship. By extracting the dates taken from unlabeled photographs, the author can pinpoint to within 24 hours of when the wreck went from its primarily intact state of 2008 through 2009, to the breaking up of the bow assemblage and disarticulation of the keel, deadwood, and stem in early 2010. Using meteorological data provided by the National Ocean and Atmospheric Administration (NOAA) from 2008 through 2010, the author attempted to discern if unusually cold weather contributed to the cause of this breaking-up. Using GPS coordinates documented by the UAB and confirmed eyewitness descriptions of the wreck's location on various dates, the author re-created the wreck's dynamic two-year littoral traversal, providing evidence of its dynamic context (see FIGURE 24).

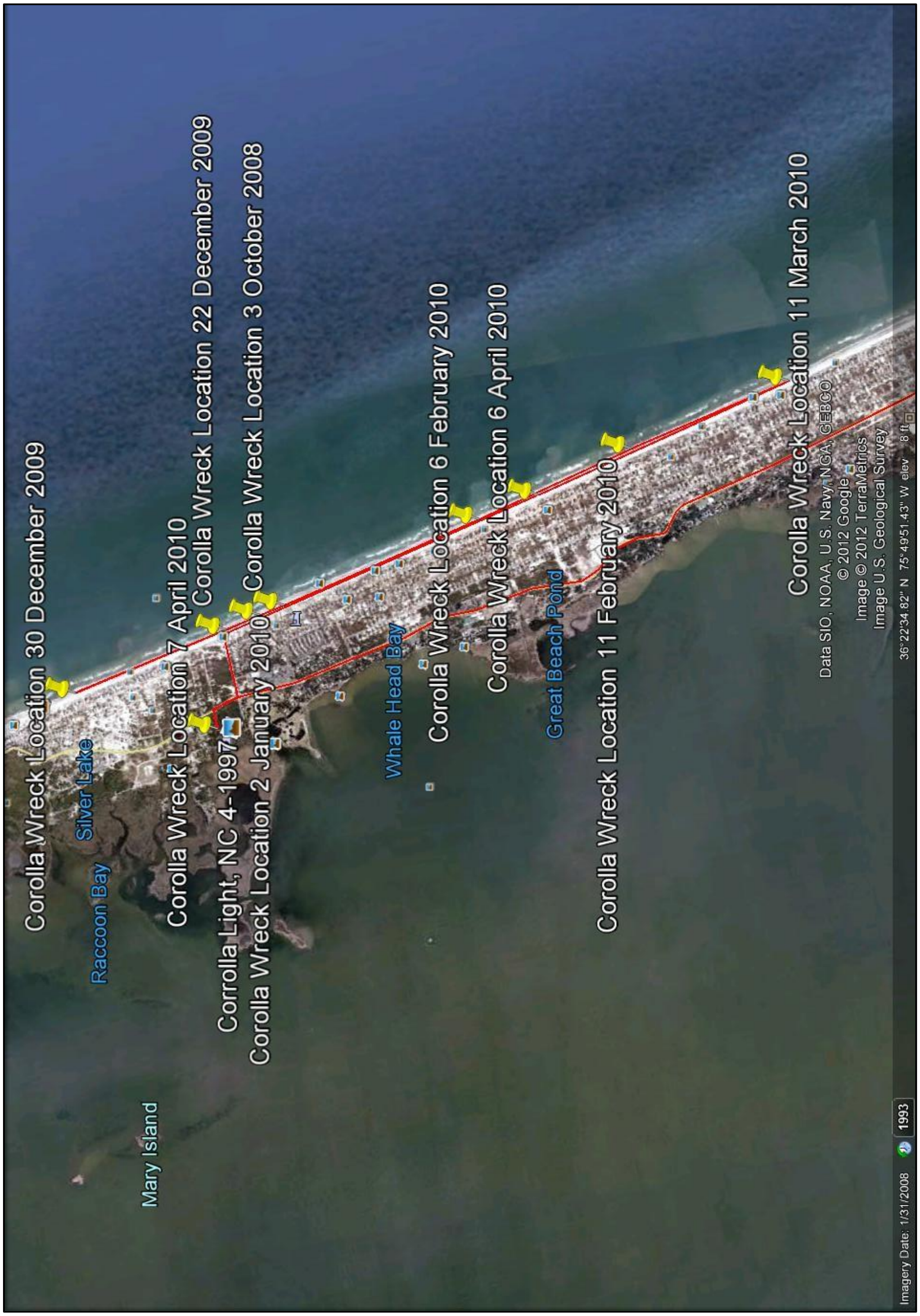

FIGURE 24. Locations of the Corolla Wreck from 2008 to 2010. (By Author, Courtesy Google Earth 2012)

Among other evidence is the material culture removed from the wreck by self-termed "treasure hunters." This includes coins, brass pins, small caliber lead shot, lead seals, round shot, rigging elements, and other miscellany. Most of the material culture proved neither diagnostic nor could the author confirm most artifacts as having come from the wreck itself. The coins with the best provenience are two French coins from the reign of Louis XIII, who ruled from 1610 to 1643; numismatic research indicated at least one of the coins hails from the 1640s.

The most significant material evidence may lie in the wreck remains. Construction features immediately suggested early 17th century in origin, according to PI Rodgers (Rodgers 2010 pers. comm.). Digital information recorded in the field was processed in spring 2011 during Dr. David Stewart's Ship Reconstruction course to produce three-dimensional models of seven timbers, including the missing stem. Analysis of wood samples contracted to the University of Pennsylvania by UAB indicated the wood was a species of European oak (Newsome 2010:2). More thorough dendrochronological analysis is pending proper sampling and laboratory results. Research in ship construction philosophies in 16th- and 17th-century western Europe suggest the vessel was built in northwestern Europe. The following chapter discusses this in detail.

CHAPTER FOUR: 16th and 17th Century Ship Construction Treatises

Introduction

In 1590, when Phineas Pett lost his financial support upon the remarrying of his widowed mother, he had to give up his education at Cambridge. Four years in, at 20 years old, Pett was forced to abandon his "Bachelor of Art," and his mother persuaded him to be content with an apprenticeship to become a shipwright, his deceased father's profession. A young man wishing to enter into a trade of such intricate craft had few options. To enter the exclusive guild of shipwrightery required apprenticeship, the standard professional education of the day. There were no shipwright-schools. Whereas a burgeoning modern mechanic attends a technical school to learn a trade, no such option existed in the 17th century. The conservative nature of guilds and apprenticeships, in this case shipwrightery, suggests that construction traditions, even when under pressure to change, might remain consistent over a long span of time. The diverse and mobile nature of shipwrights and specialized shipyard laborers implies not all shipyards utilized the same techniques, nor incorporated the same philosophy of construction at the same time. Such differences in philosophical approaches to shipbuilding and that shipwrights of many nations employed their skills abroad, especially the Dutch, aggregate this fact. This plurality of shipbuilding traditions is visible in both the historical and archaeological record. This remains true even when discussing shipwrights of the same nationality employed in different regions—again the different Dutch traditions exemplify this fact. Different approaches to ship construction appear in both ship construction treatises and the archaeological record. To continue with the Dutch, for example, the best-preserved example of 17th-century Dutch shipbuilding survives in Stockholm, Sweden (Author's pers. obs. 2010-2011)! Thus, the opportunity for confusion is rampant. This made identifying culturally or philosophically specific features of the Corolla Wreck a challenge all its own.

As another example, many present day scholars refer to any compass timbers that function as middle frame pieces as futtocks (Steffy 2994:272). Historically, in English, a futtock is joined (or scarfed) to the floor and other composite frame timbers, each labeled according to position, ground-futtocks, lower-futtocks, upper-futtocks, etcetera (Smith 1627:3; Mainwayring 1644:43). The discrepancy may be a matter of linguistic transition, translation, or interpretation of texts. Such interpretation needs to be explicit when utilizing contemporary historic documents to identify ship remains in the archaeological record. This chapter’s conclusion address questions regarding use of language. What follows is an analysis of several European ship construction treatises written during the 16th and 17th centuries and their resulting ethnic traditions. This is juxtaposed with actual archaeological evidence set forth in the following chapter on contemporary wreck sites—all of which is subsequently discussed in context of the Corolla Wreck.

Iberian and Mediterranean Shipbuilding

From the 15th century, Venetian shipbuilders recorded the earliest surviving documents concerning Mediterranean shipbuilding (Hocker and McManamon 2006:1). Iberian shipbuilding borrowed heavily, sometimes directly, from Italian shipbuilding methods, primarily in the form of *whole molding*. Whole molding is the process a shipwright used to predict the shape of all frames between tail frames (the frames at the ends of a vessel) (Hocker and McManamon 2006:2).

Mediterranean Influences

Skeleton, or frame-based construction, first appeared in the Mediterranean between A.D. 400 and A.D. 700; differing from clinker and Mediterranean shell-based construction methods, the internal structure is primary to the outer structure (Hocker 2004:5-6,33). By the late 13th or early 14th century, trade between northern Europe and the Mediterranean resulted in a technological change in both regions. First, in the Mediterranean, northern European cogs presented Italian shipbuilders with two innovations: a square sail and a stern rudder. Mediterranean fusion of cog-like features manifested in the “coche” and larger “carakes.” The second occurrence was in England, where during the early 15th century, a reciprocation of technological influence transpired with the appearance of the first two-masted ships in that country. What link may exist between flush-plank construction and multi-masted rigs is unclear. This eventually gave rise to *carvel* (flush plank) construction as the dominant European trend by the second quarter of the 16th century (Adams 2003:64-66). This innovation—the change from clinker-built hulls to flush-plan hulls—allowed for increased naval artillery, as well as larger ships that could in turn carry more guns, more stores, more men, more rig, and so forth, all allowing for longer and longer voyages at sea. These innovations challenged 16th-century minds to reconsider the design and construction of large, ocean sailing wooden vessels in western and northern Europe. Multiple Iberian sources on late 16th-century and early 17th-century ship construction have survived, allowing the undaunted academic a look into how contemporary experts thought vessels should be built. Three specific treatises reveal insight into the construction of Portuguese *naus* (the early large carvel planked vessels used in the East Indies trade). They are *Livro Nautico* (*Nautical Book*), composed between 1575 and 1590*; O Liuro da Fábrica das Naus* (*Book of Making Ships*), 1580; and *Livro de Tracas de Carpintaria* (*The Book* *of Tracks of Carpentry*), written in 1616. Because of the similar method of Portuguese and Spanish-built vessels, Spanish treatises are implicit in the following discussion.

Portuguese Treatises

Like many frame-based or skeleton-based building traditions, the foremost timber that determined the dimensions of all the others was the keel. It is the first scantling mentioned in *Livro Nautico* (1575-1590), Oliveira (1580), and Fernandez's treatises (1616). The *Livro Nautico* is an anonymous text with explicit instructions. Feature ij describes at length the size and location of timbers necessary to build a 600-ton *nau* from oak and pine (Hazlett 2007:187). The author describes a keel of seven pieces, a stem of three, and a stern post of two parts. Also described are the "many pre-designed frames," including feature xxxiiij, the *master frame* set just forward of the middle of the keel (Hazlett 2007: 17,189). Such predesign required the use of proportions and geometric methods, learned from Venetian shipyards that had been building frame-based (or frame first) vessels centuries before Spain or Portugal sought expansion beyond the peninsula. Comparisons of measurements of Basque wrecks in Red Bay, Labrador corroborate *Livro Nautico's* descriptions with the archaeological record. The proportional method of building remained in use throughout the 16th century, eventually yielding more complex developments of naval architecture in the 17th century (Hazlett 2007: 37,39).

Oliveira's treatise (1580), likewise illustrates the geometric algorithms required for determining *gramminhos* (see FIGURE 25), proportions for the shape, size, and rising and narrowing of frames set forward and aft of the master frame. Apart from mathematics, Oliveira's treatise discusses the types of wood proper for building ships and the actual construction of vessels, including a *nau*. Fernandez's *Livro de Tracas de Carpintaria* (1616) focuses on a variety of Portuguese vessels, including a four-decked carrack. He also provides list of scantlings, but without any instructions on how to build a ship. All three authors describe a keel of 17 to 18 *rumos* (A *rumo* was two hand spans, essentially an Iberian standard unit of measurement, like the English, Dutch, or French "foot,") (around 75 feet or 23 meters) as a basis. According to Iberian maritime historian Carla Rahn Phillips, the key dimension that determined the important keel was the desired beam. By the early 17th century, Spanish royal ordinances, *codos* (see

FIGURE 26), attempted to set shipbuilding on a fixed path towards a uniform practice of standardized construction.

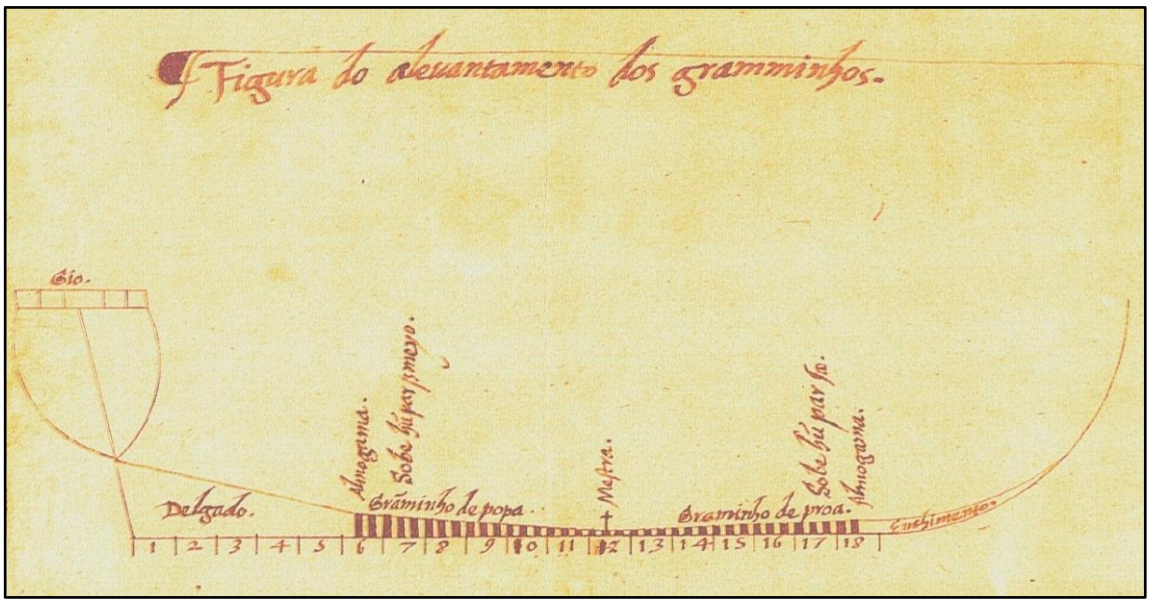

FIGURE 25. Portuguese standard proportions, *gramminhos*. (From Oliveira, 1580)

Deviating from these codes could result in an expensive fine imposed on the builder. The end result was a system that was rarely followed and poorly enforced. According to Carla Rahn Phillips (1986:52), the beam measurement determined keel length, the depth of the hold, and the breadth of the floor. After the keel was assembled, the stem and sternpost were followed by the aforementioned master frames (see FIGURE 27) (Phillips 1986:53). Hence the extensive lists provided in the treatises—a guide to avoid constructing a vessel outside the parameters approved by the crown. Thus, *Livro Nautico* and the Fernandez treatises both discuss ship components, their dimensions, numbers, and place. Yet, neither document discusses *how* the parts were assembled to one another; joinery was not addressed. Oliveira's treatise, however, gave overt instructions on the assembly of the vessel, describing the iron nails, spikes, bolts, and treenails required.

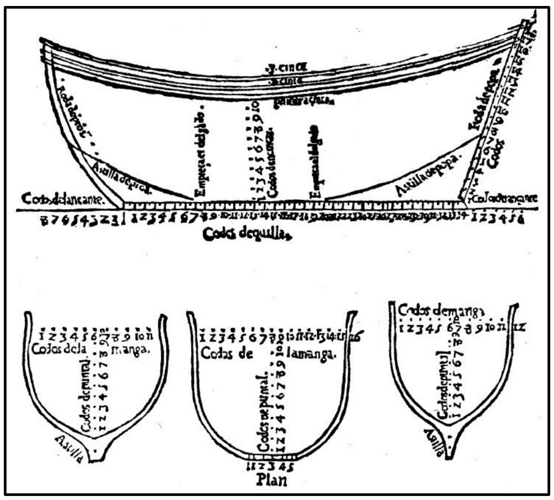

FIGURE 26. Diagram for a 400-ton *nao, Diego García de Palacio,* 1587 (*note the royal* Casa's Codos). (Phillips 1986:53)

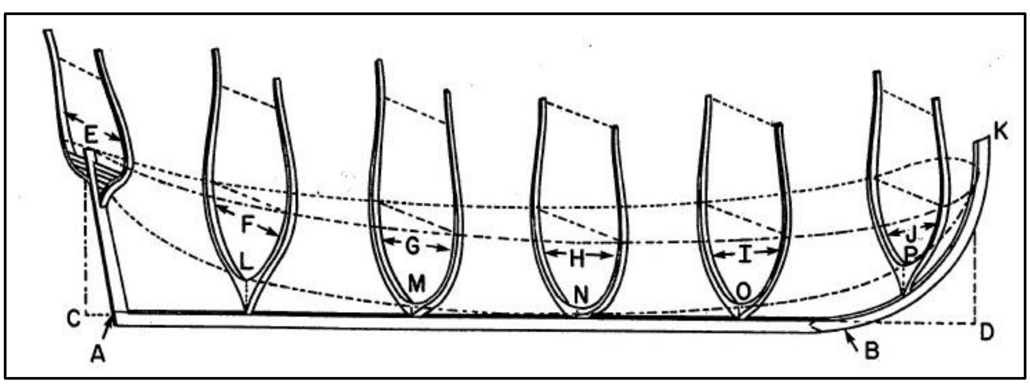

FIGURE 27. Schematic of a partially framed ship, adapted from Juan y Santacilia *Examen marítimo.* (By Lund and McLaughlin, Phillips 1986:52)

After great Scandinavian navigators of the medieval period, Spain and Portugal were the next to enterprise beyond the European waters. They left behind an abundance of material, both historical and archaeological, regarding the construction and navigation of Iberian vessels from the 15th century onward. Iberian shipbuilders preferred iron fasteners over wooden fasteners and maintained a building tradition of consistent structural features (discussed in Chapter 5), neither of which were identified on the Corolla Wreck. This leads to the next European power to follow in Columbus's wake. Though they began their explorations of North America far earlier than England or the Netherlands, French efforts at colonization were hindered for almost two hundred years (see Chapter 2).

17th-Century French Ship Construction

Unlike the Iberians, little exists that sheds light on 17th-century ship construction practices in France. Of the earliest works devoted to French ship construction (see TABLE 10), only the anonymous collection of plates known as the *Album de Colbert* displays explicit illustrations. Each of the fifty plates contains a cartouche giving a brief description of the vessel's parts from start to finish. The album is not a treatise per se, yet it is possible to glean information from the beautifully detailed drawings. Caution is required when using the *Album* as a source. Errors make scholars suspect the artists commissioned to produce the drawings were not familiar with ship construction (Berti 1988:1). Regardless, a wealth of information is apparent. The date of the work is estimated to be before 1667 since the illustration of the Toulon Dockyard on the first plate shows the tarring house of the ropewalk, destroyed by a fire that year (Berti 1988:1).

TABLE 10. 17TH-CENTURY FRENCH WORKS ON SHIP BUILDING

Author	**Title**	**Year Printed**
Hobier	*De la Construction d'une Gallaire*	1622
Abbé Fournier	*Hydrographie*	1643
Anonymous	*Album de Colbert*	1660s
Dassie	*Archicture Navale*	1677
De la Guilletiere	*Arts de l'Homme d' Epée (l'art de la Navigation)*	1678
Desroches	*Dictionaire des Termes Propes de Marine*	1687

Plate 1 shows the laying of the keel (*quille*) in four pieces, joined together with horizontal hook-scarfs (see FIGURE 28 and see FIGURE 29). Plate 2 shows the keel with stem, apron, and sternpost with wing transoms and fashion pieces. Plate 3 shows the central pair of master frames and a preassembled forward and aft frame, all with first futtocks (*genouils*) attached on the forward faces of the floors (*varangues*) (see FIGURE 30). The Plate even shows the frames in an exploded view with a numbered key with (French) descriptions. Plate 4 shows the same in plan view with an aft view of the transom as well (see FIGURE 31). From there the plates progress, illustrating systematic assembly in profile and plan views of a first-rate French man-of-war. Though the author of the introduction claims the stem is distinctly French in design (Berti 1988:3), the keel's horizontal hook-scarfs appear to be the same as Dutch keel scarfs. This particular detail puzzles the author as the French paired master- frames and main mast step appeared dangerously close to a keel scarf—something advised against in contemporary ship construction treatises (see Witsen 1670), though routinely done by shipwrights. The keel was joined with horizontal scarfs (see FIGURE 25), though the keelson and thick stuff are joined with vertical scarfs. This echoes Kroum Batchvarov's observation of French construction methods exhibiting strong southern Dutch (*Maaskant*) influence, the sole exception being the lack of space between the paired master frames (2002:127-128). Also of note is the terminology of some of the timbers: apron was *contre étrave*, literally, “opposite the stem;” rising wood was *contre quille*, “against, or opposite the keel;” keelson is *carlingue,* and ceiling planking is *doublage,* “doubling.” Referring to the ceiling as doubling reflected the structural importance of thick interior planking in the overall stiffening of the hull. It is unclear whether French shipwrights utilized the same complicated mathematical methods employed by their Iberian counterparts, but given the notable influence of southern Dutch ship building, it was not likely.

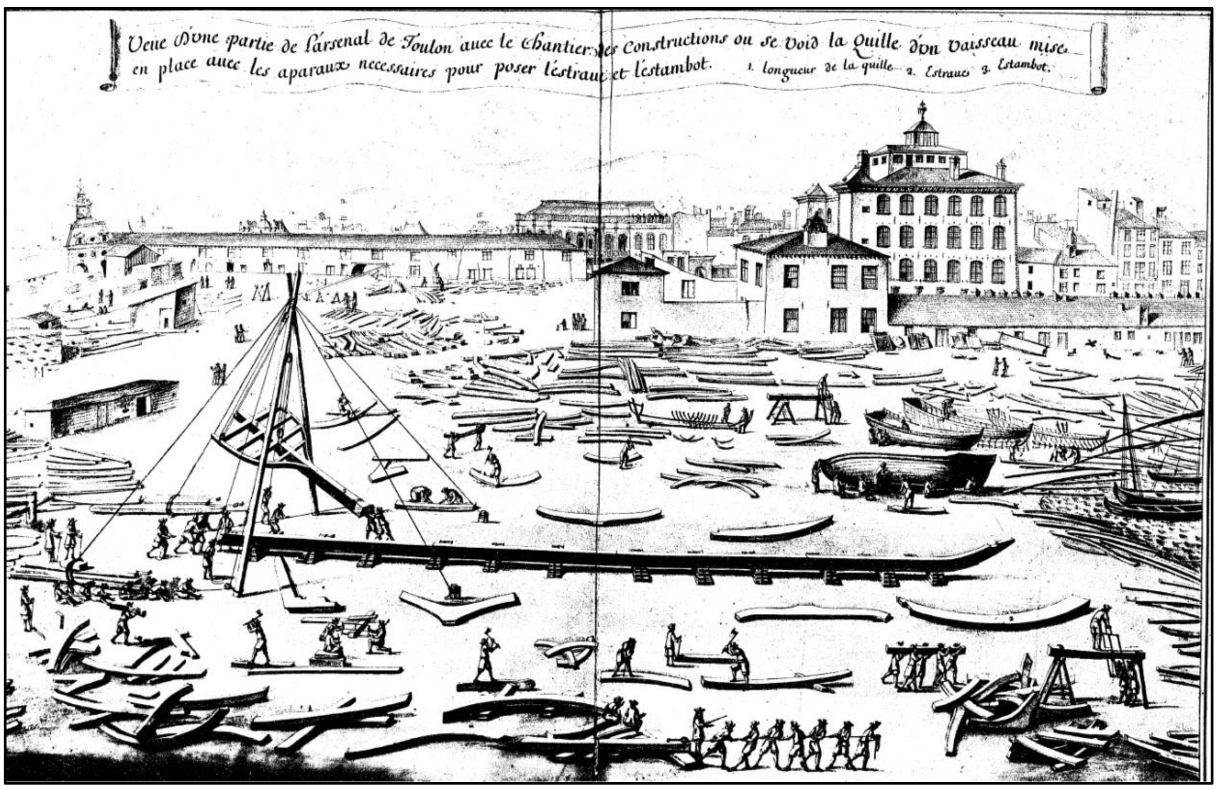

FIGURE 28. Plate 1 of the *Album de Colbert* depicting the Toulon Dockyard in the 1670s.

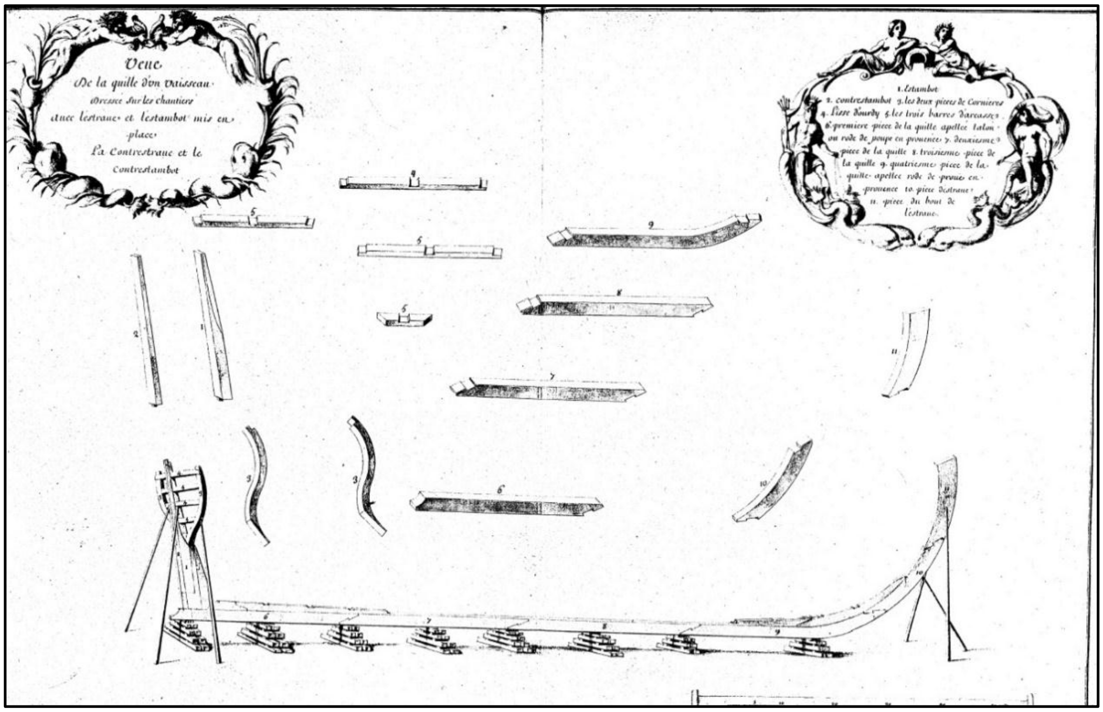

FIGURE 29. Plate 2 from *Album de Colbert* showing the keel, stem, apron, sternpost, fashion pieces, and wing transoms—the keel's horizontal hook scarfs are visible.

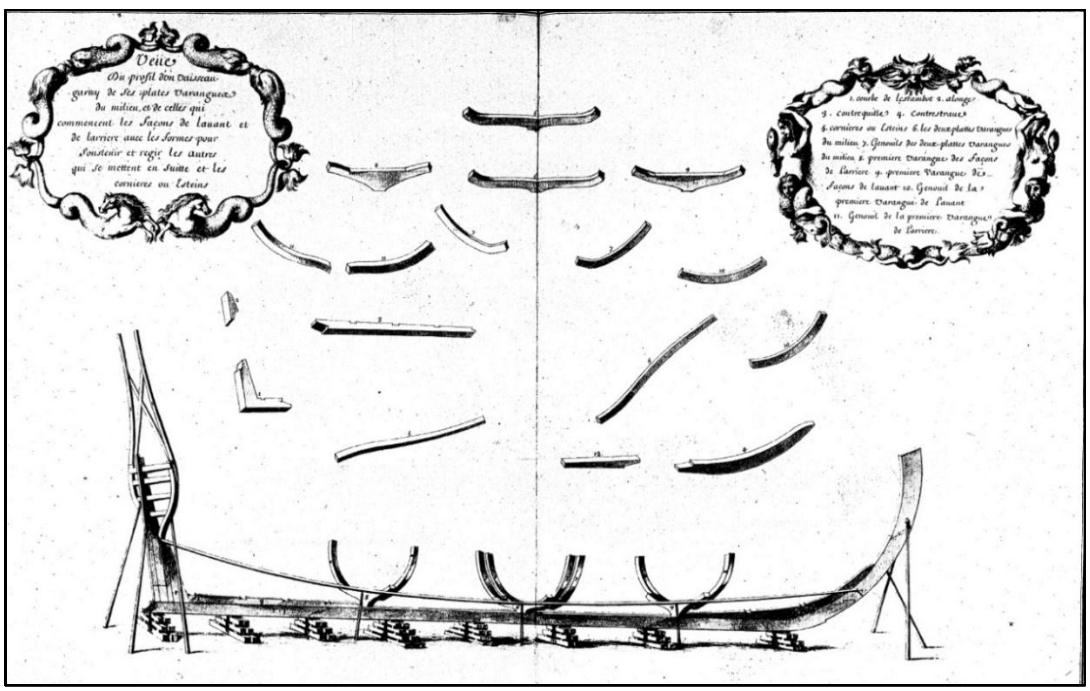

FIGURE 30. Plate 3 from *Album de Colbert* showing the paired master frames and preassembled forward and aft frames.

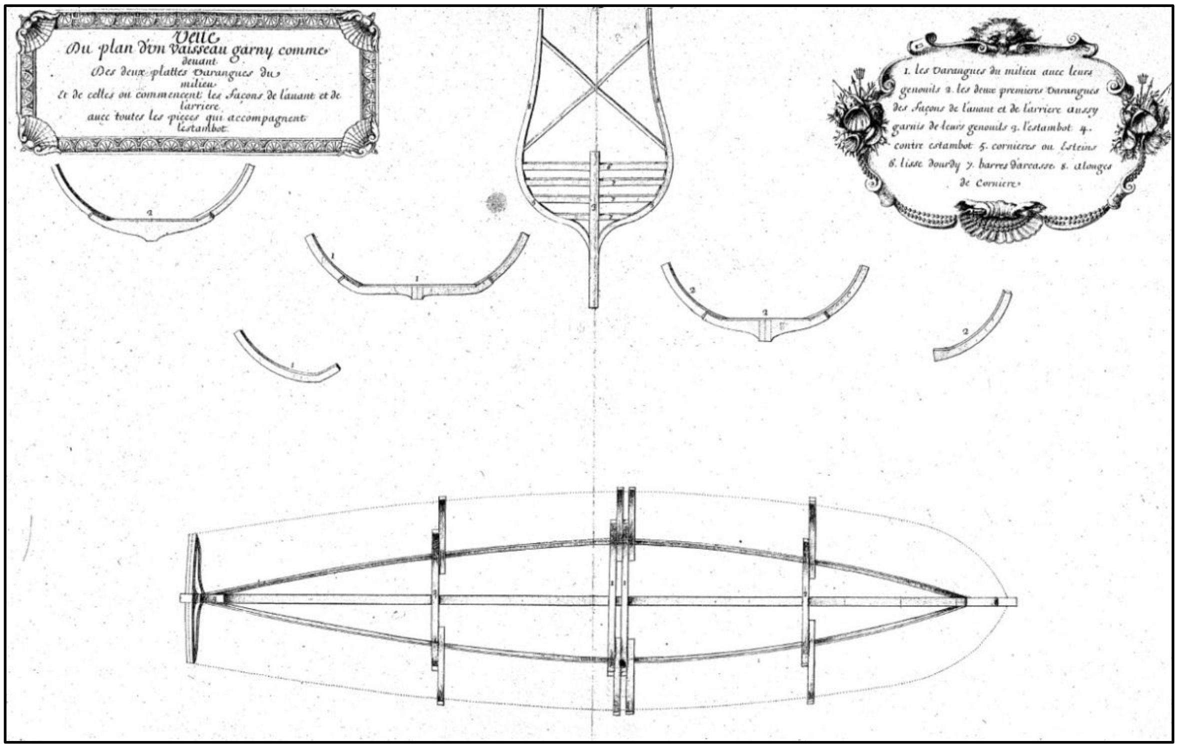

FIGURE 31. Plate 4 from *Album de Colbert*, the frames and associated scantlings in plan view.

That is not to say that the Spanish-occupied Dutch territories existed in a vacuum beyond Iberian influence. Rather, many Spanish concepts, such as yachts and galleons, were built in Dutch methods. The French probably utilized similar proportional rules as the Dutch, with French measurements.

Dutch Treatises

Dutch shipwrights made do without the complicated geometric formulas employed by rival Iberian builders, even if they copied design concepts. Instead, Dutch vessels were built based on a series of proportions derived from the length between perpendiculars, or length on keel. Unlike the concise dimensions worked out by complex geometric formulas borrowed from the Italians by both Iberian and English builders, Dutch shipwrights worked within guidelines, not rigid algorithms.

Similar to examining French ship terminology, philosophical clues can be extracted in the language of contemporary Dutch treatises. Reflecting the independent, interpretive nature of the Dutch master shipwright, only two substantial works concerning ship construction in Holland were published in the 17th century. Dutch shipwright guilds that flexed extensive political muscle focused their efforts on mercantilist protection of guilds being open only to locals. Guilds were both political and competitive; thus, it is no surprise to find a variation of conceptual approaches and execution depend on locality.

Despite Holland's size, shipbuilding practices differed in two main districts, north or south. *Noorderkwartier,* northern Dutch practice (also called Amsterdam style) was to build a ship from the bottom first, meaning hull strakes were attached to the keel and held in place with temporary cleats until frames were put in and fastened with treenails to the hull planks (see FIGURE 32, *R*, and FIGURE 34). *Maaskant*, southern Dutch (also called Rotterdam style) practice was to assemble the skeleton of the ship first, keel, stem, sternpost, and then insert frames that would then be planked over. First addressed is the *Noorderkwartier* method.

Witsen and the *Noorderkwartier* Tradition

Nicolaes Witsen was the first Dutchman to compose a written work on Dutch shipbuilding practices; a prominent renaissance man of Amsterdam, he describes the northern tradition. *Ancient and Modern Shipbuilding, Naval Architecture, and Naval Management* was published in 1671, with an expanded reprint in 1690. Witsen was neither a shipwright nor a designer of ships—his experience with vessels was as a passenger, not a master. This is readily apparent in his treatise with the extensive amount of detail devoted to describing the *hut* or cabin.

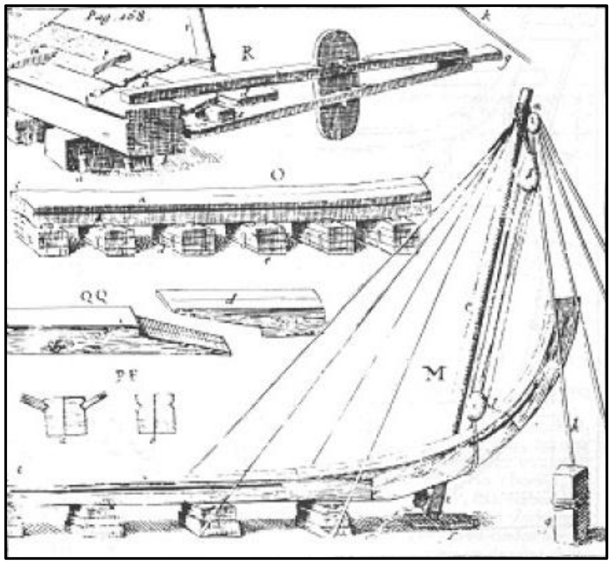

FIGURE 32. Detail from Witsen's treatise detailing early hull assembly. (By Nicolaes Witsen, 1671)

Deemed an almost impenetrable document by A.J. Hoving (2012:5), the author undertook a translation of “Chapter 8: How One Build’s Modern Ships.” After much deciphering, it is possible to learn something of how northern Dutch vessels were constructed. Hoving’s work is an excellent translation and reorganization of the overwhelming 625-page treatise. Early on, Witsen (1690:94) gave a disclaimer stating that proportions were to be observed as a guideline that so long as one followed the rules will prevent “against awful blunders.”

He then went about the building of a pinnace (see FIGURE 33) of 134 Amsterdam feet (1 Amsterdam foot = 11 inches, approximately 123 feet, or 37.5 meters). Dispersed throughout was commentary on ships and well-illustrated figures, the illustrations among the more useful contents of the expanded 1,404-page 1690 edition. Perhaps conscious of the credibility or liability of his treatise, Witsen stated, “Nobody, however, should expect that all the ship parts will be mathematically described, only those that are the most important. The others will follow without giving the ratios and the measures” (1690:96).

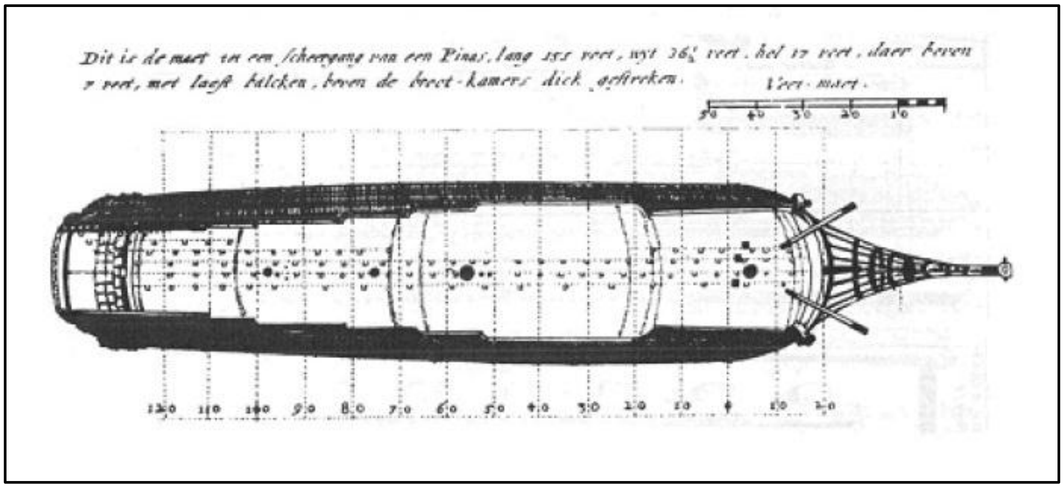

FIGURE 33. Plan view of a Dutch pinnace. (By Nicolaes Witsen, 1671)

Witsen began first with length, “from which the width [or beam] and depth are derived” (1671:30 in Hoving 2012:36). Length in Dutch shipyards was from stem to sternpost. The width was determined as one quarter of the length as a basis (in this case 33.5 feet), either adding three or four feet, or on merchant ships subtracting two to five feet, though for ships under 100 feet, less than a quarter (at the discretion of the yard’s master), and for fluyts, one fifth; the result is 29 feet (Witsen 1671:25,38 in Hoving 2012:37). The depth is determined by taking one foot for every ten feet of length, resulting in a depth of 13 feet from the height of the master ribband (see FIGURE 34, D) (Witsen 1671:38,48 in Hoving 2012:37).

From there he relates how “One makes the keel.” The keel dimensions were derived from the stem, its molded dimension (thickness) being one quarter of the same of the stem (16 inches), and its sided (breadth) dimension one quarter more than the same of the stem (2 feet) (Witsen 1671:66,149 in Hoving 2012:39). Witsen explains keels of one, two, or three pieces were preferred and for a keel of three pieces to use the best timber in the middle piece (1671:72 in Hoving 2012:39).

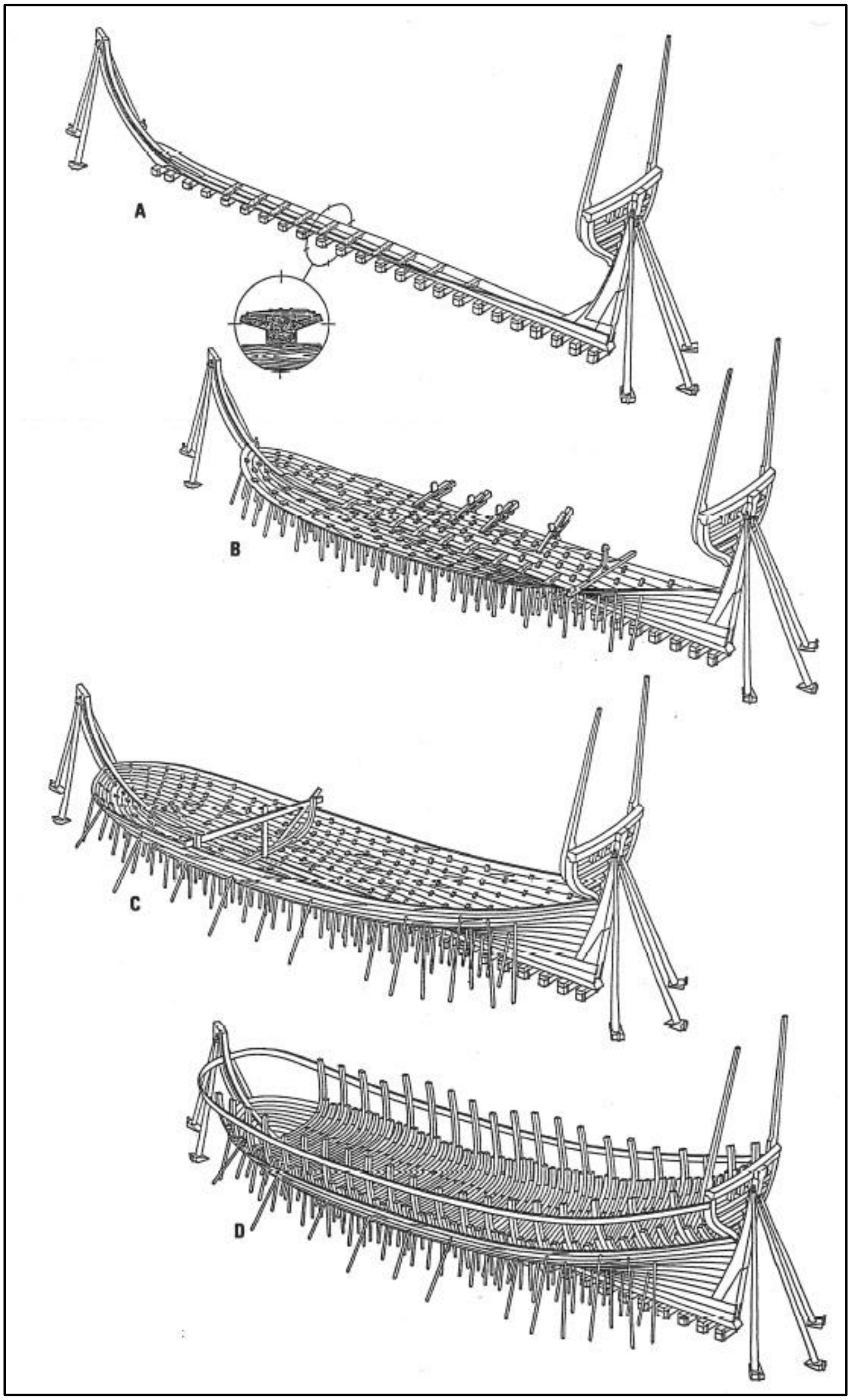

FIGURE 34. *Noorderkwartier*, or northern Dutch bottom-based construction. (By A. Heuvel, 2010)

This was usually the location of the mainmast. The pieces are joined by horizontal scarfs (see FIGURE 27, *QQ*) and bolted through the top with eight bolts. The surfaces of the scarf are drilled through with stopwaters, filled with moss and plugged with wooden dowels (see FIGURE 35) (Hoving 2012:40). The bulk of the chapter systematically describes the parts of a ship from the planking (*vulling*) to floor timbers (*bukstukken*) to the transom (*rantzoenhout*) (Witsen 1690:97-105). Once the keel, stem, and sternpost were assembled, the garboard was laid in, followed by more planking (see FIGURE 29, B). Strakes are secured with clamp-thongs, hooks, and chains, then temporary cleats were nailed across plank seems, later to be plugged with small dowels, or *spikkerpennen*. FIGURE 36 shows a more detailed version of the same sequence described above.

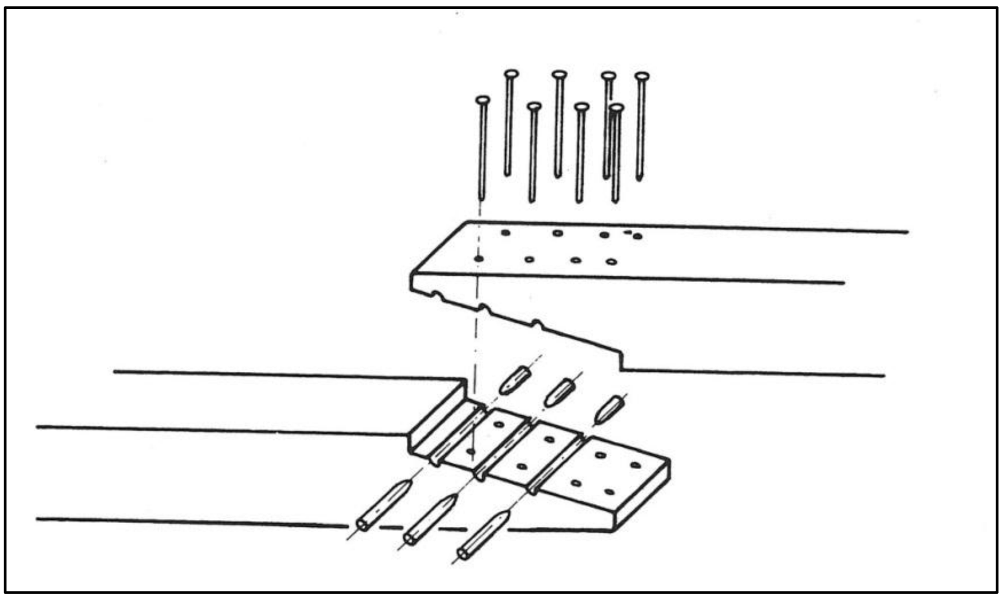

FIGURE 35. Detail drawing of a horizontal keel scarf. (By Hoving, 2012)

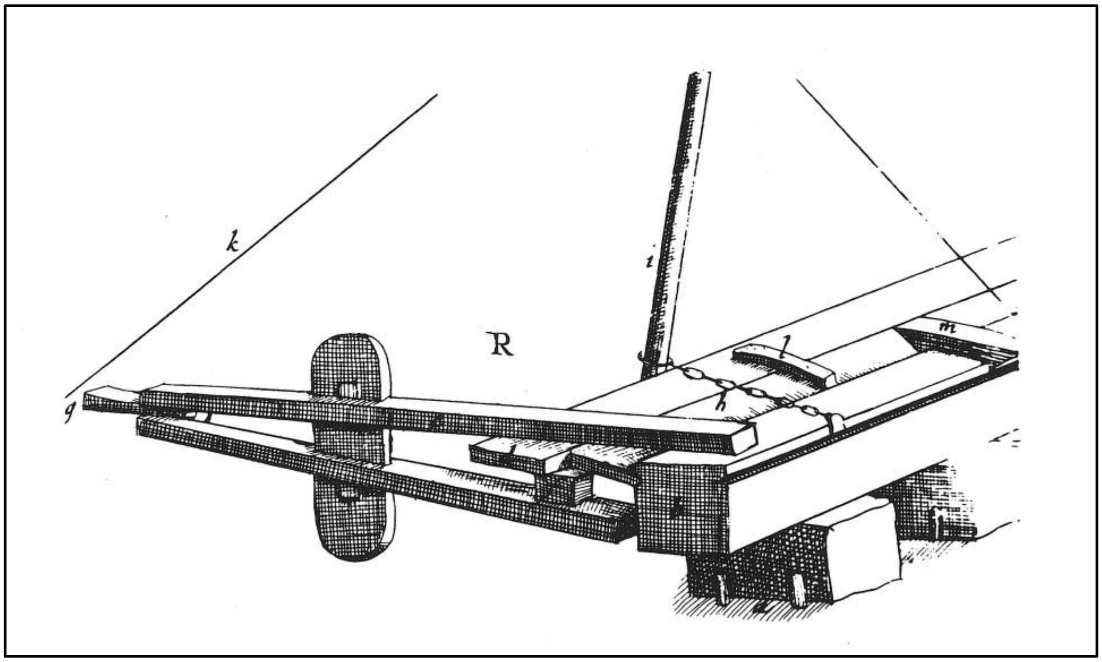

FIGURE 36. Detail from Plate L, drawing *R*. (By A.J. Hoving 2012, after Witsen 1671)

Witsen then follows with a detailed description of the cabins and decks, giving measurements and referring to his carefully labeled illustrations. Descriptions of the beakhead, galleries, and all the masts and their rigging likewise follow. Witsen finishes the chapter with commentary on sailing, a list of a ship's anchors, and a list of the names of flags and their usage (Witsen 1690: 113-126).

Though naval architecture was in its infancy in Holland, cosmopolitan intellectuals like Witsen expounded on the values of deriving dimensions, capacity, and hull shape using complex mathematical formulas—even if some of Witsen's math did not always add up (Hoving 2012:17). The common practice in shipyards, however, remained completion of the vessel under the scrutinizing eye of the master. In southern Holland the practice utilized was called *whole-molding*, the order of plank-on-frame assembly was not at all the same, resulting in a differently shaped hull.

Van Yk and the *Maaskant* Tradition

Cornelis van Yk was a master shipbuilder in Delfshaven (Rotterdam). His contribution to our knowledge of 17th-century southern Dutch construction was published in 1697 with the title, *The Netherland Shipbuilding Art Unveiled.* Amsterdam and Rotterdam are only 100 kilometers apart, yet a striking difference is found between Witsen and Van Yk's treatises, in method, order of assembly, and even terminology. Van Yk's approach was far more practical and began by setting up the shipyard, describing stocks 3.5 feet high, much higher than those depicted by Witsen. The reason for this resulted from different orders of planking and means of caulking. The raising of the stem, sternpost, and laying the keel were the same as in the north, as was the installation of the garboard strake (1st run of planks attached to the keel). From there the similarities ceased (see FIGURE 37, A). While Witsen continues planking the bottom of the hull as described above, Van Yk describes the raising of two master frames at specific locations on the keel (see FIGURE 37, B). A ribband is raised on either side to stabilize and determine hull shape, more frames are added, and more ribbands (see FIGURE 37, C and D). Finally, hull planking would commence—done on the stocks, which was why in the south the stocks were higher, to allow the swing of a hammer. In the north, the vessel was tipped on its side to facilitate caulking, then the other side; hence, there was no need to get under the hull (Hoving 2012:9-11).

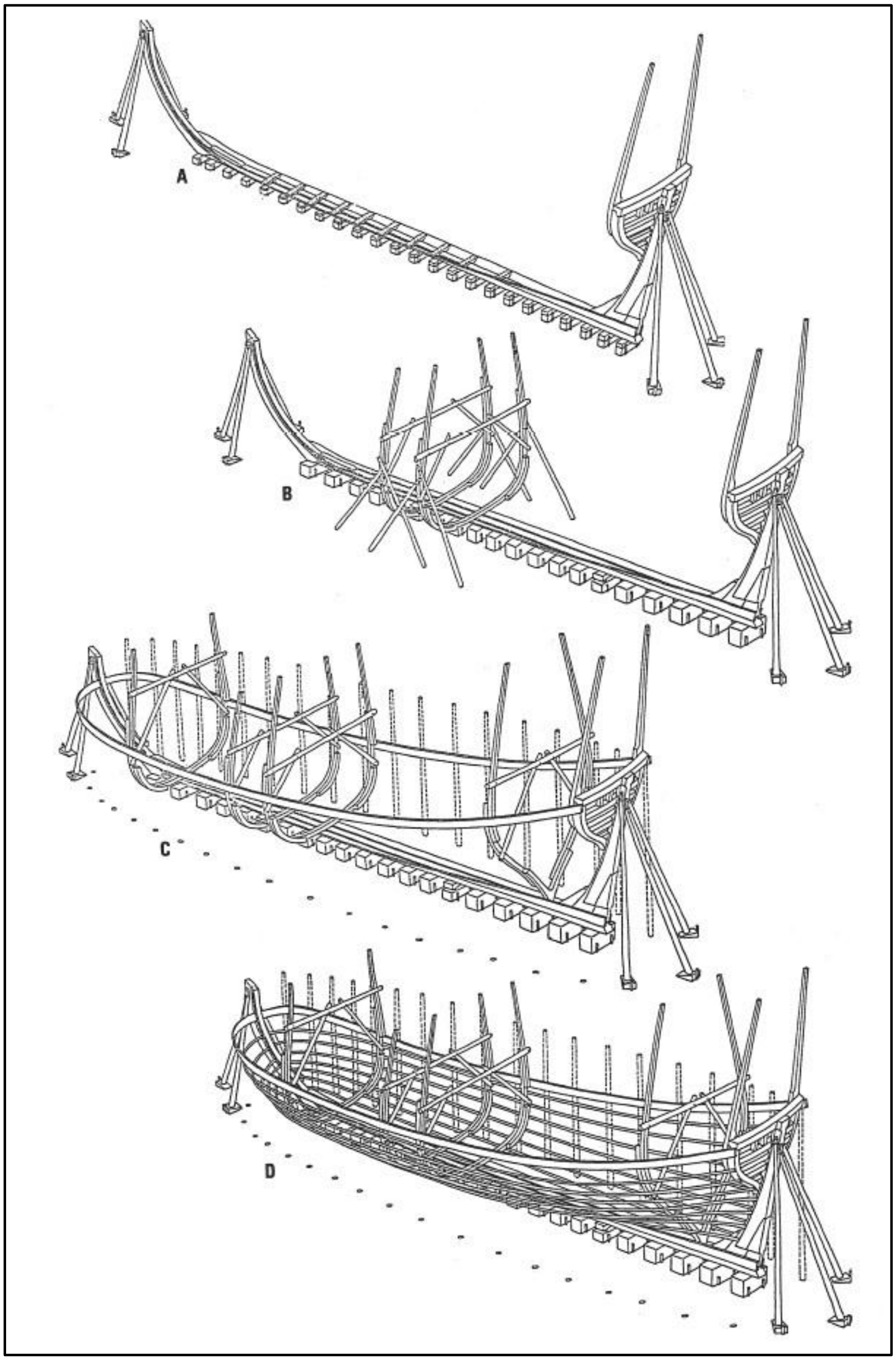

FIGURE 37. *Maaskant*, or southern Dutch frame-based construction. (By A. Heuvel, 2010)

The finished vessels would appear mostly the same with the exception of hull shape (see possibly influenced by Iberian occupation in the 16th and 17th centuries. As mentioned, the differences in construction style also appeared in the very language used to discuss ship parts.

FIGURE 38. A flatter, bottom-based hull shape (*left*) compared to a curvier, frame-based hull shape (*right*). (By author 2013)

In Witsen's treatise, a floor is *buikstukke,* the first futtock *sitter*, and the second futtock *oplangen,* garboard strake *kielgang,* keelson *kolsom,* and a carling *karvielhout.* In Van Yk's treatise a floor is *legger*, first futtock *buikstukke,* and second futtock *oplangen*, garboard strake *zandstrook*, keelson *zaathout*, and a carling *klamaai* (David Stewart 2010 pers comm., Hoving 2012:9). That *oplangen* means the same thing to both is the exception, though *buikstukke* for a futtock instead of a floor may reflect the curvier shape of a southern hull form; a first futtock in a southern built vessel may have occupied the somewhat flatter outboard extent of a floor in a northern vessel. The question of *kielgang* versus *zandstrook* for a garboard strake may also reflect hull shape differences. *Kiel-gang* literally translates to "keel-course," whereas *zand-strook* is "sand-strip." Given the shallow waters Dutch vessels operated in, a flatter hull had a navigational advantage, whereas a curvier hull might be more likely to ground—hence "sand-strip." *Kolsom* versus *zaathout* for keelson is more puzzling; the latter half of *zaathout* means "wood," whereas *kol* means "witch;" *som* is less clear. In modern Dutch *som* means "sum," but in Old Norse the word for keelson meant "crone," similar to above, and the French word for keelson, *carlingue,* is derived from the Old Norse *kerling* (Fred Hocker 2013 elec. comm.).

One can get lost in the cryptic etymology of ship terminology quite easily; for example, the English term keelson derives from "son-of-the-keel," futtock, from "foot-hook." Although ship terminology may differ even within a single country like the Netherlands, Witsen and Van Yk wrote their treatises a generation apart, and whereas Van Yk was an actual shipwright, Witsen was a cosmopolitan statesman and intellectual, with much of his treatise based on much older contracts from the 1620s and 1630s (Fred Hocker 2013 elec. comm., Hoving 2012). Despite these multiple variations, some cognates and derivations can be found across northern Europe (keel and *kiel,* for example). It is widely known that the Dutch exported their success and skill in shipbuilding beyond Holland. Henrik Hybertson, a Dutch shipwright from Riswijk, built the Swedish warship, *Vasa*, with about half of his laborers from Amsterdam. That the English and the Dutch traded more than just goods before the first Anglo-Dutch war can be found among influences in ship construction, and even terminology.

Early English Naval Architecture

Henry VIII took a keen interest in artillery, and even more so than his father, in his Navy Royal. A century before broadside tactics were executed with effect, Henry VIII demanded his great ships carry his equally impressive artillery (pieces firing shot from 18 to 60 pounds!). The king's master shipwright, James Baker, had the idea of putting the "gun deck" between the cargo and upper deck, cutting square gun ports (as opposed to French round ports) in the ship's side. By the 1530s, English builders began to add gun ports to the main deck as well, allowing the heavier pieces to remain closer to a vessel's center of gravity. This in part encouraged the adoption of carvel style planking, as the heavier framing and far thinner planking made cutting holes in the hull far more practical (not that it was not tried, unsuccessfully, on more than one carrack). The adoption of carvel planking meant a relatively rapid transition to frame-based construction in English shipyards before the mid-16th century (Nelson 2001:36-38). Sixteenth-century English shipwright Matthew Baker, considered a genius by contemporary John Davis, was the first Englishman to pen a treatise on how ships ought to be designed and built. In 1562, authorities designated Baker a master shipwright, then a royal master shipwright just ten years later. By 1605, he was the head of the "Art or Mystery of building and making of Ships" and later the first master of the Company of Shipwrights (Perrin 1918:178).

England's First Known Naval Architect: Matthew Baker

Scholars estimate Baker completed *Fragments of English Shipwrightry* ca. 1586. The work is a collection of observations, tables, and drawings, comprising more than 30 geometrically defined midships sections. Baker includes methods to determine the rising and narrowing of the bottom of the vessels in the central portion. When Baker died in 1613 (the age of 89, overseeing a rebuild), he left the work to his understudy, John Wells. The latter part added by Wells deals chiefly with geometric calculations and logarithms ca. 1610 (Fred Hocker 2013 elec. comm.). It is the earliest known English work on naval architecture. Baker does not discuss which woods or materials best make a ship; he does not even discuss structure. The work is purely mathematical conjecture. Some interesting natural elements are included, such as the derivation of the ideal hull form from the body of a fish (see FIGURE 39).

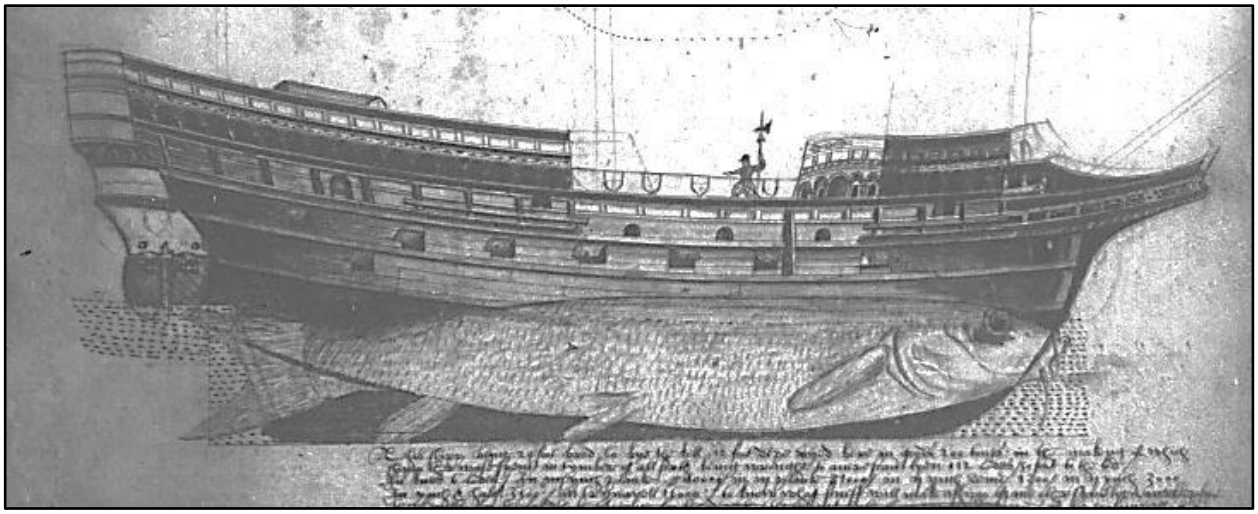

FIGURE 39. The famous head of a herring and tail of a cod drawing, from *Fragments*. (By Baker, 1586; courtesy Madgalene College, Cambridge University)

It is possible to glean some general structural features distinct to late 16th- and early 17th-century English ships from a few drawings. The revolutionary contribution of Baker's *Fragments* (half the collection comprises of drawings, a total of 160 pages), was the movement from the design of a vessel from a model to paper (see FIGURE 40). Baker's calculations were far more intricate than his Iberian contemporaries. This ultimately led to better hull design and better ships: the celebrated race-built galleons that gave the Spanish Armada so much trouble were of a sleeker, English design. Elizabethan shipwrights soon abandoned Henry's archaic great ships and towering castles bristling with guns (see FIGURE 41). The English penchant to design for speed under sail lasted well over a century.

A 1559 list named Baker along with two other principal shipwrights, Peter Pett and Richard Chapman. Pett died in 1589, succeeded by his sons Joseph and later Phineas. The Petts, of course, continued a long legacy of shipwrightery, though little is known about Chapman (Oppenheim 1896:151-152).

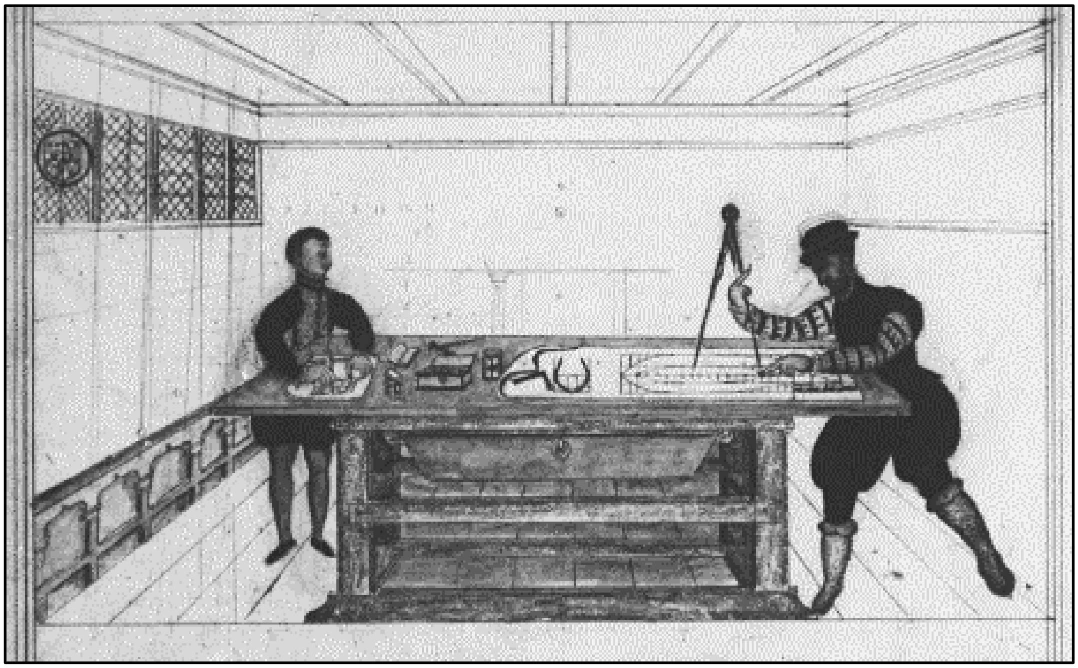

FIGURE 40. A master shipwright and apprentice illustrated with the representative tools of their trade. (By Baker, 1586; courtesy Madgalene College, Cambridge University)

Baker shows up in the navy record in 1562 on the Deptford Ordinary; he and Peter Pett are listed as the only two master shipwrights, paid £4 16s., and £5, respectively (Hattendorf et al.1993:125). Historians credit Baker with developing a new method to calculate tonnage in 1582. The simple formula was to multiply a ship's breadth by its depth and multiply the product by the length of the keel (B x D x K), the end product to be the divisor. Divide by 100 and the result is the tons burden. To calculate measured tonnage, one third was added to the tons burden. Thus, "*Ascension*… being in breadth 24 feet, depth 12 feet… by the keel 54 feet" comes to 15,552, divided by 100 yields a burden of 160 tons, add one third and her measured tonnage is 213 1/3. (Montgomery MS in Oppenheim 1988:132). Baker must have rounded, to get 160 tons one must divide 15,552 by 97.2.

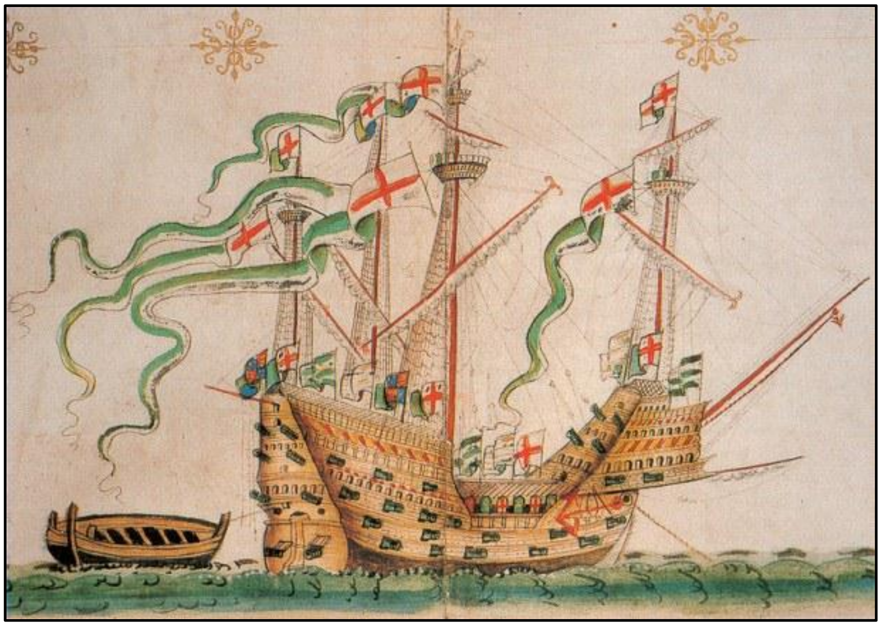

FIGURE 41. Sister ship to *Mary Rose*, *Peter Pomegranate* (*note the towering castles and heavy armament*). (From the *Anthony Roll* ca. 1540s)

By the last quarter of the 16th century, ship design had changed; the fighting castles (see FIGURE 42) of bygone were reduced. Though Pett enjoyed a grander reputation and legacy, more than one qualified judge, including Pett, considered Baker his superior (Perin 1918**)**. Explorer John Davis praised him "for his skill and surpassing… knowledge in the building of ships… not in any nation [exists] his equal" (*Seaman's Secrets* in Oppenheim 1988:152). The two masters became bitter rivals under the supervision of John Hawkins, who eventually edged them out of later contracts (Oppenheim 1988:162). The use of superior English gunnery and faster ships in staving off the Armada in 1588 testified to the success of race-built galleons (see FIGURE 43 and FIGURE 44) (Martin and Parker 1989:203). Baker, surprisingly, did not leave the sort of legacy spawned by his rival Pett, whose descendants dominated royal shipyards and ship design for generations. This continuity may reflect both professional success and perhaps fecundity, but not necessarily perfection.

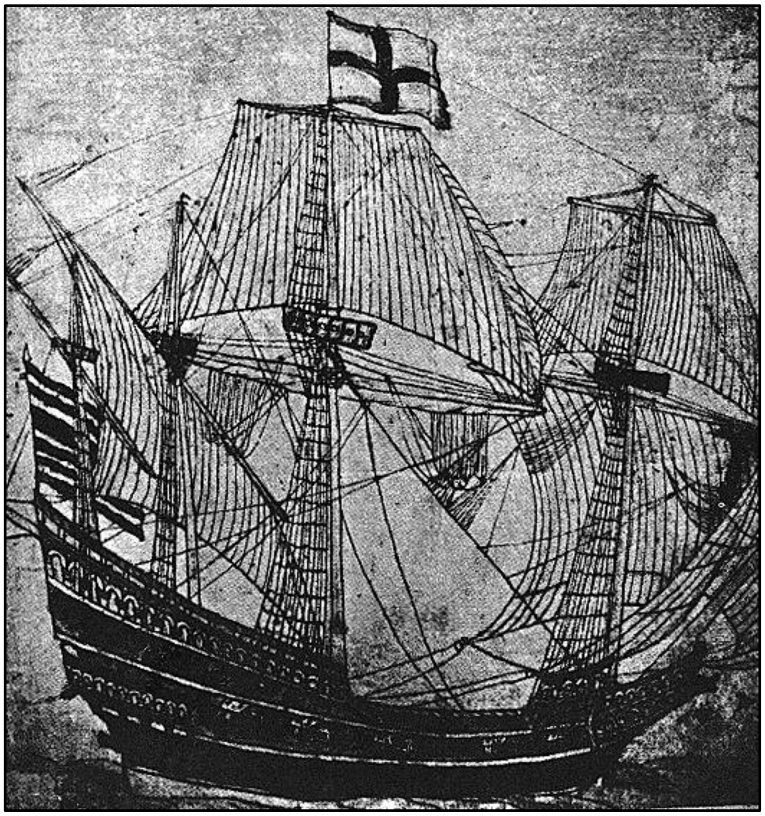

FIGURE 42. An Elizabethan galleon from 1570, the *Tiger* or *Bull.* (Author unknown, from Oppenheim 1988)

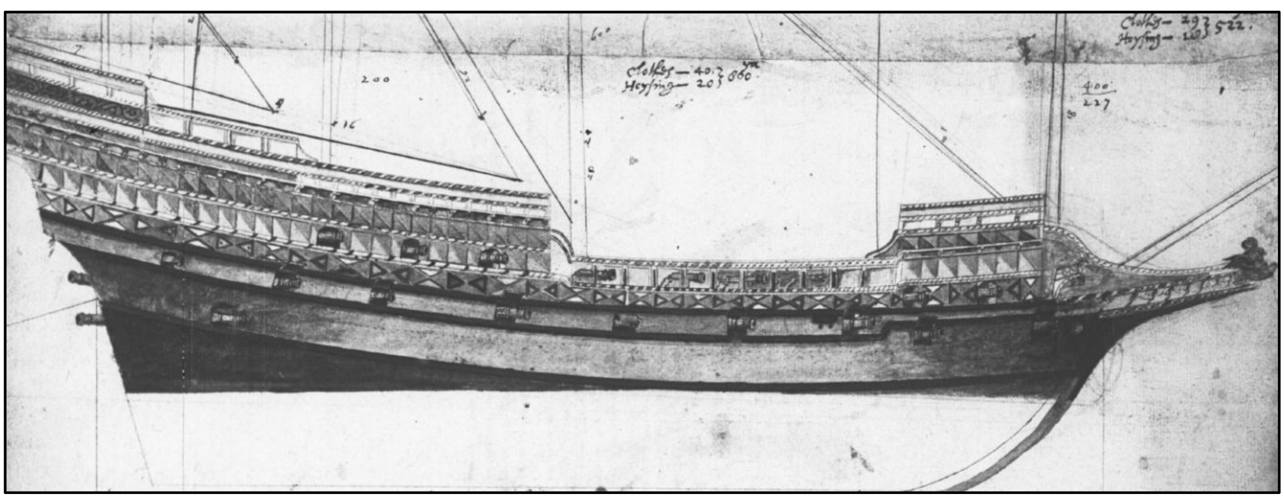

FIGURE 43. This design foreshadowed the two-decker 70 and 74 guns ships that became the mainstay of the Royal Navy for centuries. (By Baker, 1586; courtesy Madgalene College, Cambridge University)

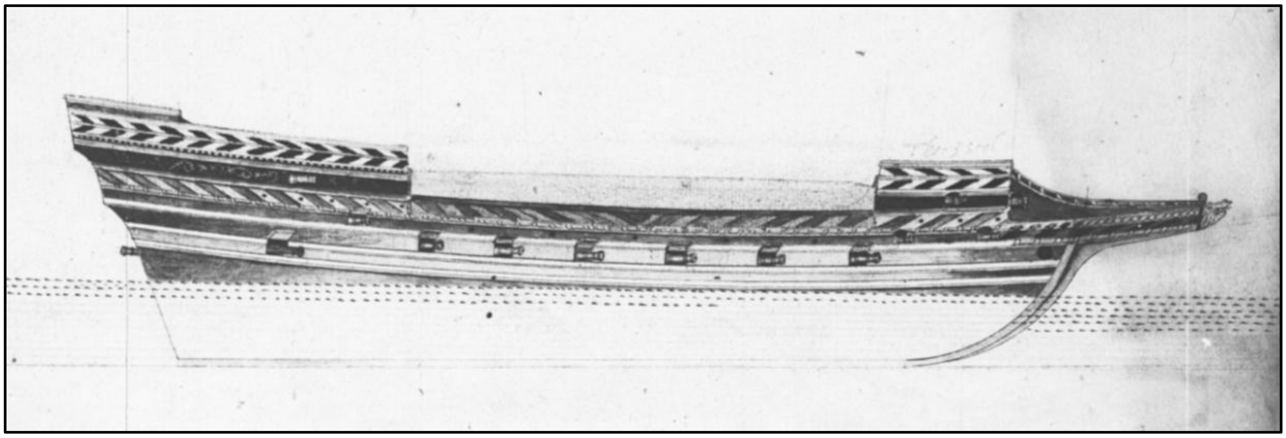

FIGURE 44. Another race-built galleon from Baker, essentially a frigate before rated ships even existed. (By Baker, 1586; courtesy Madgalene College, Cambridge University)

Though Baker never discussed structure beyond the mathematical, he provided several scaled drawings. From these, certain dimensions can be lifted. The cross-section (see FIGURE 45) shows a midships section with a worker carrying a knee to be installed. From the scale, the molded dimension of the floor appears to be 1 foot (30 cm). The floor is notched to receive the keelson, which is a little over 1 foot sided and just less than 1 foot molded. The floor rider is molded 2 feet (61 cm) at midships, is notched over the keelson, then 1.5 feet with a 6 inch chamfer, running 14 feet (4.27 m) either side of the keel atop the floor (the rider actually terminated a few inches shorter on the right).

Another detailed drawing shows the basic skeleton of a frame-based English vessel (see FIGURE 46). Using Baker's scale (not shown), the following dimensions can be determined (see By Baker, 1586; courtesy Madgalene College, Cambridge University)

TABLE 11). The keel is molded 12 inches (30 cm), approximately 60 feet long. The stem 29 feet long, made of three pieces, sided 12 inches where it joined the keel, 18 inches (45 cm) at its head.

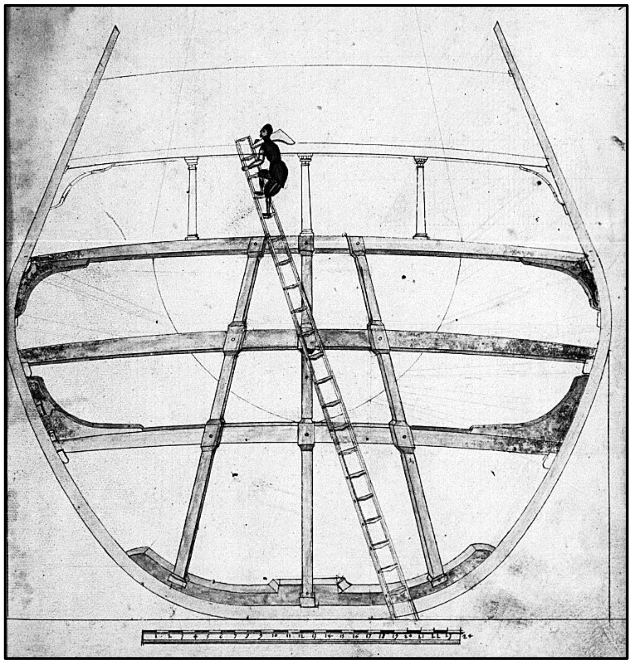

FIGURE 45. One of the more detailed midships sections from *Fragments*; note the use of perspective projecting the vessel's stern interior. (By Baker, 1586; courtesy Madgalene College, Cambridge University)

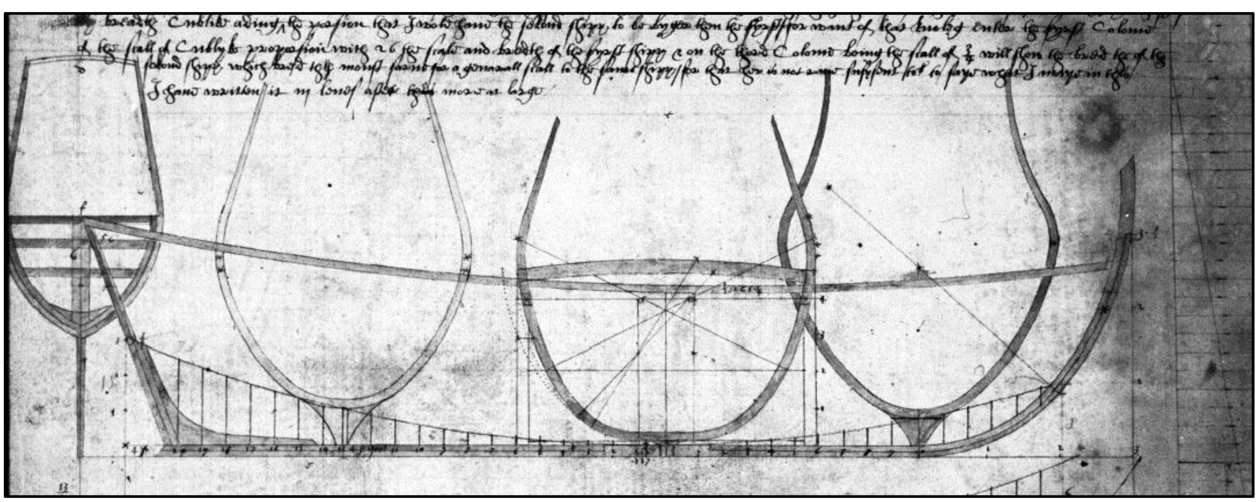

FIGURE 46. From *Fragments*, the only schematic drawing of a ship's skeleton in the work. (By Baker, 1586; courtesy Madgalene College, Cambridge University)

TABLE 11. DIMENSIONS FROM BAKER'S PLAN.

Scantling	**Feet**	**Meters**
Keel	60	18.29
Stem	29	8.84
Stern Post	19	5.79
Transom	12	3.66
Aft Tail Frame	20	6.10
Midships Frame	23.5	7.16
Forward Tail Frame	23	7.01

The master midships frame is molded 12 inches at the floor and the turn of the bilge and the top timbers are molded 6 inches (Baker 1586:21). The English foot of 12 inches was used as the standard for shipbuilding in England, hence the dimensions above roughly being units of 6, 12, 18, or 30 inches. This is, of course, a drawing; how vessels took form and dimension never went strictly by plan. Even the more meticulous English builder could not escape Witsen's warning about proportional guidelines, figures as a basis, and so forth. Regardless, Baker's contribution to naval architecture remained unparalleled for nearly a century, when a new generation of shipwrights returned to the drawing board to employ arithmetic and geometry to build better ships. Before Pepys's day, other experts contributed their knowledge to the technical aspect of ship construction, but few ever measured up to Matthew Baker.

The Sea-Man's Dictionary

Though several documents following Baker's treatise exist, none of them have been digitized or published (including Baker). These include the Scott manuscript ca. 1600, possibly authored by Phineas Pett, Newton's anonymous manuscript, also ca. 1600, Thomas Harriot's manuscript, and John Wells's *Treatise on Shipbuilding and A Treatise on Rigging*, ca. 1620-25. The next work devoted to English ships came from a pardoned pirate, knighted captain, and retired admiral with extensive seafaring experience. Sir Henry Mainwayring wrote the first known substantial English treatise on seamanship in 1623. Though it was not published until 1644 (see FIGURE 47), it freely circulated among naval commanders at the time of its composition (Oxford DNB 2013, Royal Museums Greenwich 2013). In his introduction, Mainwayring explains his purpose for writing his book was not to instruct those with equal or greater experience than himself, but to educate those who "cannot…gain knowledge of Termes, Names, Words, the Parts, Qualities and manner of doing things with Ships, by long Experience" (1644:1).

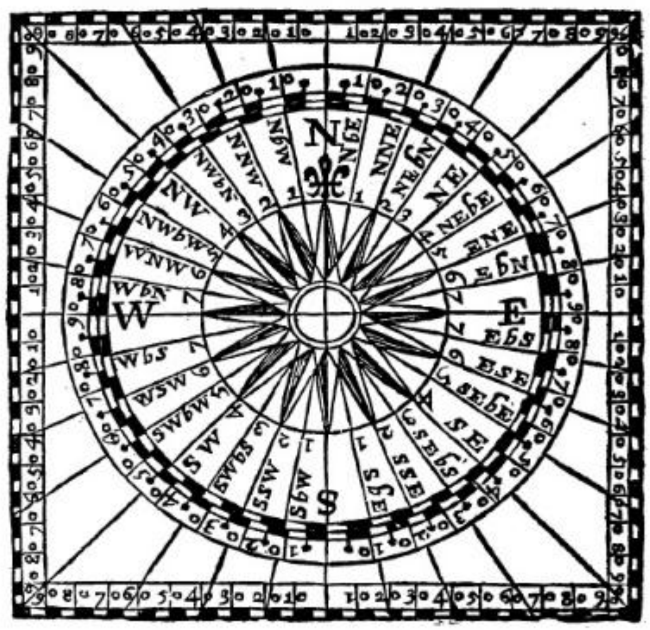

FIGURE 47. A compass rose from the frontispiece of the 1667 reprint of Mainwayring's dictionary, appropriate given the empirical nature of his knowledge. (By Booker, 1644)

At the end of his preface Mainwayring also comments on the value of his dictionary to the ordinary seaman or gentleman who went to sea, both of whom he refuses to forgive for what he viewed as willful ignorance of navigation and nautical terminology. Mainwayring neither discusses ship design nor provides formulas and calculations; rather, his is an empirical, alphabetized guide to nearly every ship part or feature, including rigging, ordnance, and navigational terms. The book was reprinted multiple times after Mainwayring's death in 1653. The 1667 edition contains a postscript that offers advice for everything from weighing anchor, to multiple sail handling scenarios, finishing with a detailed account of a man-of-war engaging and taking another vessel as a prize, with layman (or rather, lubber) interpretations of nautical jargon in tidy parentheses (Mainwayring 1667:125-132). Authorship of the postscript is dubious. The most likely contributor being Samuel Sturmy, another writer on seamanship and author of *Mathematical and Practical Arts*, 1669. Mainwayring's contribution was a simpler document by far than Baker's, a pragmatic one. It is an invaluable resource to the maritime historian and the nautical archaeologist.

Of specific interest are Mainwayring's explicit definitions of the keel, stem, sternpost, floors, futtocks, rabbet, garboard, lower hull strakes, and treenails—the remnants (if one is lucky) one typically finds as the wrecked remains of a ship. They are examined in that order. First, the keel "is the first timber which is laid of a Ship, and is the bases [basis] whereon all the rest are fastened [and] at the one end… is scarffed in the Stem, and at the other…the sterne-post" (Mainwayring 1644:55). Mainwayring further adds that to the keel all "ground timbers [floors] and hooks [futtocks], fore and aft [are bolted] and on them… upper-works are raised" (Mainwayring 1644:55). The author believes he is referring to all floors and futtocks (or in this case, half-frames) along the length of the ship, and not fore and aft iron fasteners.

Second, "the Stem of the ship, is that great timber… compassing from the Keel… up before the fore-castell," explaining it may consist of more than one piece, as was common of "great ships" (Mainwayring 1644:100). Mainwayring does not give sternpost its own entry; rather he describes the stern as simply the aft-most-outside end of the ship. In a separate entry devoted to scarfing, he refers to this as the preferred method of assembling a keel from more than one timber, what he described as “wood and wood,” as in equal portions of the timber ends removed to create a solid joint (Mainwayring 1644:80,88). After the stem, Mainwayring details the frames:

> *Floor.* The floor of a ship, is… the bottom of her, as she doth rest upon when she is a-ground… those which have long and broad floors, lie fast and safest with the ground… (see “ground-futtocks” below) (Mainwayring 1644:41).
>
> *Futtocks.* This word is commonly pronounced, but I think more properly it should be called Foot-hooks; for the Futtocks are those compassing timbers, which give the breadth and bearing to the ship, which are scarfed to the ground-timbers: And because no timbers that compass, can be found long enough, to go up through all the side of the ship, these compassing timbers are scarfed one into the other, and those next the Keel, are called the lower ground Futtocks [half-frames], the other are called the upper Futtocks (Mainwayring 1644:43).

Moving from framing is Mainwayring’s description of planking: rabbetting “is the letting-in of the Planks to the Keele, which is a little hollowed away, that the Plank may joyn in the better, and closer to the hookes and the Keele,…. the hollowing-away is called the Rabbet of the Keele” (Mainwayring 1644:80). From the rabbet to the garboard: “the first plank, that is brought on… the keele,” the garboard-strake defined as the first seam of planks next to the keel (Mainwayring 1644:44). Mainwayring has no specific entry for planking, hull or ceiling. He defines a strake as “a seam betwixt two planks” (1644:102). Fortunately, Mainwayring mentions treenails and explains their importance at length:

> *Tree-nells.* (*Quasi* nails are made of tree) Are the long wooden pins made of the heart of Oak, wherewith they fasten all the planks unto the timbers, for though we bolt the bulk-heads for the better assurance and strength, yet the tree-nells are they which do most fasten the planks (for we do use as little Iron underwater, as we may conveniently, lest the ship should grow Iron-sick.) These tree-nells must be well seasoned, and not sappy, for then the ship will be continually leake, and it will be hard to find [the leak]... (Mainwayring 1644:109).

The Oxford English Dictionary (2012) defines "Iron-sick" as, "Said of a wooden ship when her bolts and nails are so corroded with rust that she has become leaky." In actuality, it was the deterioration of the wood around the metal fasteners that die the most damage (Fred Hocker 2013 elec. comm.).

Scholars can garner a wealth of information from Mainwayring's *work*. His explanation of "Foot-Hooks," for example preceded the later spelling (as in Smith, below) of futtock. Likewise, his spelling of "Gard-board" yields a better understanding of the origin and later standardized spelling of the part and its function. He does not discuss ceiling but defined "Seale…to make fast…any ropes together," and then states that it is a general term that implied "binding any thing together, so as they cannot slip out…" (Mainwayring 1644:88). It is, perhaps, a misspelling of seize? Most useful is his lengthy explanation of treenails, a ubiquitous feature on northern European vessels. Mainwayring was the first Englishman on record to announce the English preference for wooden fasteners below the waterline, as opposed to the Iberians or French who much preferred iron fasteners for their strength (Mainwayring 1644, in McCarthy 2005:64,81**)**. From Mainwayring it is possible to get an early 17th-century English definition of major scantlings, joinery, mast arrangements, even a *marling-speeke* (Marlinspike is an Anglicization of the Dutch *marlingpriem*, a "pack-cord," or "marling spike" (Sewel 1708:265)). Illustrations would undoubtedly improve Mainwayring's contribution to standardizing nautical and ship-related terminology, but contemporaneously that information would mostly serve a shipwright, the kind of person for whom the work was never intended. His commentary on *Flemmings'* preferences interspersed throughout the work reflected the consciousness of the increased rivalry between England and the Netherlands.

John Smith

Before Mainwayring actually engaged John Bellamy of London to publish his work in 1644, the phlegmatic and famous Captain John Smith (see FIGURE 42) published his own version in 1626 and 1627. That he borrowed heavily from Mainwayring is putting it lightly—such was the practice of most 17th-century writers, even the Bard himself. Smith, a former admiral and sometime governor, was not a shipwright but felt sufficiently authorized to put forth *A Sea Grammar* in 1627. In it, he relates his advice to "the Reader, And all worthy Adventurers by Sea, and well-wishers to Navigation" (Smith 1627:a). The short book is an expansion of his 1626 *Accidence for young Sea-men,* arranged in 15 chapters, the contents of which are often directly lifted from Mainwayring's dictionary of 1623.

FIGURE 48. Captain John Smith, *National Portrait Gallery*. (Courtesy Smithsonian Institute, Washington, DC)

Fortunately, for his readers, Smith includes a table of contents based on their folio and chapters. Among the myriad of topics Smith offers, only chapter 2, “How to build a Ship, with the definition of all the principals of every part of her… also how they are fixed one to another, and the reasons of their use,” concern this study.

As expected, he begins with the keel, “a great tree or more, hewn to the proportion of her burden.” The keel is scarfed at one end to the stem and at the other the sternpost (Smith 1627:2). In a somewhat orderly fashion, Smith proceeds to describe the fashion pieces, the “ground timbers, [which] do give the Floor of the Ship, being straight, saving at the end they begin to compass, and here they are called the Rungheads.” The floors (see FIGURE 49), says Smith, “direct the Sweep or Mould of the Foot-hooks [futtocks] and Naval Timbers.” In an almost direct quote from Mainwayring’s definition, Smith states these gave the “compass and bearing of a Ship, those are Skarfed into the ground Timbers,” scarfing as “so much wood cut away from the one as from the other.” He elaborates about the futtocks, describing those next to the keel as “ground Foot-hooks, the other upper Foot-hooks,” but instructs that “first lay your Keelson over your floor Timbers,” bolting it through the floors, “that when the Foot-hooks are scarfed as is said, and well boulted, when they are planked [ceiling?] up to the Orlop they make the Ship Howle” (Smith 1627:3). Smith does not specify hull or ceiling planks, his only reference to “sealing” being to “bind fast any ropes together, with some small ropeyarne” (Smith 1627:25). This, like his definition of the garboard, is direct from Mainwayring. The “garboard…the first plank next to the Keel on the outside, the Garbord Strake is the first seam next the Keel.” Then he returns to discussing floors and futtocks as the “rising timbers…the hooks, or ground timbers and foot-hooks…rise by little and little, so doth [give] the Run [rising and narrowing] of the ship.” (Smith 1627:3). What is important about Smith’s work, despite his flagrant use of Mainwayring's book, was that it was published *first*. This basic description is among the earliest accessible works in English laying out how to construct a vessel. Like Mainwayring, Smith does not give specific dimensions, proportions, or calculations for drafting midships sections, the rake of the stem, etcetera, though he gets heavily involved in the mathematics of war conducted with ordnance, something with which he had extensive experience. Basic as it is, it reiterates the origins of terms like futtock. Smith's sparse description of the hull assembly may reflect his limited experience in the construction of the skeleton of a ship as opposed to its outfitting, repair, navigation, or use as a fighting platform. With Mainwayring and Smith and covering the early half of the 17th century, naval architecture continued to grow into its own with several treatises appearing a few decades later. These, like Baker's and Wells's, returned to mathematics as a logical approach to determining hull shape.

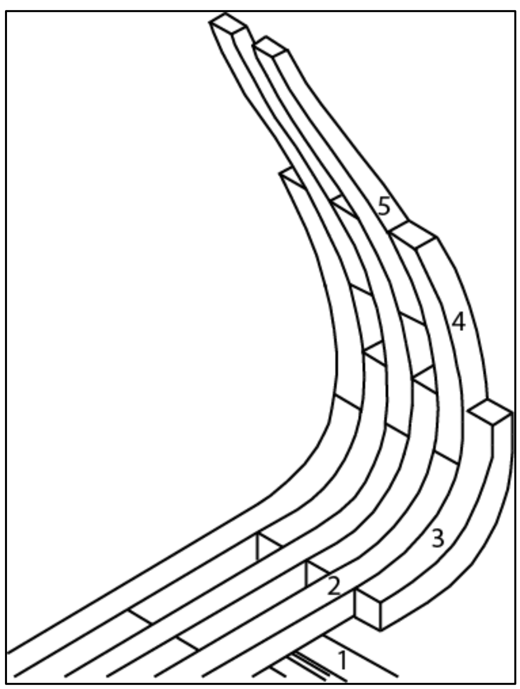

FIGURE 49. Smith's text interpreted: keel (1), floor (2), ground-futtock (3), upper-futtock (4), naval timber (5). (By Author 2013, after Batchvarov 2002)

The Compleat Ship-wright and *Mariners Magazine*

Edmund Bushnell and Samuel Sturmy were among the many post-Restoration scholars who sought to redress the demand among yeoman farmers and "practitioners of mechanical arts for handbooks…disseminating theoretical skills like arithmetic (Hunter 1981:109). In 1664, Bushnell published his treatise citing a strong national interest in his trade, that his treatise was "written only for the good and profit of my Country-men," men "ignorant of what they should know in their Trades, and desire instruction"(Bushnell 1669:i). In an introduction similar to Mainwayring's, Bushnell explains he did not intend to tell experienced, successful shipwrights (namely royal shipwrights) how to conduct their trade. Bushnell's background was rather difficult to pinpoint. English science historian Michael Hunter has listed him as part of the Royal Society in the 1660s, one of many members with "expert knowledge of their chosen topics" (1981:109). Bushnell did not seek to innovate how ships were built, rather, he sought to dispel the mystery of the "Art" for those kept ignorant by their masters. He proceeds in a mercantile vein, expressing a desire to educate carpenters beyond their mere ability to "Hew, Dub, or Fay a piece when it is Moulded to his place assigned." Bushnell attempts to present opportunity for those carpenters who wished to venture to "Virginia, or New-England, or the like countries" but were prevented from doing so owing to their ignorance and inability to operate without a master. He finishes with a claim that these targeted readers "should find instructions sufficient for Moulding of any Ship or Vessel… drawing of Draughts… if they can but read English, and have the benefit of a little Arithmetick, as Addition, Subtraction, Multiplication, Division" (Bushnell 1669:i).

Bushnell begins with a series of four geometric problems in increasing complexity but still simple in nature. He devotes chapter two to the making of the shipwright's scale (Bushnell

1669:1-4). In chapter three he instructs piecemeal how to draw the draught upon paper (see FIGURE 50), giving directions for the drafting of vessel with a 60 foot (18.3 m) keel and 20-foot (6.1m) beam. He begins with the keel as a straight line between points A and B, AC drawn as the sternpost with much explanation as to its height's structural role. Bushnell then explains the stem, describing it "is not so much racked as was the old proportion of England,…20 foot… no more than 15 foot, just 3/4 of the breadth," going at length about the dangers of too much rack (rake) and the benefit of keeping as much of the rake underwater (Bushnell 1669:5-6).

Chapter four continues with Bushnell employing the exercises covered in chapter one to show how to "sweep out the Bend of Moulds," using a system of parallels and sweeps. He comments on the "old Proportion," in a vessel of 20 foot breadth would give the breadth of the floor 8 feet (2.44m), more than the contemporary standard of one third of the breadth, 6 feet 8 inches (2.03m). After extraneous commentary on the benefit of erring with more breadth than less, he adds diagonals, draws in the arcs signifying the turn of the bilge, the sweep above the waterline, and tumble home (see FIGURE 51) (Bushnell 1669:7-9). Compared to his contemporary, Sir Anthony Deane, Bushnell's drawings and appear rather rudimentary, his hull shapes reminiscent of earlier 17th-century designs, perhaps lifted from copies of Baker and Wells. Bushnell continued his discourse on mathematics with simple explanations peppered with commentary about how design affects the sailing quality of a vessel.

Bushnell covered rising and narrowing by various means, "Arithemetically shewing how to frame the Body of a Ship,"(though he did not mechanically describe such a process). He explained how to extract square roots, described the use of table squares, how to measure ships, and finished his discourse on design with a chapter on masts.

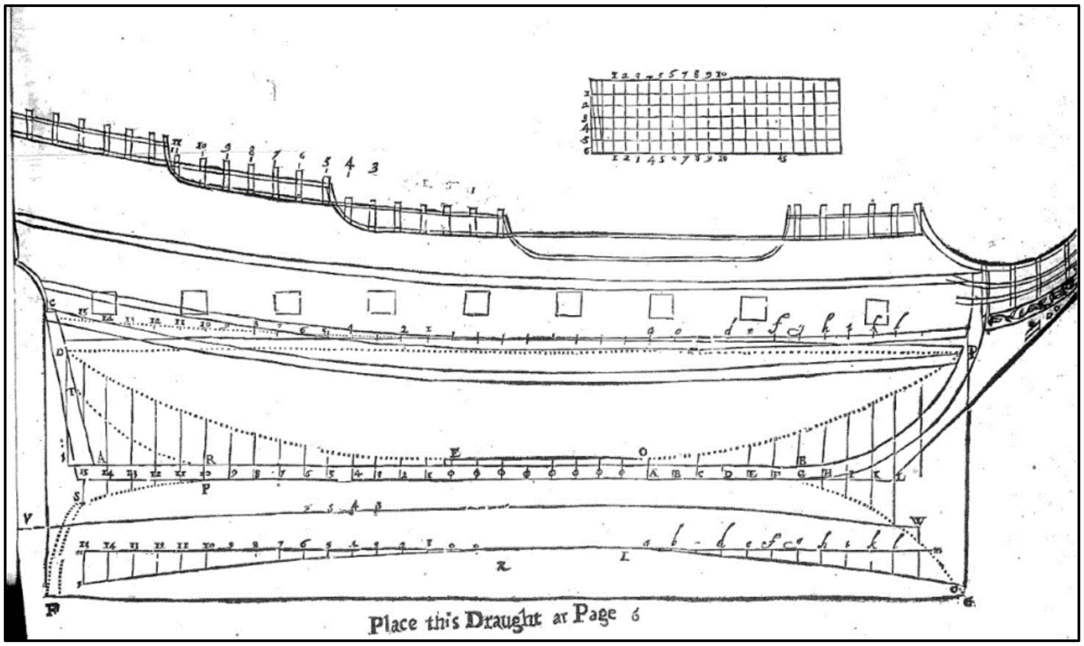

FIGURE 50. The completed draught. (By Bushnell 1664)

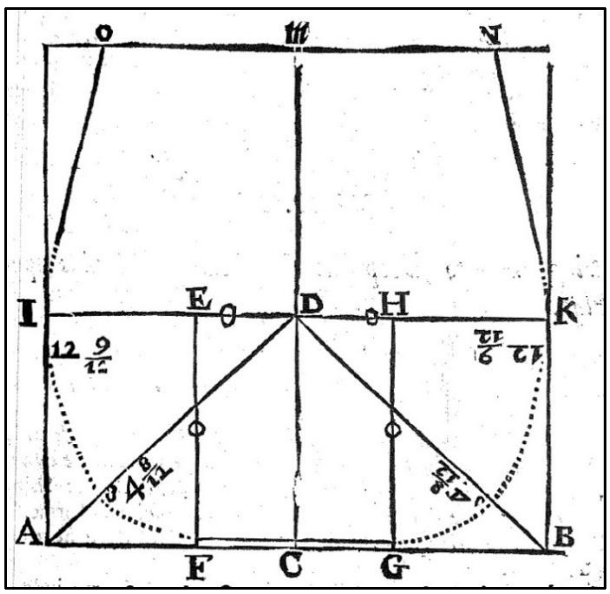

FIGURE 51. The completed midships section for a vessel with a 60 foot keel. (By Bushnell 1664)

In a renaissance flair of invention and ego, the final chapter has nothing to do with designing ships, but is a contrivance on how to row ships mechanically when they were becalmed by using the capstan as the engine for such a device. It is a clever concept, with a crude schematic (see

FIGURE 52) included with explanation and calculations on the efficiency of such a system foreshadowing by 100 years the future of ships driven by neither brute force or wind, but mechanical propulsion. Not nearly as refined as Baker's work, Bushnell was perhaps ahead of his time in desiring to educate English shipyards with pragmatic, simple means of designing better sailing ships for the good of England. Whatever his motivation, his book was a success. A third printing appeared in 1669.

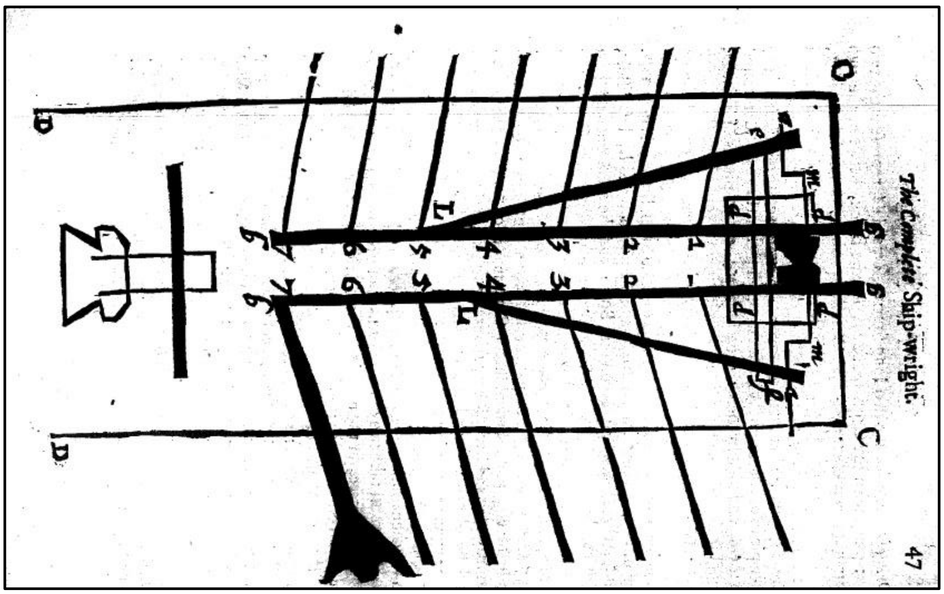

FIGURE 52. A drawing of a "means of Rowing of a Ship, by the heaving at the Capstain." (By Bushnell 1664)

Bushnell's fellow Royal Society member, Captain Samuel Sturmy, published a much lengthier compendium the same year of Bushnell's third printing. Starting out as sailmaker and ending his brief life as captain and member of the Society of Merchant Venturers, his aim was to provide his sons, brothers, and young seamen with everything they could possibly need to know, so long as they could read and perform some arithmetic (McConnell 2013).The work ranges far beyond the details of compass, tides, and working the ship, as displayed on its title-page:

> The description and use of the scale of scales … the art of navigation … a discourse on the practick part of navigation … a new way of surveying of land … the art of gauging all sorts of vessels … the art of gunnery … astronomy … the art of dialling … whereunto is annexed, an abridgement of the penalties and forfeitures by Acts of Parliaments… relating to the customs and navigation (Sturmy 1669).

To this Sturmy addes a compilation devoted to fortifications, contributed by Philip Staynred, the Bristol teacher of mathematics, and a set of Briggs's log tables, augmented by Sturmy himself (McConnell 2013). While Sturmy's work was a grand contribution to the mariners for whom it was intended, he deals little with structural design of the vessel. He warrants mention as he published his work just one year before Sir Anthony Deane wrote his *Doctrine,* and though he did not live to see its success. Sturmy died in July 1669 just four days after visiting a lead mine to inspect the tides of an underground river (McConnell 2013). The circumstances and symptoms surrounding his death resemble a case of the "bends" or decompression sickness. His work went on into a series of revised editions, the fourth published in 1700 (McConnell 2013).

Deane's *Doctrine*

Following on Bushnell's and Sturmy's success, Anthony Deane (FIGURE 53) wrote his *Doctrine of Naval Architecture* in 1670, according to Deane, "at the instance of Samuel Pepsy Esq" (Lavery 1981:21). Deane sought to enlighten his fellow shipwrights, many of whom were innumerate, even in royal shipyards, to the benefits of employing arithmetic and geometry in designing ships (Lavery 1981:7,33) —something that would ultimately benefit Pepys as well. At the age of 22, Deane was appointed assistant master shipwright in Woolwich Dockyard. At their first meeting two years later, he made a significant impression on Samuel Pepys, which landed him the position of master shipwright of Harwich in 1664, and master shipwright at Portsmouth in 1668 (Pepys 1662:144; Lavery 1981:7). The two, for good or bad, became lifelong friends. It was at his Portsmouth post that he penned his *Doctrine*. Like Baker or Bushnell, Deane said little of the actual construction or parts of a vessel; rather, he was concerned with the mathematical conceptualization and series of proportions aimed at creating a fast, stable, weatherly ship.

FIGURE 53. Sir Anthony Deane, by Sir Godfrey Kneller. (Courtesy the *National Portrait Gallery*, London)

Deane dividesd his text into three parts: rigging, arithmetic, and hull design, and he was explicit. In typical 17th-century style, a single sentence explains that the first stroke “is the line of the keel,” to draw it according to one’s scale, to be sure to leave room for the bow and stern and half breadth, and if the paper or board is not big enough, draw a smaller keel, or use a different scale (1670:37 in Lavery 1981:52). Three lines paraphrase Deane’s 125 word sentence. True to his introduction, Deane leaves “nothing unfolded which may advance anything to the meanest capacity” (Deane 1670:1 in Lavery 1981:21). Truly, in only a few of his instructions does Deane skip a step, such as in “To draw a bend of timber in the midships,” (see FIGURE 54) a valuable ability in any shipwright. By the fifth step, a new line appears parallel and above AB with no reference in the text whatsoever. Lavery explains it is the dead-rising, but Deane never refers to it.

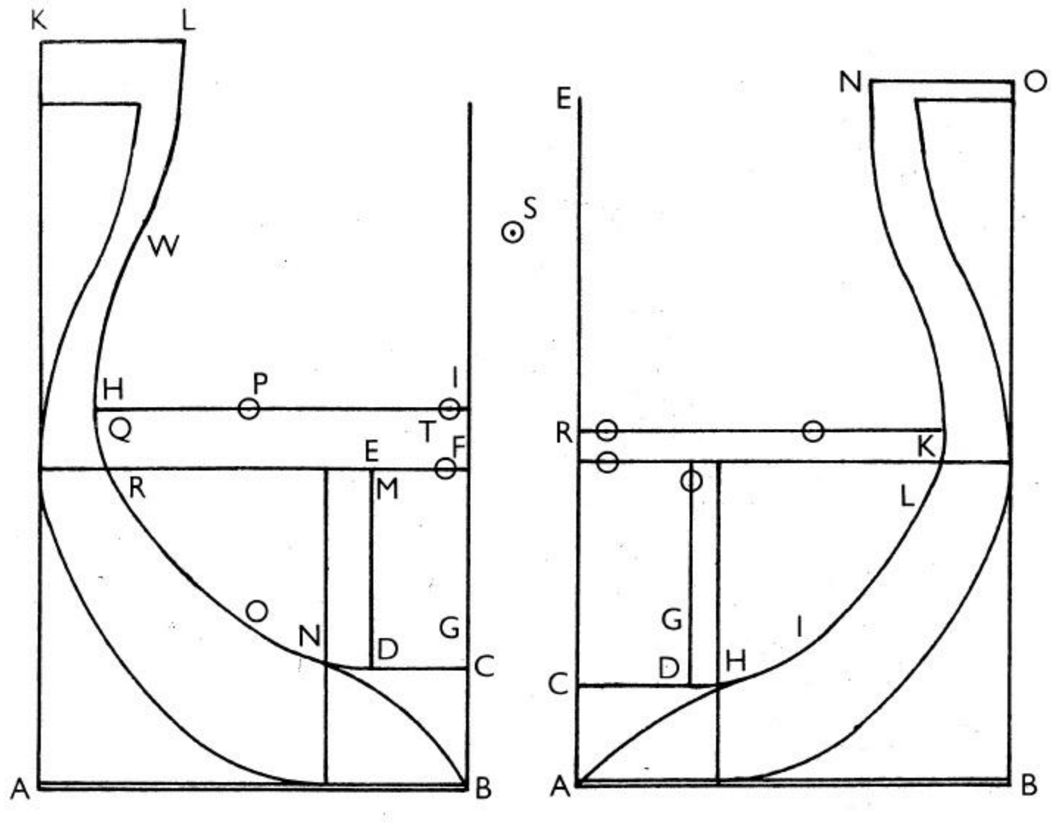

FIGURE 54. Deane's completed midships bend. (Lavery 1981:69)

At times, his math does not add up, either owing to error on the author’s part or perhaps the transcriber, as Lavery (1981:21) has noted that the text has a very conversational, instructional tone. This seems probable as Deane had a bit of a teaching streak, revealing to Pepys at their first meeting the “mystery of off-square” in measuring timber, and even at dinner together, practicing “measuring of the tables and other things, till I [Pepys] did understand measuring of timber and board very well” (Pepys 1662:144).

The use of Deane's *Doctrine* to the nautical archaeologist is encrypted in the intricate calculations of sweeps and bends. Deane based all of his proportions on the length of the keel (see FIGURE 55). Thus, by looking at hypothetical midships sections, one might try to reverse engineer such a dimension. Deane did not discuss the fabric of shipwrightery, neither the wood, nor the scantlings, as individual parts. Yet Deane was no armchair draughtsman; his introduction to Pepys involved the hewing of the king's lumber. In 1677, he scoured England for quality wood to build the commissioned 30 Ships—an impressive feat given the scarcity of fine wood after the English Civil War, three Dutch Wars, and the Great London Fire (Lavery 1981:8). To the naval historian he gifts an in-depth list of actual vessels, the price of their hulls, number of stores and men, rigging, victualing, and wages, and full charge for six months ready fixed for sea. His 70-gun 3rd Rate design remained the standard until 1755 when they were replaced by 74s (see FIGURE 56).

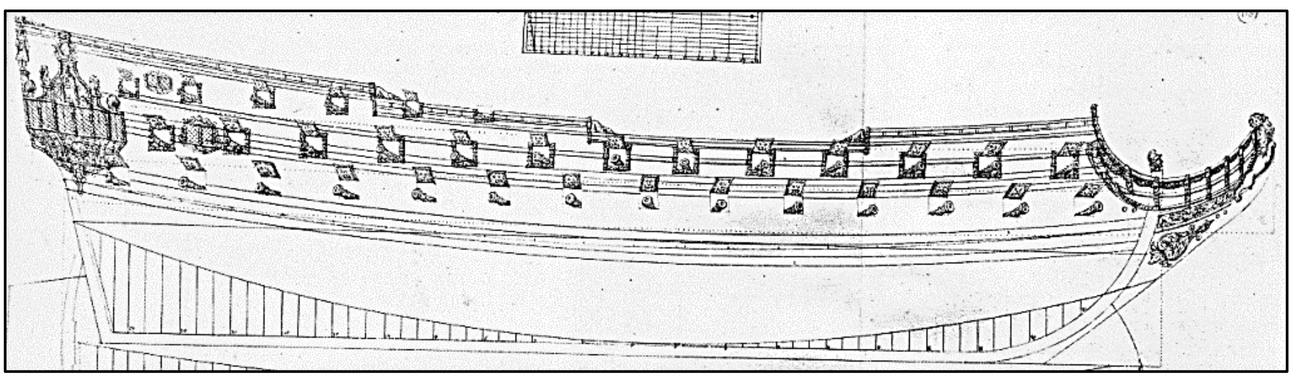

FIGURE 55. Deane's completed draught, 1670. (Lavery 1981:70)

That the man knew how to design and build ships is unquestionable. His tendency to favor sleeker, faster ships led him to build excellent frigates and yachts (see FIGURE 57), and leave a lasting legacy on the great ships, proving a ship of two gun-decks could retain some sailing ability and still house provisions for a lengthy cruise and enough guns to shatter the enemy.

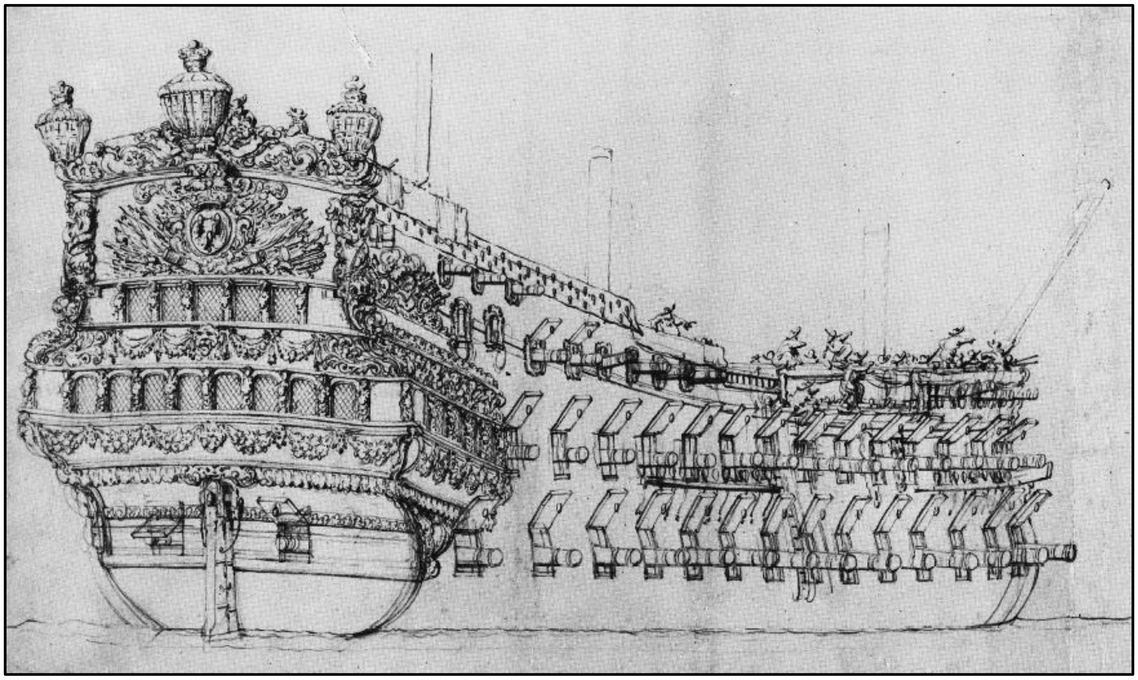

FIGURE 56. One of Deane's inspirations, the French 74-gun *Superbe.* (By Van de Velde the Elder, Courtesy *National Maritime Museum,* Greenwich, London)

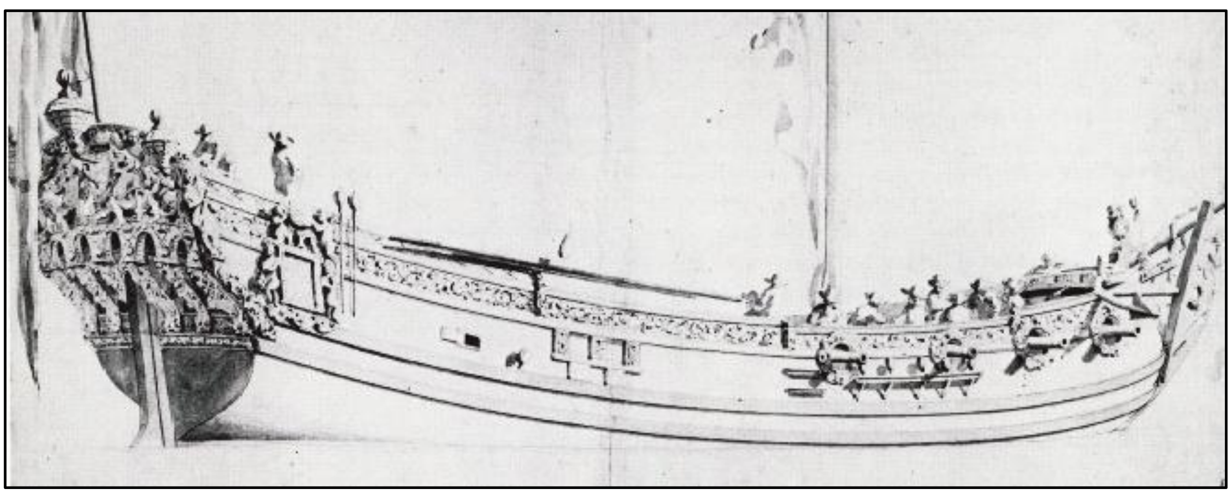

FIGURE 57. Deane's royal yacht, *Charles*, built 1675. Deane never shook his Commonwealth days tendency to favor smaller, faster ships. (By Van de Velde the Elder, Courtesy *National Maritime Museum,* Greenwich, London)

Conclusion

The late 1660s and early 1670s experienced a burgeoning interest in naval architecture and ship construction, similar to Iberian publications in the late 16th and early 17th centuries. It is no accident that Bushnell's third printing, Deane's *Doctrine*, the *Album de Colbert*, and Witsen's treatise were all completed within two years of each other. Improvements in naval artillery production led to changes in ship construction techniques that coincide with the publications. These changes were modest (compared to the 16th century), mostly technical improvement (chocks, double frames, and greater efficient use of timber stores) on consistent design concepts from the early 17th century. They were significant, however, in that they allowed for larger ships able to carry greater firepower. As European navies struggled and competed for dominance on the ocean seas, so the men who designed such their vessels also competed for contracts, posterity, and successful designs to forward the mercantile and military interests of their respective nations. As observed, most shipbuilding treatises actually dealt very little with *construction*, rather than design concepts and philosophy. Oliveira (1580), Smith (1626), Witsen (1671), and the anonymous author of the *Album de Colbert 1670,* provided the most specific information on the actual assembly of a vessel. The written descriptions were informative, but the illustrations literally showed parts of the ship, joined or free. Witsen and Van Yk both provide numbers in the way of tables (some of Van Yk's were copied direct from Witsen), but neither explored the benefit of geometric calculation to ship design. They did, however, address timber sources, and other key naval stores such as sailcloth and tar. Baker, Fernandez, Bushnell, and Deane delved more into the mathematical side of ship construction. At times authors discuss materials, but never at length. Deane, for example, did not tell his readers where to find their timber, which tree to select, which type of wood, or how to hew it and shape it to the desired shape, even though he was quite knowledgeable about such things.

Most treatises yielded insufficient information when comparing design concepts with archaeological facts. Making out a keel, *keil* (Dutch), *quille* (French), or *quilla* (Spanish) in the archaeological record is one thing. More confusing are the variation of terms within historical documents, sometimes even in the same language. A floor timber in English (same in French, *varrangue*) was a *buikstukke* ("belly piece") to the Witsen, a *legger* ("lies") to the Van Yk. What can be called a futtock in English might be interpreted as a *sitter* ("seater"), *oplanger,* or *buikstukke* ("belly piece"), according to Witsen and Van Yk, respectively. This might also be called a first-futtock, or ground-futtock, or lower-futtock in English if joined to the floor. Beyond the turn of the bilge, whether it was fastened to another frame member or not, floating frames or futtocks were *oplangen* in Dutch, simply curved timbers that were "lengtheners," or, prolonged a ship's sides. A similar word in French, *alonger,* has nothing to do with framing but refered to deadwood atop a stern knee. The similarity was in its function, not location. A French *genouille* (root *genou*) translates to "knee" but in English, a futtock, whereas a knee in English is not part of the frame system at all.

Perhaps a Latin form for these terms would be more appropriate, as flora and fauna in scientific study are labeled. Yet, the Romans built ships their way too. What may serve the archaeologist better is not just the way in which one scantling was associated with another, but what was its function, *why* was it fashioned that way, what did it do? Seek out the reason why one timber joins another, as opposed to the fact that it does so in a very specific way. Was it similar enough to another example to be considered categorical in function, if not form? Can archaeologists agree to categorize half-frames, futtocks, *sitters,* and *oplangen* as curved-frame-pieces? To begin with, publication, digitization, and translation of extant 17th-century ship construction treatises would go far to advance the archaeological community's collective understanding of how European built ships changed throughout the period. Fortunately, a number of wrecks have been discovered and recorded.

CHAPTER FIVE: A Comparison of Twenty-Two Historic European Shipwrecks

Introduction

How the major European powers of the 17th century constructed ships is a question best answered by the archaeological record. Fortunately, a tiny fraction of 17th-century vessels that plied the oceans has been the subject of extensive archaeological survey, and in some rare instances, excavation. Having established the systemic historical context of the Corolla Wreck, and discussed contemporary ship construction treatises, this chapter deals with pertinent 16th- and 17th-century wrecks for purposes of comparison with the Corolla Wreck. A discussion of the Iberian tradition is paired with a survey and juxtaposition of twenty 16th- and 17th-century northern European shipwreck sites. Specific dimensions of timbers are given only when relevant to construction techniques.

A French Connection?

There are few known examples of French shipwrecks in the archaeological record. Under Jean-Baptiste Colbert, France's revitalized interest in building up a strong navy focused on building infrastructure and dockyards (Palm 1924:657; Belemessous 2005:327). As a result, most warships were purchased, primarily from the Dutch (Batchvarov 2002:123). As Batchvarov (2002:124-127) demonstrates, the Dutch exercised great influence over French shipbuilding practices, with the only major difference being that of the space between pre-erected master frames amidships. Batchvarov (2002:128) describes it as French interpretation of southern Dutch (*Maaskant*) ship construction practices. The two 17th-century French vessels discovered and recorded are discussed below for comparison. A reflection of France's late play for the zero-sum game of colonial exploitation, both vessels hail from the end of the century (Palm 1924:653).

La Belle

La Salle's ill-fated expedition to the Gulf Coast resulted in the loss of all but one ship. Spanish pirates absconded with *Sant François*, and after *Amiable* ran aground, *Joly* returned to France (Arnold 1996:68). In 1686, La Salle's only remaining ship, *La Belle,* wrecked at anchor in a storm. It was found again in 1996 when archaeological survey and test excavation revealed the remains of a wooden ship in Matagorda Bay. Subsequent artifact analysis and historical research confirmed it was the remains of *La Belle* (Arnold 1996:84). Arnold (1996:83) estimates the vessel was built in 1684 with a length of 80 feet (24.4m), a beam of 19 feet (5.8m), and a depth of hold 8.5 feet (2.6m). At 65 tons, armed with six guns, maritime historians consider *La Belle* an example of a French *barque longue*, a lighter, faster auxiliary vessel (Arnold 1996:82-83). Final publication is pending, however, some description of the hull remains are available.

Surviving hull dimensions measure 53 feet (16.15m) by 15 feet (4.57m) with several paired frames averaging 11 inches (28cm) sided and 5 inches (12.7cm) molded, with one frame comprised of three pieces, a possible midships master frame (Arnold 1996:82). The paired frames (seeFIGURE 58) all suggest preassembled floors and futtocks, a departure from the Dutch-Franco tradition of vessels built just a decade earlier where pairs of master frames were erected then spaces between filled with frames (Batchvarov 2002:128-130). The keel was composed of two timbers; the forward timber is 18 feet (5.85m) long, the surviving portion of the after timber is 33 feet (10.97m) long (Greico 2003:10). Just forward of midships is a 3-foot (97.6cm) long flat scarf that joins the two keel pieces (as depicted in *Colbert* above) (Greico 2003). The keel's sided dimension is 6 inches (16.3cm), molded dimension, 8 inches (21.7cm), increasing to 13 inches (35.2cm) at the forefoot at the after end of the stem scarf (Greico 2003:10-11).

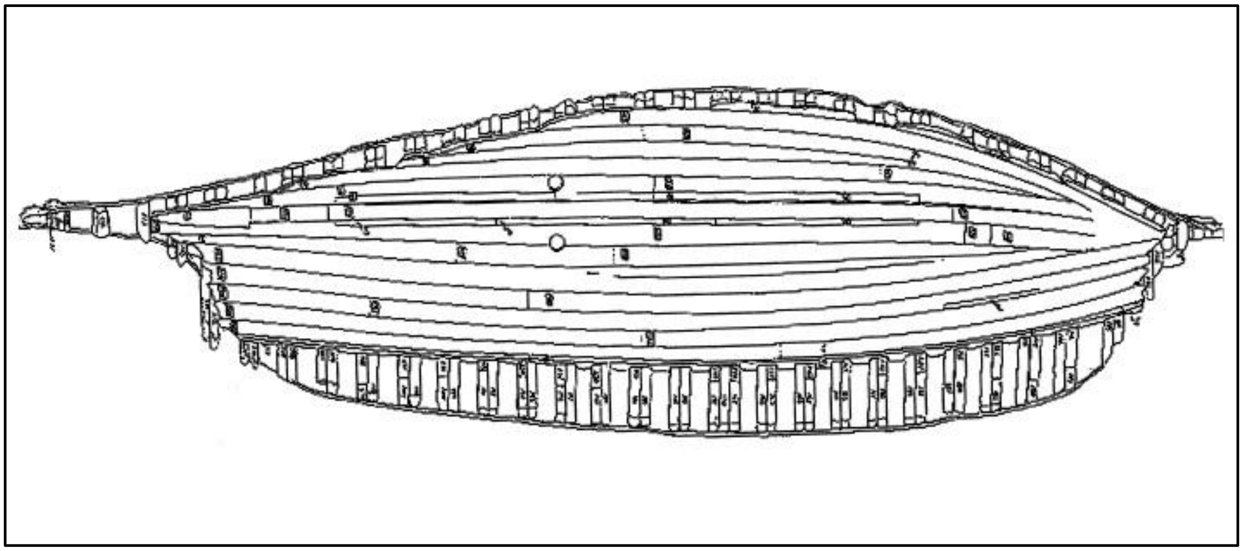

FIGURE 58. *La Belle.* (By Glenn Grieco, 2003)

Roman numerals along the port face of the keel indicated frame locations, spaced about 18 inches (48.8cm) apart. In total, 30 frames survive, spaced at 18 inch intervals apart, each secured with a single iron bolt (Greico 2003:16). Frames are composed of a floor with overlapping first, second, and third futtocks; forward of the master midships frame, the first futtock is fastened to the forward face of the floor; aft of midships, the first futtock is fastened to the aft face of each floor. Floor-to-futtock assemblies are fastened with three evenly spaced iron bolts (Greico 2003:16-18). Floor timbers' sided dimensions average between 5.5 and 7 inches (14.9 and 19cm); the molded dimension at midships was 5.25 inches (14.2cm), decreasing to 4 inches (10.8cm) at the head of the floor. As would be expected, molded dimensions increase over deadwood and the apron, the heads of the floors averaging 4 inches (10.8cm) (Grieco 2003:18). Instead of limber holes cut into the floors, a gap between the garboard and the bottom of the floor provided by the 1 inch (2.7cm) space between the edge of the rabbet and the top of the keel allowed water to flow to the lowest point of the bilge for the pumps (Grieco 2003:18-19). A similar technique found on Dutch vessels appears later in this chapter.

Planking thickness averages between 1.75 and 2 inches (4.7 and 5.4cm) with plank width varying from 12.5 inches (33.9cm) to 7 inches (19.cm). All plank ends are scarfed and secured to frames with a combination of spikes, 1-inch (2.7cm) treenails and iron bolts through bolts peened over roves. Planks were fastened between the scarfs to futtocks with one treenail and one spike in an alternating pattern (Greico 2003:21) (see FIGURE 59).

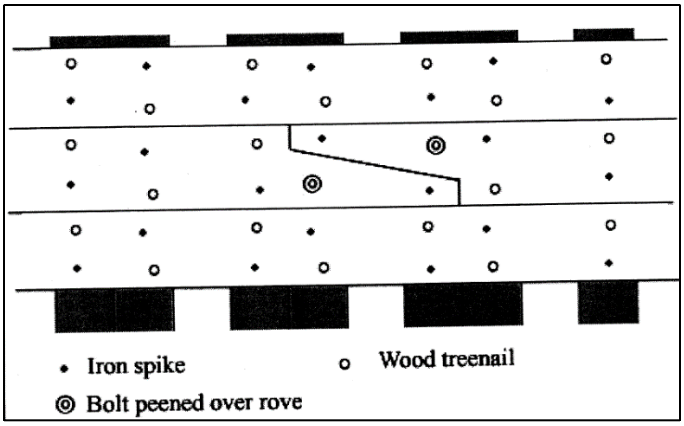

FIGURE 59. Diagram illustrating the scar fastener pattern used in planking La Belle. (By Glen Grieco, 2003)

Final publication on *La Belle's* hull structure is pending at this time. The discussion continues with another 17th-century French ship that has been both identified and surveyed.

<u>*Le Hazardeux*</u>

Built in 1698, *Le Hazardeux*, a third-rate French warship, was lost to the English after a battle in the English Channel in 1703 (Owen 1988:286). Renamed *Hazardous*, the ship wrecked in a severe gale in the Downs off Kent in 1706 (Owen 1988:286). A survey in the late 1980s and another in the 1990s revealed 137.80 feet (42m) of ship remains. Nineteen paired frames remain, fastened with iron bolts 20.5 inches (52cm) long with 1-inch (25mm) heads (Owen 1991:327). The frames average 20.5 inches (52cm) sided and 15.75 inches (40cm) molded, spaced 4 to 5 inches (100mm to 125mm); three sets of station (or master) frames are spaced 9.84 feet (3m) apart and filled with four pairs between each station (Owen 1991:327). Hull planking averages between 3 inches (75mm) and 4 inches (100mm) primarily fastened to frames by 1-inch treenails (25mm) (Owen 1991:325,327). Pine sheathing 3 inches (75mm) thick is present along with lead strips suggesting lead caulking and possibly lead sheathing (Owen 1991:325). Several nations tested this sheathing technique. The English experimented with it on 20 ships from 1670 to 1691; they abandoned the method after authorities realized the lead damaged iron bolts (McCarthy 2005:102). Ceiling planking is fastened to frames with 0.6 inch (15mm) nails and treenails; Owen (1991:327) calls the style of construction typically French. Cant frames found on *Hazardous* predate Royal Navy orders instructing the use of cant frames by 17 years suggest French ship construction was already improving before the end of the century (Lavery 1988:33).

The use of pre-erected frames on both vessels possibly reflects the lingering southern Dutch influence among French shipyards. Yet, the presence of paired master-couple frames, cant frames, and the experimental use of lead sheathing suggests the builders of this vessel had departed from earlier 17th-century northern European construction traditions. This, in part, reflects France's departure into its own, ambitious and successful shipbuilding enterprises of the 18th century.

Shipwrecks of the Iberian Tradition

There are a significant number of known 16th- and 17th-century Iberian shipwrecks. This reflects centuries of maritime traffic conducted by *La Casa de la Contratación de Indias* (Spain's House of Trade). Spain and Portugal were the earliest, and for decades, by far the most successful European powers in the Americas. Nautical archaeologists agree, for the most part, that an Iberian ship construction tradition existed alongside Northern European and Mediterranean traditions in the 16th and 17th centuries (Oertling 2001:238). A review of every known 16th- and 17th-century shipwreck is beyond the scope of this thesis. For the sake of comparison, however, Iberian construction traits (revised by Oertling 2001:235-236 and in Oertling 2004.) are discussed below. This list is meant to be diagnostic, not comprehensive.

(1) Preassembled central frames are present, futtocks joined to the floor with a dovetail mortise and tenon, and lateral treenails and iron nails (see FIGURE 60) (Oertling 2001:235).

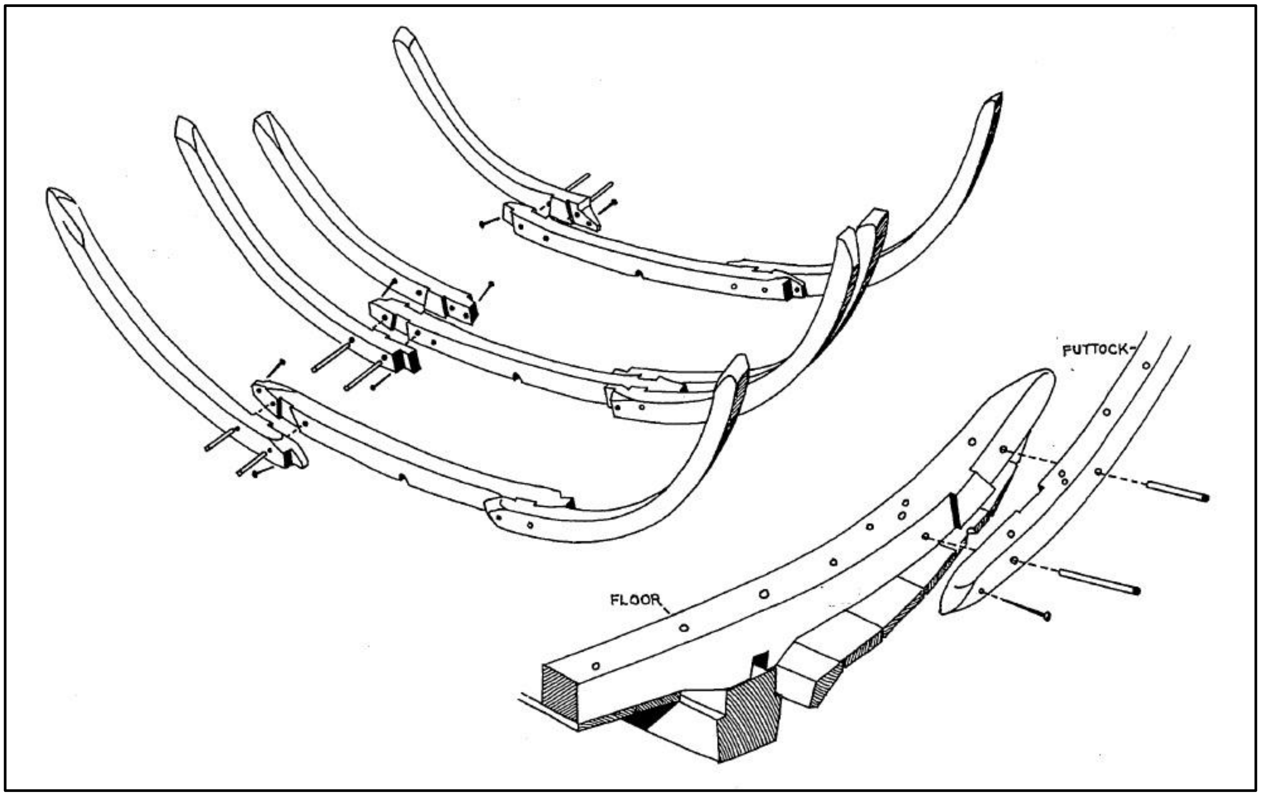

FIGURE 60. Iberian dovetail mortise and tenon frames. (By Richard Barker, 1991)

(2) The hull consists of carvel planking fastened to frames with a combination of nails and treenails (Oertling 2001:235), where the nails are often bent over clench rings (Watts 1993:111-112). Scholars have observed that iron fasteners for planking were more prominent on Iberian vessels than English or Dutch ships (Lavanha 1608:16,147-148 in McCarthy 2005:81). (3) The after-end of the keels is a knee of compass timber scarfed to the sternpost (Watts 1993:113;

Oertling 2001:236). (4) A single-piece deadwood knee sits on top of the keel (Oertling 2001:236). (5) Stern Y-timbers are tabbed into the deadwood knee (Oertling 2001:236). (6) The keelson is notched over the tops of the floor timbers (Oertling 2001:236). (7) The mast step is an expanded portion of the keelson, part of which is cut to seat the ship's pump (Oertling 2001:236). (8) The mast step is supported by buttresses and bilge stringers (Oertling 2001:236). (9) Ceiling planking ends just above the floor timbers with short, removable, transverse filler planks (Oertling 2001:236). (10) A flat transom with the sternpost proud of the transom face is the final (though not definitive) feature observed on Portuguese and Spanish vessel finds (Oertling 2001:236).

The Corolla Wreck is held together primarily with treenails, not iron fasteners, and the frames do not have any dovetail work. No master frame was observed on Corolla, but floors laterally fastened to futtocks with treenails were observed on three frames. Many other Iberian features, however, such as the keelson, mast-step, transom—the entire stern as a matter of fact—simply did not survive. Thus, Corolla's features are not necessarily exclusive to northern European vessels. This older, cheaper (depending on iron resources) method is found on older wrecks such as the 15th-century Newport Wreck, believed to have been built in the Basque Country (Friends of the Newport Ship 2013). Yet, with known patterns of Spanish and Portuguese trade and settlement, the Corolla Wreck is probably not of Iberian origin, not that it could not have been a Spanish *owned* vessel. The conclusion of this chapter discusses this in more detail below. The lack of structural evidence that could fall into the Iberian list makes it impossible to rule out an Iberian origin entirely. Several of the above 10 traits, like the notching of the keelson, were not exclusively Iberian or 17th-century. The list serves for comparison of other nations' techniques. Thus, it is with skeptical certainty that other nations' traditions must be examined. If neither Spanish nor Portuguese, perhaps the wreck is French.

Swedish Wrecks

There are a score of Swedish shipwrecks in the 16th- and 17th- century archaeological record; few, however have been extensively published. The following Swedish wrecks represent a melding of frame-based traditions, exhibiting northern European and Iberian/Mediterranean construction features. All date from the 16th and 17th centuries. *Vasa* is included, though the shipwrights who designed and oversaw its construction were Hollanders, it was a vessel commissioned by the king of Sweden built and built in a Swedish shipyard by mostly Swedish laborers. The first discussed is the oldest in this section.

The Kravel Wreck

Swedish archaeologists first thought the Kravel Wreck was Gustav Vasa's flagship, *Swan of Lubeck*, lost in 1524. The features of this vessel, however, were too small. Like *Swan*, the vessel was carvel-built and almost certainly early 16th century in origin (Adams 2003:74-75). Based on archaeological observation and known English proportions of the time, Jon Adams (2003:85) estimates the keel to have been originally 56 to 62 feet (17 to 19m), beam between 21 and 23 feet (6.5 to 7m), depth of hold to 10 and 11.5 feet (3 to 3.5m), with a capacity of 120 to 150 tons. The structural remains are primarily oak with planks fastened to frames by treenails (Adams 2003:76). The wale appears more Mediterranean carrack style, turning forward to continue to the stem; the stem is similar to *San Juan* of Red Bay, and the stern is square (Adams 2003:76-78). The discovery of the true *Swan of Lubeck* would make for interesting comparison with the Kravel wreck and *Elefant*.

Elefant

Built in 1559, *Elefant* was a massive ship. Like Henry VIII's *Mary Rose*, King Gustav Vasa had *Elefant* built to serve as his flag ship (Adams 2003:87). The intention was for his son, Erik, who succeeded the throne in 1560, to make a grand impression in a bid for Elizabeth I's hand. Erik never got his chance; *Elefant* was damaged and sank in 1564 near Kalmar (Adams 2003:87).

The archaeological record shows that the hull planks are fastened to frames with treenails, other timbers (knees, deck beams, etc.) with iron bolts; the vessel has thick hull and ceiling planking along with stringers reinforcing the strength of the hull (Adams 2003:88). Unlike later hulls that incorporated deadwood in the ends to accommodate frames, *Elefant* has composite V frames comprised of two timbers (Adams 2003:89). There are heavy wales bolted through riders and knees, like *Mary Rose*; also similar are rectangular blocks placed over seams inboard—not throughout the hull, but in various locations, held in place by rabbets cut into frames. *Mary Rose* had covering pieces nailed over outer hull seams to reinforce caulking (Adams 2003:89). Adams (2003:89-90) suggests these rare examples of seam coverings may reflect northern European shipbuilders adjusting to technical challenges of the transition from clinker to carvel planking: the notion of using the surface of another flat piece of wood to aid in creating a water tight seal. In clinker-built tradition, this had always been a part of the succeeding plank overlapping a lower plank.

Vasa

King Gustav Adolf commissioned the Swedish royal warship *Vasa*, in 1624 as one of the first (Swedish) ships of a new class to be equipped with two full gundecks and 72 bronze, 24-pound guns. Launched in 1627, the warship was completed and christened in 1628 (Hocker 2011:31,39,46). *Vasa's* fame, however, extends not from its prowess in battle—the vessel never fired a shot in combat—but its terminally brief career. Intended to aid the Swedish king in his wars in Poland, his new flagship foundered and sank before the eyes of thousands in Stockholm harbor in August 1628.

What was a humiliation for the king, and all those involved with the ship, and a tragedy and abrupt end the 30 to 50 lives lost in its sinking, is today the best-preserved and intact shipwreck in the world (see FIGURE 61). Two Dutch shipwrights oversaw *Vasa's* construction (Hocker 2011: 122-127,36), built in the northern Dutch style, bottom first. *Vasa's* keel is 130.5 feet (39.79m) long, comprised of four pieces, 23-24 inches (58-61cm) sided and molded. Its floor timbers dimensions have a drastic range from 7 inches to 21 inches (18cm to 54cm) molded, most between 8 to 14 inches (20cm to 34cm), with varying sided dimensions—a typical feature of Dutch-built vessels (Kroum Batchvarov 2013 elec. comm.)

FIGURE 61. The Swedish warship, *Vasa*, housed in its own museum in Stockholm, Sweden; 95% of the original structure survived its 1628 deposition in Stockholm Harbor. (Photo by Author, 2010)

Frames are held in place by thousands of spiled (square-wedged) treenails and fastened through 4 inch (10.16cm) thick hull planking and slightly thicker 4.5 inch (11.43cm) ceiling planking in the hull (Cederlund 2006:44, 2011 pers. obs.). The keelson is bolted atop the frames, 30 inches sided and 10 inches molded Nearly 6,000 iron bolts and heavy 18 inch (45-50cm) squared riders reinforced *Vasa's* multiple gundecks (see FIGURE 62). Wales, 8 inches (20.3cm) thick, reinforce the hull along with heavy bilge stringers. Intended to operate in the cold brackish waters of the Baltic, the common Dutch practice of double-hull and pine sheathing was unnecessary for the warship and thus absent. A full discussion of the remaining scantlings defies comparison with most other archaeological sites and is presently the subject of future publications.

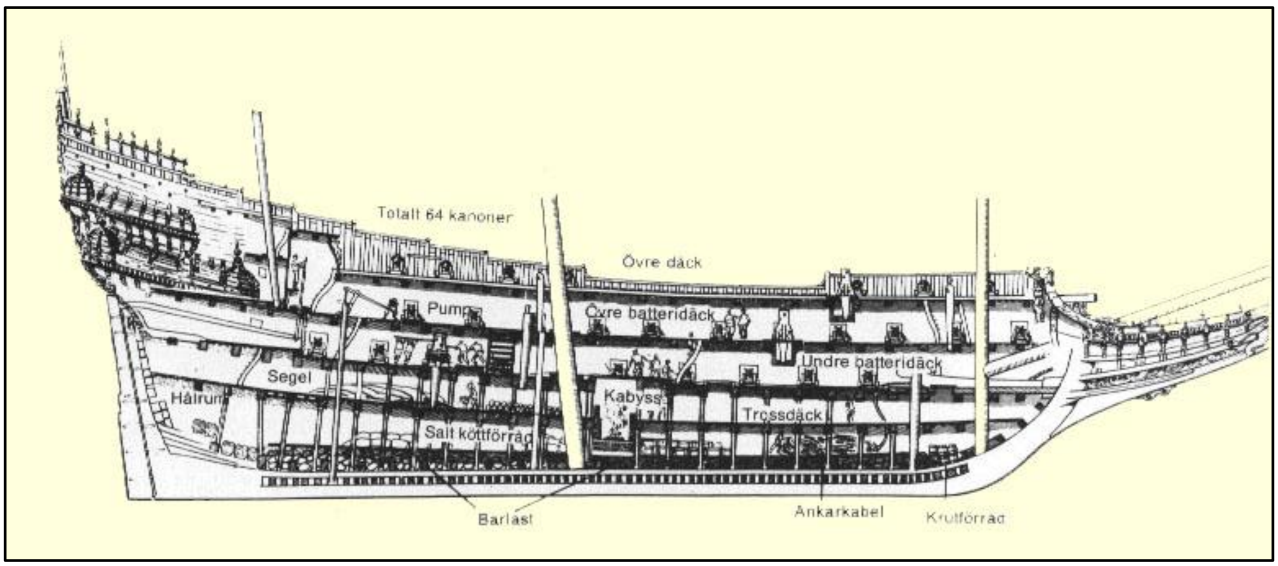

FIGURE 62. *Regalskeppet Vasa*, (*the* Undre batteridâck (*lower gundeck*), Ôvre batteridâck (*upper gundeck*) *and the* Ôvre dâck (*main deck*), *housed 64 of the intended 72 guns*). (By Carl Olof Cederlund, 2006)

17th-Century Dutch Shipwrecks

The utilization of wind energy for poldering in the Low Countries was adapted for proto-industrialized shipyards in the 16th century. The standardization of timbers, mechanized sawn planks, and highly organized labor guilds allowed for faster and cheaper production of merchant vessels. At their peak, Dutch shipyards produced more than 1,000 vessels annually (Wendy Van Duivenvoorde SHA 2012). With the astounding number of Dutch vessels that plied the seas of Europe and the world's oceans, more examples from 16th or 17th century continue to be the subject of archaeological study. *Vasa*, the ill-fated warship discussed above is one; four examples of fluyts and four Dutch-built East Indiaman follow.

The development of the *vlieboot*, or flyboat, from the Dutch buss tradition occurred well into Dutch primacy on the world stage of global trade, with the flyboats first making trans-Atlantic voyages in the 1590s (Unger 1978:36). A larger, similar shallow drafted vessel developed into the fluyt by 1595 with length to breadth ratios of 4:1, 5:1, and even 6:1 (Unger 1978:36-37). Fluyts were built primarily with pine a superstructure, an oak frame, and planked hull; this lighter build and efficient cargo hold (very box like) made them efficient but vulnerable (Unger 1978:37). To protect fleets of fluyts, the Dutch employed heavier built pinnaces as armed escorts for convoy duty (Unger 1978:38, Hoving 1988:333). Both the northern Dutch, bottom-based method, and the southern, skeleton-based method, were used to build the fluty, the Netherlands' equivalent of a freight truck in the 16th and 17th centuries.

<u>The Jutholmen Wreck</u>

In the 1960s, Swedish sport divers discovered historic wooden vessel remains just off the island of Juthomen, part of Sweden's Koster Marine National Park. Early investigations concluded it was the remains of a 17th-century fluyt. Sport divers revisited the site, working with archaeologists in the 1970s and again in 1982. The National Maritime Museums has continuously surveyed the site since (Edriksson 2010:5-6). The most recent survey, undertaken in 2008, collected the most detailed data to date and provides information on both the ship's architecture and continued deterioration (Eriksson 2010:2). At an estimated 200 tons burthen, the vessel is 81.5 feet (24.8m) long, has a breadth of 22.5 feet (6.9m), and depth of hold of 9.5 feet. (2.91m) (Eriksson 2010:21) (see FIGURE 63). The vessel is presumed Dutch and according to the Amsterdam foot would have been very close to 75 feet, by 21 feet, with a depth of hold of 9 feet. The irregularity of the framing suggests it was built in the *Noorderkwartier* tradition, bottom first, with frames added after planking. The hull is made of oak; frame elements are not connected other than two parallel joined timbers at the stem (Eriksson 2010:16,18-20). An even more preserved example of a fluyt was discovered five years before the 2008 survey but did not undergo scientific investigation until 2010.

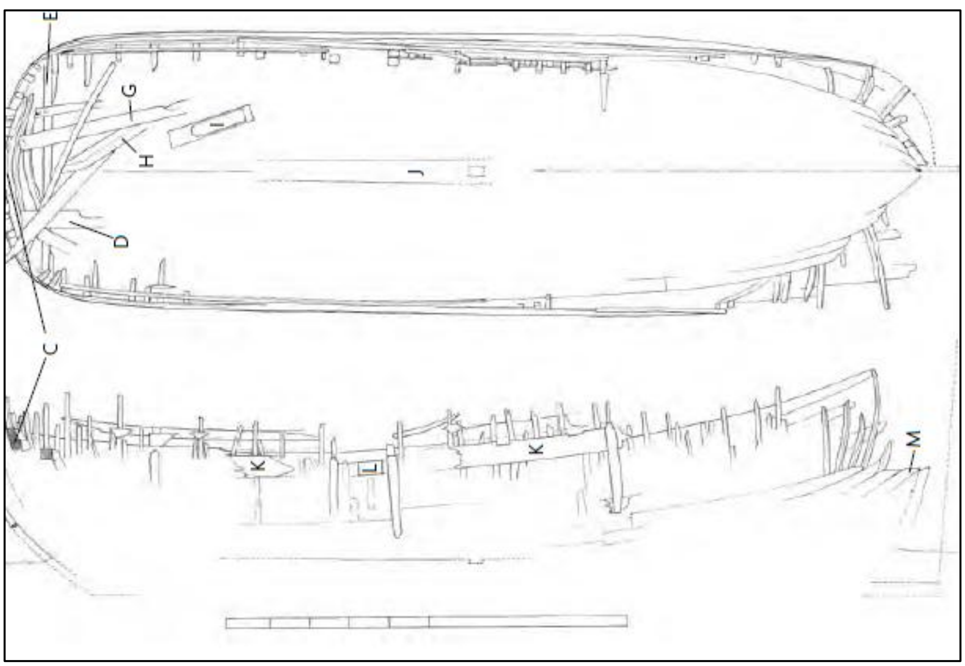

FIGURE 63. The Jutholmen Wreck; *note the very bluff, box-like shape of the vessel*. (By Niklas Eriksson, 2010)

The Ghost Ship and the Lion Wreck

In 2003, the Swedish geophysical surveying company, Marin Mätteknik, discovered an extremely well preserved shipwreck in the Baltic near Gotland. Dubbed the “Ghost Ship,” the vessel is the most intact archaeological example of the once ubiquitous fluyt. Initial observation found the vessel to be 82 feet (25m) long and 19.5 feet (6m) wide. The stern is round, the transom in a pear shape. Flower motifs near the helm appear typically 17th-century Dutch. Further research is pending publication (Björdal and Gregory 2011:17-18). A similar discovery occurred seven years later.

The dates of a Dutch wreck surveyed in the Baltic in 2010 are yet unknown, though the construction style suggests 17th century (Eriksson 2011:1). The vessel is 71.5 feet (21.8m) long (Eriksson 2011:3). Length to beam ratios of 5:1 and 6:1 were common for fluyts, thus, the breadth likely measures between 14.3 (4.36m) and 11.91 (3.63m) feet (Unger 1978:37). The transom is pear shaped, and below the wales, the vessel is double planked with a layer of tar and hair or moss, acting as a sealing agent (Eriksson 2011:3). The double planking, not present on *Vasa*, appears to be an economical attempt to provide a thick solid bottom with smaller (more prevalent) timber resources and provide a watertight hull. Further publication on this site, like the Ghost Ship, is also pending.

Christianshavn BW5

The other fluyt discussed is also the most thoroughly recorded, if not as intact as the above examples. In 1996, six shipwrecks dating between 1580 and 1640 were unearthed during construction on the former site of Grønnegaard Harbor in the old planned town of Christianshavn (Lemée 2006:25-27). Two of them, BW2 and BW5, are briefly examined below in order of ship type as archaeological examples of late 16th- and early 17th-century Dutch-built seagoing vessels. According to dendrochronological analysis, BW5, a fluyt, was built ca. 1625 and rebuilt around 1644 (Lemée 2006:24). Surviving elements measure 91.86 feet (28m) in length, 26.25 foot (8m) beam, with a depth of 9.84 feet (3m) (see FIGURE 64) (Lemée 2006:148).

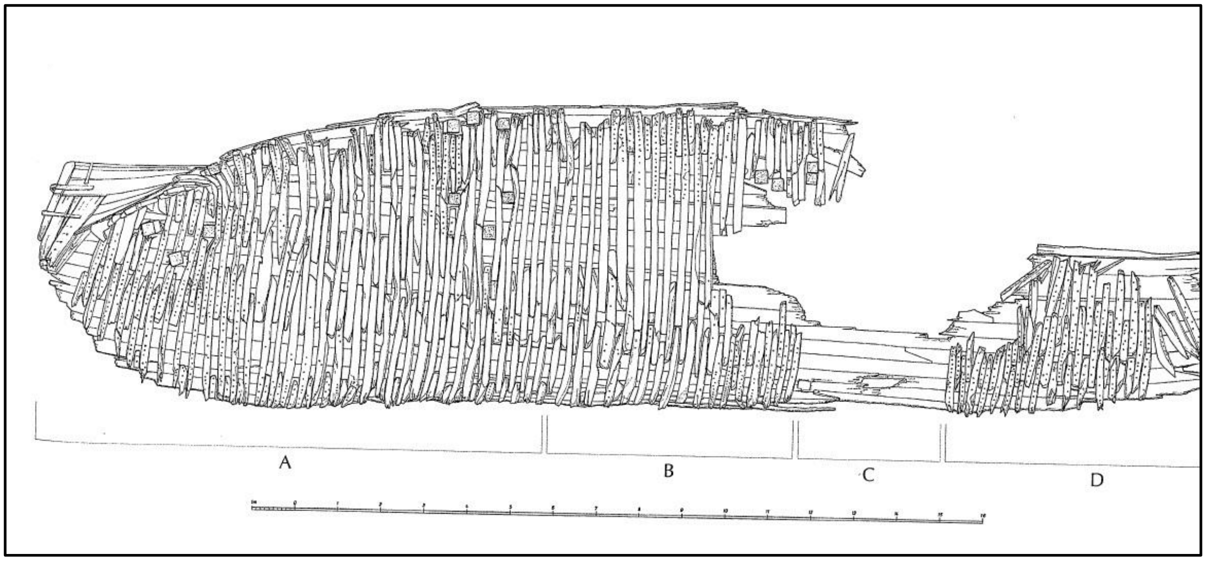

FIGURE 64. Christianshavn BW5 frames. (By Christian Lemée, 2006)

A total of 54.5 feet (16.6m) of keel survived, consisting of apparently a single timber, though a scarf might have been concealed by 20th-century damage. Its foremost end measured 18 inches (46cm) sided and 1 foot (31cm) molded, tapering to 10.2 inches (26cm) sided and 8.7 inches (22cm) molded at the aftermost end. The keel had a 2 to 2.8 inch (5 to 7cm) deep rabbet for the garboard strake, fastened with iron spikes; no false keel was identified (Lemée 2006:153-154). Of the keelson, 38.7 feet (11.8m) survived, comprised of two pieces joined with an 18 inch (46cm) scarf. The better preserved aft timber of the keelson measured 9.8 inches (25cm) sided, 6.3 inches (16cm) molded, tapering to 18.5 inches (47cm) sided and 7.5 inches (19cm) molded at the foremost broken end (Lemée 2006:154). The stern was preserved for an impressive 10.5 feet (3.2m) above the keel, made of three oak timbers stacked atop the keel. With no stern knee, the garboard and second strakes helped fasten the sternpost to the keel (Lemée 2006:154). Draft marks in Roman numerals were spaced at 11 inches (28.3cm to be exact), very close to the Amsterdam foot. Outer-hull strakes consisted of a single layer of oak planks, ranging from the longest preserved of 62.3 feet (19m), the shortest 16.4 feet (5m); width varying between 11.4 and 24.4 inches (29 and 62cm), thickness 2 to 3 inches (55 to 75mm) (Lemée 2006:155-156).

The framing displayed a composition of four distinct sets of timbers, lying side by side, not laterally fastened (see FIGURE 65). Framing consisted of floor timbers, lower futtocks, futtocks, and top timbers. Floor timbers spanned the hull, regularly spaced between 7 to 8 inches (18 to 20cm). At the turn of the bilge, lower (or first) futtocks were placed between floor timbers with little space, [second] futtocks at the wrung heads of the floors, and so on.

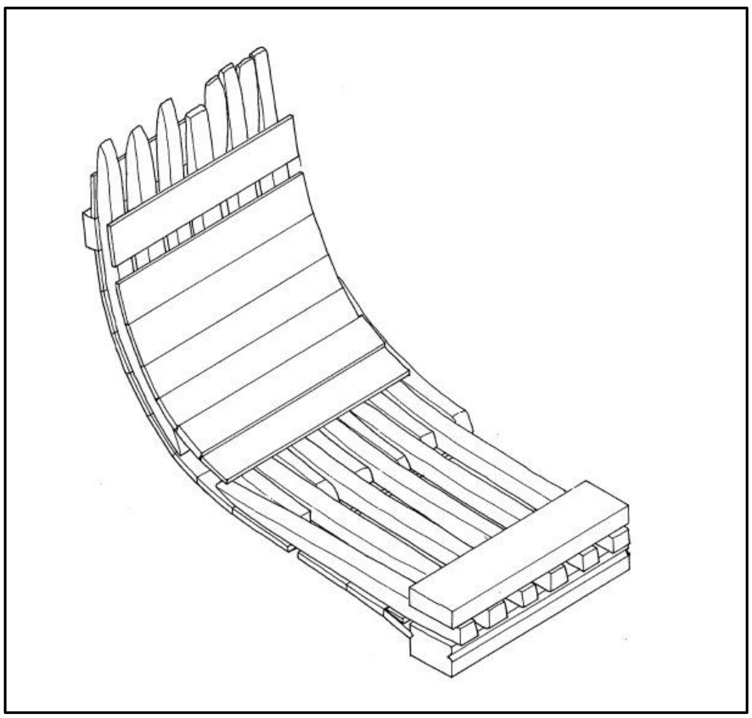

FIGURE 65. Isometric view of hull section excavated from BW5 (*note the* tingel *between the garboard and floor*). (By Christian Lemmée, 2006)

None of the framing elements were fastened together. Rather, they were secured with treenails through hull planking into ceiling planking. Thus, no pre-erected frames were distinguished. Timbers ranged in quality from high to low quality, including timbers made from crooked branches with bark extant (Lemée 2006:159,161). Framing style and quality suggests the frames of the vessel were considered equal in importance to the strength provided by the thick hull and ceiling planking. Site CKB0022's remains, restricted to a portion of the hull, preclude further discussion of BW5's finds. For a far more comprehensive report of the framing and other surviving timbers up through a portion of the starboard waterline, see Lemée 2006, 4.2. From the ubiquitous fluyt, the discussion moves to the pride of the VOC, Dutch East Indiamen, *Mauritius, Batavia, Campen*, and a Dutch-built Danish East Indiaman.

Mauritius

Built in Amsterdam between 1601 and 1602, *Mauritius* was likely a three-masted ship 131 to 147 feet (40-45m) long of 700-720 tons burthen. En route from Madagascar with spices and zinc the vessel "perished and broke to pieces" (L'Hour:64). Discovered in 1985, an excavation team recovered the wreck and remnants of its cargo that same year. Northern Dutch shipbuilders practiced bottom-based construction with an emphasis on structural integrity based in the vessel's hull rather than framing (Hocker 2004:82; Van Duivenvoorde 2008:188). *Mauritius* was double planked, a standard feature of Dutch East Indiaman up through the 18th century (Van Duivenvoorde 2009:62,65). The keel is oak 16.5 to 17 inches (42-43cm) molded and 15 to 16.5 inches (39-42cm) sided. A double layer of pine protected the oak keel (L'Hour 1990:64). Of the frames, 24 floors and elements of 22 futtocks survive. The floors are 12 inches (just one inch shy of an Amsterdam foot) (30cm) molded and range from 7 to 13 inches (18-34cm) sided. None of the futtocks are laterally fastened to floors. *Mauritius* provides the oldest known example of Dutch double planking. The interior strakes are oak, with an average thickness of 2.75 inches (7cm); the exterior planking the same, nailed to the interior strakes.

With many of the treenail heads covered by floors, it is clear the hull was built bottom first, with the frames added later. Strakes are fastened to floors with oak treenails driven from the outside, averaging 1 to 1.5 inches (3-4cm). The ceiling averages 3 inches (8cm) thick with consistent widths between 12 and 21 inches (30-55cm). A double layer of pine 1 inch thick protected the oak planking, fastened with small nails with a layer of lead sheathing between the oak and pine planking (L'Hour 1990:65) (see FIGURE 66).

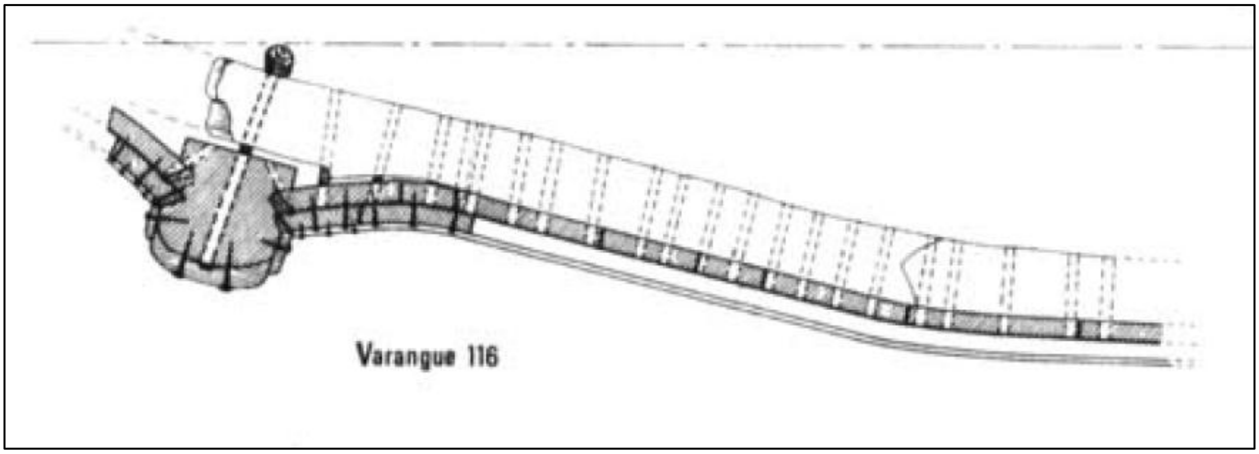

FIGURE 66. A profile view of *Maritius's* frame 116; *note the multiple layers of planking and pine sheathing on the keel.* (By M. Rival, 1990)

As is the case in nautical archaeology, catastrophic loss is the historian's gain when it comes to understanding 17th-century ships and their construction. Few losses were as infamous in their day as the VOC's *Batavia*.

<u>*Batavia*</u>

Launched in 1628, *Batavia* (see FIGURE 67) was built in the northern Dutch, or *Noorderkwartier*, tradition. As a vessel belonging to the VOC, *Batavia,* like *Mauritius*, is representative of Dutch East India construction in the first half of the 17th century (Van Duivenvoorde 2009:68).

FIGURE 67. The reconstructed replica of *Batavia.* (Courtesy Batavia Werf.nl, 2009)

Batavia was double planked, with the integrity of the hull based on a total of five layers. Outside, two layers of oak hull planks (1 and 2) (seams offset) were tarred and sealed with goat hair before a layer of pine sheathing (3) was attached with closely spaced iron nails, which once rusted, created a protective layer of iron oxide. Inside, a thick layer of oak ceiling planking (4) received a layer of pine flooring (5) of the same thickness as the sheathing to protect the oak ceiling from wear (Van Duivenvoorde 2009:62,65) (see FIGURE 68).

Framing, integral to the strength and structure of the hull, is irregular and less solid than English ships (Van Duivenvoorde 2008:188, 2009:62). With a philosophical approach from the bottom first, the irregular size of the frames probably reflect Dutch efficiency in maximizing wood from available sources. There are frames on *Vasa* for example, that retain sapwood (Kroum Batchvarov 2012 pers. comm.). A total of 46 frame elements survive. Frame components are not interconnected nor display lateral fasteners (Van Duivenvoorde 2008:188). Builders fastened the frames through the hull with treenails, pegged with hardwood square pegs, or *spiles* (see FIGURE 69) on the outside (Van Duivenvoorde 2008:188,192).

FIGURE 68. Remains of *Batavia*. (Courtesy of *Western Australian Museum*)

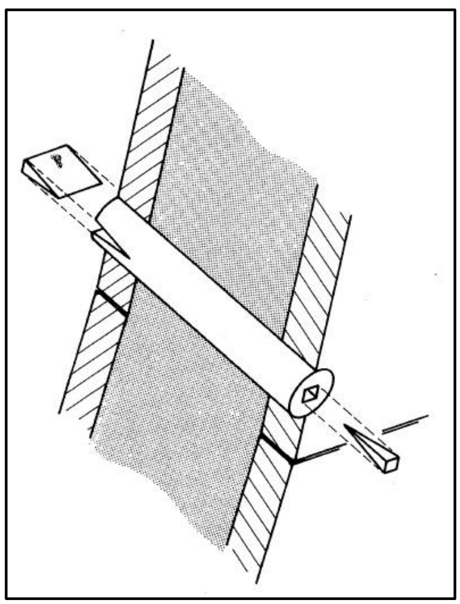

FIGURE 69. A square-pegged treenail. (By A.J. Hoving, 1994)

Campen

Archaeologists noted similar features on the Dutch East Indiaman, *Campen*, wrecked in 1627 as part of a small VOC fleet off the Isle of Wight on the Needles Rocks (Larn 1985:2). Archaeological survey in the 1980s revealed little left of its structure. A fragment 2.5 feet long (.78m) with two treenails was among the only structural elements left of the 300 ton *jacht* (yacht) (Larn 1985:2,15). Divers found thin sections of deal planking (pine sheathing) 0.39 inches (1cm) thick, associated with tufts of animal hair suggesting an outer layer of sheathing similar to that described above. Several artifacts were recovered and discussed in the initial publication (1985) but little of the vessel's structure remained to analyze (Larn 1985:15). Dutch shipbuilding was so efficient and prolific, it was more convenient, and at times cheaper, for other nations simply to purchase vessels made by Holland's shipwrights. BW2 is such an example, another contemporary East Indiaman subject to more extensive recording.

BW2

The second vessel located during the Christianshavn excavations was a Dutch-built Danish vessel. Its origins are debated and its proportions and features are not necessarily in keeping with Dutch East Indiamen, though it was used for this purpose by the Danes (Fred Hocker 2013 elec. comm.).Of an estimated original length of 5 to 92 feet (26 to 28m), only an area of 47.5 by 24.6 feet (14.5 x 7.5m) remained. The entire forward section of the ship was missing, having been dug out for construction purposes in 1962. Of the stern, 7.55 feet (2.3m) survived above the keel, along with the foremost preserved section reaching 8.5 feet (2.6m) above the keel. Dendrochronological dates put the original year of construction ca. 1606. Later, around 1622 (+/-5 years), a second layer of oak planking and pine sheathing was added to the ship (Lemée 2006:196-197).

Elements of the keel, false keel, and keelson survived, all fastened together with iron bolts measuring 0.8 to .87 inches (20 to 22mm). Of the keel, 43 feet (13.1m) of a single oak timber remained, 13.4 inches (34cm) molded, and 17 inches (43cm) sided. The keel was mortised 5 inches (13cm) from the after end for the sternpost with the sternpost secured by two stopwaters and an iron band (rusted away but its impression remained). The keel had two rabbets: the inner layer of planking nailed to the upper rabbet, 2.36 to 2.76 inches (6 to 7cm) deep, the outer planking to the lower rabbet, 1.18 inches (3cm) deep. The false keel survived to a length of 42.52 feet (12.96m), increasing from 5 inches (13cm) to almost 6 inches (15cm) molded. The false keel consists of two oak timbers connected by a 30 inch (76cm) diagonal nibbed horizontal scarf. The surviving portion of the keelson was 24.8 feet (7.56m) long, at the foremost end 8.3 inches (21cm) molded and 18.9 inches (48cm) molded, decreasing to 4.3 inches (1cm) sided and 14.2 inches (36cm) molded at the aft end (Lemée 2006:200-202).

Though the stem did not survive, 10.17 feet (3.1m) of the sternpost was preserved above the keel. The sternpost consisted of two oak timbers fastened together with treenails and iron bolts. At its base, the lower piece of the sternpost was 5.64 feet (1.72m) long, and 7.9 inches (20cm) thick. At its top, the sternpost was 29.1 inches (74cm) wide and 11 inches (28cm) thick on the front face. The garboard and second strakes were fastened with 1.18 inch (30mm) treenails to the sternpost. Tennons observed on the underside and top sides of the sternpost were likely the remains of the connection to the fashion piece. Surprisingly, remnants of copper plates fastened with copper nails were noticed on the aft face of the sternpost, though no draft marks were found. A stern knee 7.55 feet (2.3m) long was fastened with treenails to the stern post, though it was unsure how this timber was connected to the keel (Lemée 2006:202).

As was so often the case in the age of sail, different nations contracted the construction of ships from each other, employed foreign shipwrights in native shipyards, purchased pre-existing vessels, and of course, captured them as prizes on the high seas. The above vessel may be the Danish Indiaman *Elefant*, originally a Dutch-built armed merchant vessel purchased by the Swedish in 1609 and later lost to the Danish (Fred Hocker 2013 elec. comm.). In another example, it was an English shipwright who designed *Vasa's* successor, *Kronan.* By the 1660s, the English style officially regarded as superior to other styles (Ralamb 1691:2 in Einarsson 1990:279), including the Dutch. This reflects England's rise to ascendency in the Atlantic by the end of the century. The next section deals with ships of the Netherlands' decades long rival, the English. The first wreck discussed suffered the same fate as *Vasa* almost a century earlier (see FIGURE 70).

FIGURE 70. Artist's depiction of the demise of *Mary Rose*. (By Richard Schlecht, 2008)

16th- and 17th-Century English Shipwreck Sites

After the multitude of Dutch Polder wrecks, and the vast number of Iberian shipwrecks, are those of 16th- and 17th-century English vessels. The remains of eight confirmed English vessels, and a possible ninth, have been the subject of archaeological surveys ranging from phase I (visual survey) to full excavation and reconstruction.

Most famous and most thoroughly investigated is the ill-fated *Mary Rose*, Henry VIII's flagship. The latest vessel is HMS *Anne*, wrecked in 1698. Discussion of these eight wreck sites follows chronologically, with emphasis on construction features that may or may not be exclusively English, but collectively reflect a distinct shipbuilding tradition.

<u>*Mary Rose*</u>

Scholars estimate the warship *Mary Rose*, sunk in 1545, was built 106 feet (32.31m) on the keel (overall length uncertain) with a beam of 39 feet (11.89m) (Marsden 2009:36). The remnants of the keel are in three pieces, the central one is of oak, and the ends are elm (Marsden 2009:81). The keel pieces are joined by vertical stop splayed scarfs (Marsden 2009:76). The remnants of 53 framing timbers survive (see FIGURE 71), filler frames overlap at the height of the orlop (Marsden 2009:47). Frames are fastened to ceiling and outer hull planking by treenails; the outer end splayed with triangular or cross cut wedges; some treenails are wedged on their inboard ends as well (Marsden 2009:77). In the deeper sections of the hull, a continuous central limber hole is cut into floor timbers (Marsden 2009:Sheet F4). Five heavy stringers reinforced ceiling planks (Marsden 2003:94). These would have provided additional longitudinal strength along the hull. The central limber, animal hair caulking, reliance on heavy longitudinal timbers, predominant use of treenails to fasten frames to planking, and the reliance on vertical keel scarfs (though slightly less complex) on a keel made of three pieces are English construction methods observable well into the 17th century. The seam battens, filler frames, floating futtocks, and overlap at the orlop level are features that do not persist into 17th-century English construction, as will be seen in examining later 16th- and 17th-century wrecks.

FIGURE 71. Remains of *Mary Rose*. (Courtesy of *The Mary Rose Trust*)

Gresham Ship

The Gresham Ship (named for a gun thought to be from that foundry) was discovered in Princes Channel and excavated in 2003 and 2004. The wreck's excavation resulted in five hull sections that may be the remains of a 10-gun vessel 50 to 65 feet (15 -20m) long on the keel, with a tonnage of 150 to 250 tons, built after 1574 (Auer and Firth 2007:225, 233). Included in these sections are a portion of the bow with stemson and apron, two portions of the port side with 13 futtocks attached to several broken upper ends of floors, with filling frames between (Auer and Firth 2007:225). Most interesting is the evidence of furring; the frames are doubled above the turn of the bilge; a stringer served to strengthen the added frames at the level of the orlop (Auer and Firth 2007:227-228). Single or double trapezoidal dovetails joined floors and futtocks, secured with a single treenail through the center (Auer and Firth 2007:229). This feature is typically thought by Thomas Oertling (see above) to be Iberian, though the primary reliance on treenails, as opposed to iron bolts, is much more Northern European. Hull planks are fastened with oak treenails averaging an 1 ¼ inch (30mm); most outboard ends split in a V-shape or cross cut to receive caulking; inboard ends usually split and wedged (Auer and Firth 2007:229). Only about six feet (1.82m) of the keel survived; one end joined to the stem with a flat vertical scarf (Auer and Firth 2007:228) (see FIGURE 72).

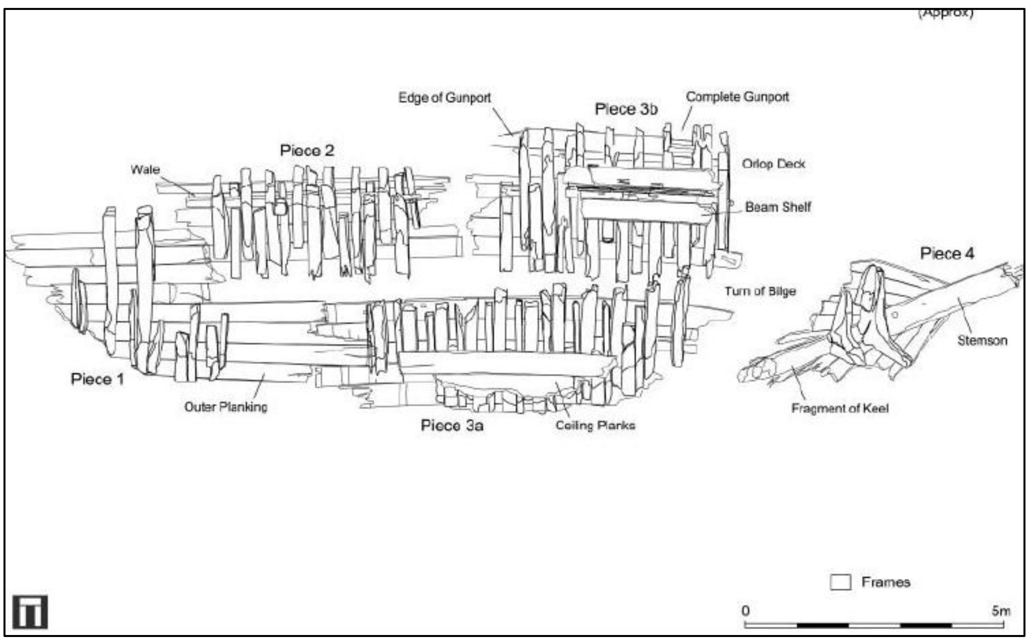

FIGURE 72. The "Gresham Ship," *plan view of the preserved section of the hull.*(by Kitty Brandon, 2004)

<u>*Sea Venture*</u>

The next vessel, *Sea Venture,* is a rare example of an identified and documented 17th-century English vessel. A century after the crown gave the order to build *Mary Rose*, *Sea Venture* ran aground off Bermuda, and its survivors partially cannibalized the wreck to build two new vessels (Adams 1984:3). An estimated 250 to 300 tons burthen, 52 feet of keel survived (15.85m) out of a possible original length of 72 to 75 feet (22 to 23m) (Wingood 1982:338, Adams 1985:289). The keel is of three pieces joined by three vertical scarfs and bedded with a compound of animal hair and pitch (Adams 1985:289-290). Treenails, split and wedged, attached fames to hull planking and ceiling (Wingwood 1982:335). Floor timbers and first futtocks overlap at the turn of the bilge (see FIGURE 73). They were butt jointed to other futtocks (no lateral fastening is present) where the ceiling is thicker; two possibly three runs of heavy “sleepers” reinforce the overlap (Adams 1985:290-291, Bojakowski 2011:27). Most fasteners are treenails, though the builders used bolts to reinforce sleepers and stringers; amidships every third floor timber is bolted through the keel (Adams 1985:292). A single, central limber hole runs through the frames along the keel (Adams 1985:289).

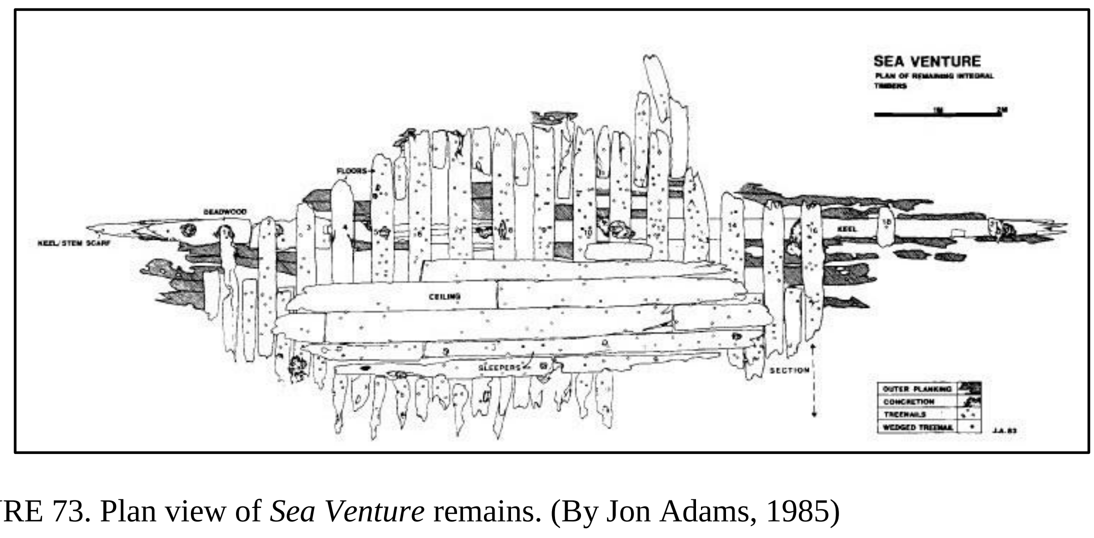

FIGURE 73. Plan view of *Sea Venture* remains. (By Jon Adams, 1985)

Warwick

arwick was a vessel that wrecked exactly one decade later. Though its features hearken to late 16th-century construction techniques, *Warwick* was probably constructed between 1617 and 1618 (Bojakowski 2011:41, 2013). At an estimated 300 tons burthen and a length on deck of 100 to 110 feet (30-33m), *Warwick* was a solidly built vessel, comparable to *Sea Venture* in size, but not entirely in construction. Twenty-nine exposed framing timbers (see FIGURE 74) are of smaller than *Sea Venture's*, but similarly, there is distinct overlapping between frame elements (Bojakowski and Bojakowski 2011: 41,44).

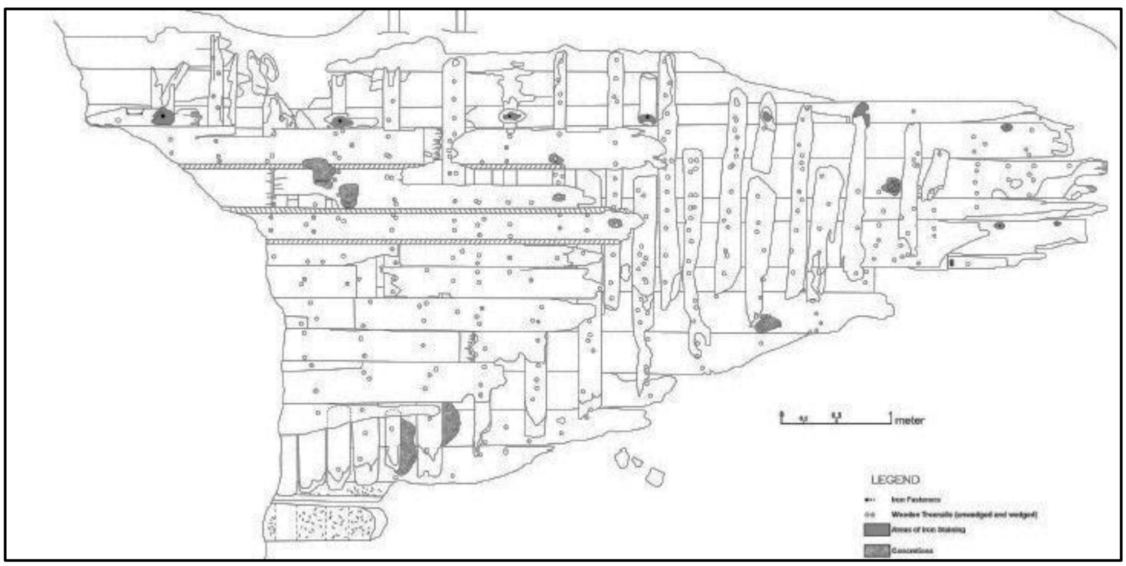

FIGURE 74. Plan view of *Warwick*. (By Peter and Katie Bojakowski, 2010)

No lateral fastening is apparent, yet heavy fore and aft stringers running the length of the ship are placed throughout the hull, not just at the level of floors' wrungheads (as on *Sea Venture*) (Bojakowski and Bojakowski 2011: 45). This feature is similar to the older *Mary Rose* with its multiple stringers. *Warwick* was double hulled with only the first layer of planking fastened to frames by treenails; the second layer fastened to the first with iron spikes. Finally, sacrificial sheathing, caulked with animal hair and resin, was affixed to the second layer with tacks (Bojakowski and Bojakowski 2012:19). Iron fasteners are present, but the vessel appears to have relied mostly on treenails (some wedged) to hold its timbers in place (Bojakowski and Bojakowski 2012:14-18). Some of these treenails were pegged with square wedges, a feature once considered typically considered Dutch in practice (Bojakowski SHA 2013).

<u>Monte Christi Pipe Wreck</u>

The Monte Christi Pipe Wreck was probably built after 1642, based on dendrochronological finds, this analysis also determined it was made from English oak. This, combined with its construction features, led to the belief it was an English-built vessel hauling a Dutch cargo (largely of clay pipes), possibly under a Dutch flag (Hall 1996:21, 2006:20). The extent keel is 42.92 feet long (14.3m), averaging 12 inches (30cm) molded and 13 inches (33cm) sided with two vertical scarfs. Seventeen frames consisting of 15 floors and 13 futtocks, with futtocks overlapping floor timbers, are fastened obliquely with treenails (see FIGURE 75) (Hall 1996:75).

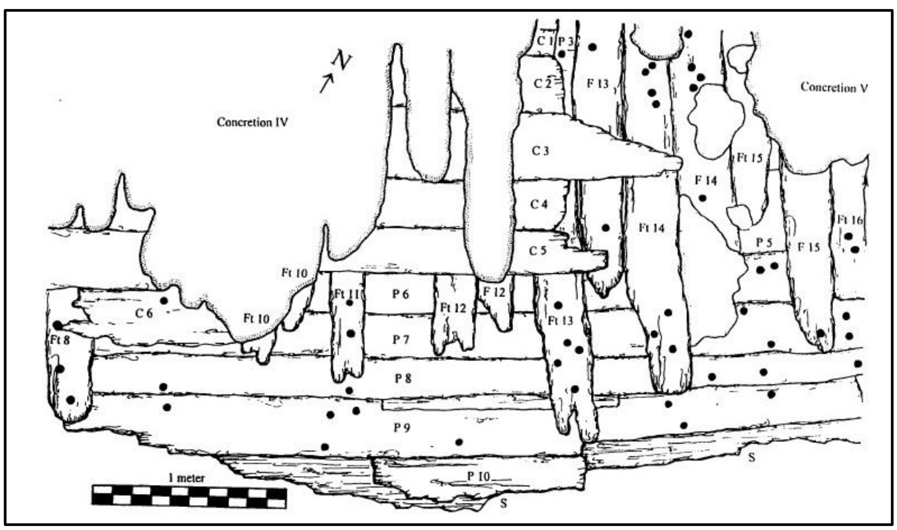

FIGURE 75. Hull remains of the Monte Christi Pipe wreck (By Jerome Hall, 1996)

Treenails, 1 to 1.5 inch (25 to 38mm) in diameter, fastened frames to the outer hull and ceiling planking (Hall 1996:77). Hull planking is sheathed with spruce or larch and sealed with cattle hair and tar (Hall 1996:70). Material culture found on this wreck initially suggested Dutch origin, but the lack of evidence of temporary fasteners or *spijkerpennen* and construction features suggest an English vessel with Dutch cargo (Hall 1996:69). The lack of lateral fasteners (Hall 1996:75) is consistent with early to mid-17th-century English vessels. Changes that occurred sometime in the last half of the 17th century can be found on the next wreck discussed below.

<u>*Dartmouth*</u>

The small 36-gun warship *Dartmouth*, launched in 1655 and wrecked in 1690, posed some confusing questions to nautical archaeologists upon its initial investigation. Further analysis by Martin (1998) and Batchvarov (2007) have thankfully answered many of them. *Dartmouth* was constructed with a keel 80 feet (24.4m) long, a beam of 25 feet (7.6m), depth in hold of 10 feet (3.05m), a draft of 12 feet (3.66), a total of 266 "tuns burden" (Martin 1978:29). The ship underwent a major refit in 1678 that added chocks between floors and first futtocks and rising deadwood; these features, never before encountered on a 17th-century English warship, were puzzling at first (Batchvarov 2007:351).Eventually, archaeologists realized these were added when the keel was replaced along with several other degraded timbers (Martin 1978:55). The keel was of elm, originally thought to be three pieces, joined by two intricate vertical table scarfs (see FIGURE 76), caulked with hair and tar on the faces (oakum between the butts), sealed with a nailed cap piece, and held together with eight one inch (25mm) iron bolts (Martin 1978:43-44).

A total of 34 paired frames are bolted at intervals through the keel; the paired frames are not laterally fastened but depend on the strength of the ceiling and hull planking, which are fastened to the frames by treenails (Martin 1978:47). Treenails, 1.5 inches (38mm) are cross or triangular cut, pegged, and caulked with oakum; some one inch bolts (2.5mm) are present as well (Martin 1978:47-48). Five runs of elm ceiling precede a stringer just inboard of the rungheads, strengthened by floor riders (Martin 1978:50), adding both longitudinal and lateral support to the hull. Shipwrights sheathed the hull with fur deals, a layer of hair and tar applied between the deals and hull planks (Martin 1978:49). The paired frames mark a departure from earlier English design that incorporated a solid wall of timbers around the turn of the bilge.

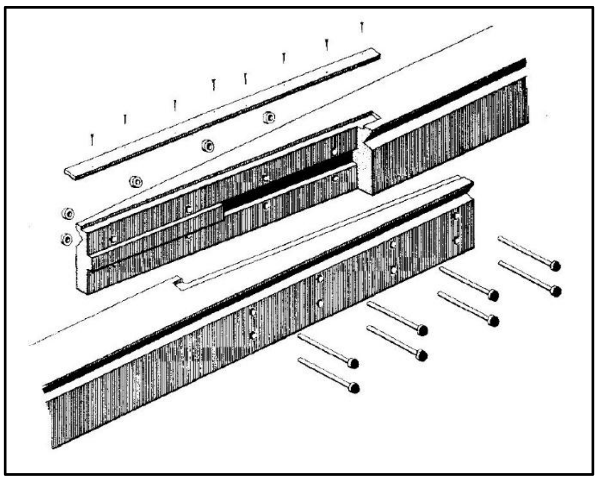

FIGURE 76. Reconstruction of *Dartmouth's* vertical keel scarf. (By Colin Martin, 1995)

Regalskeppet Kronan, HMS *Anne* and the Port Royal Wreck

Designed by English shipwright Francis Sheldon, King Karl XI launched the Swedish Royal ship *Kronan* (The Crown) in 1672, after years of delay. In 1676, it foundered during the decisive Battle off Southern Öland. The ship exploded in one of the most dramatic wrecking events of the century; 800 of the 850 men on board were lost. The ship split into three main pieces, the bow, remains of the starboard side, and a large section of the port side (see FIGURE 77). The bow was lost, but the rapid sinking of the vessel resulted in a well preserved site with little intrusive material because of the low traffic area of the sinking. Scantling dimensions of the lower hull are not yet available, but some basic dimensions are. It is debatable whether *Kronan*, like *Vasa*, was crank (unstable) or sank because of a mistimed maneuver. Given its ambitious size, this is no surprise: it displaced an estimated at 2,140 metric tons, was 197 feet (60m) long overall, with a beam of 43 feet (13m) (Einarsson 1990:279-281). This gave the vessel a length to beam ratio of 1:4, somewhat more slender than English warships built in the last quarter of the 17th century. The sleek design harkens to Deane and other builders who favored speed under sail for vessels of war over beamy stability.

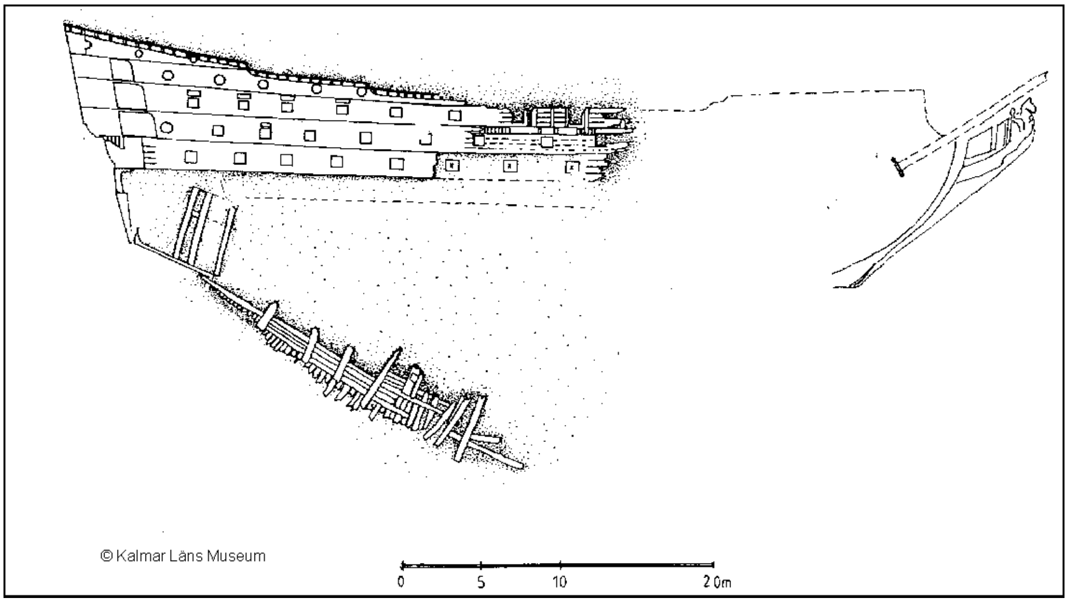

FIGURE 77. Site Plan of *Kronan.* (By Lars Einarsson, 1990)

Another warship wrecked the same year as *Dartmouth*. Launched in 1678, the 70-gun ship-of-the-line *Anne* was built on a 128 foot keel (39m), an overall length of 150 feet (45m), a beam of 40 feet (12m), with a total displacement of 1,089 tons (Marsden and Lyon 1977:9). Unfortunately, other than a Phase I survey, little else is known about the vessel's construction. Further research on this mid-late 17th-century vessel may reveal changes in English construction techniques after 1650. The remains of another vessel thought to be English and from a similar date as *Anne*, is the Port Royal Wreck.

The remains of this vessel consist of 74 feet of keel (22.86m) made of two pieces of slippery elm (Clifford 1993:82). These pieces were joined by a vertical table scarf (Clifford 1993:100). Unlike the above wrecks, the keel was chamfered and not rabbetted (Clifford 1993:82). The remains of 33 frame components are bolted to the keel with 1 inch (25mm) iron bolts (Clifford 1993:89). Floors are paired with futtocks, but neither lateral fasteners nor chocks were observed; limber holes are cut out of the bottom of floor faces on either side of the keel in both rectangular and triangular shapes (Clifford 1993:90). Treenails appear to be the primary fastener attaching planking to frames, though the odd lack of ceiling planking (Clifford 1993:91) left open the question of whether the treenails functioned to sandwich ceiling planking, frames, and hull strakes together. No stringers were present, making analysis of this wreck problematic. Clifford (1993:146) suggests this wreck is HMS *Swan,* a Dutch built warship captured by the English. It served 20 years before being condemned as a fireship, and later refitted as a warship. The author disagrees with this conclusion, however. The remaining evidence clearly suggests English or North American origins. England did import American timber but it is widely known English shipwrights detested American timber, considering it inferior to English hardwoods, with the exception of American elm.

Conclusion

The whereabouts of other 17th-century English wrecks are known but are awaiting scientific investigation. To establish a cohesive comprehension of changes in English ship construction in the 16th and 17th century, these and others not yet identified, must be examined. The above discussion, however, illustrates there are distinct differences in how different nations built ships. A ship's intended purpose defined its construction. This construction, in turn, was restricted by resources (timber and iron) and balanced the forces of gravity and buoyancy in a formula of efficient sailing and utilization—most often as a gun platform or cargo carrier (Steffy 1994:9-11). As mentioned, Iberian vessels were distinct in both the proportions from which they were built and in construction methods. Iron fasteners are more prevalent on Iberian and French vessels. More 17th-century French wrecks must be discovered to allow for direct physical comparison of this scant archaeological resource. Dutch vessels differed slightly in outward appearance from French, English, or Iberian ships, though they were drastically different beneath the skin (Dutch term for the hull). By the 17th century, the older, northern Dutch tradition of basing the strength of the vessel upon the bottom of the ship had been reduced to a matter of construction sequence (Fred Hocker 2011 pers. comm.). Influences of the bottom-based tradition might be suggested in southern Dutch vessels that employed a double hull of thick planking. Unlike English vessels which incorporated equally thick hull and ceiling planks, regularly distributed frames, and a system of wales and stringers, some Dutch ships utilized multiple layers of planking to provide strength to the hull, reflecting a philosophical reliance on the ship's bottom for hull integrity. This practice too, bottom based construction in the Nnorth, phased out sometime around the mid-17th century.

Such differences in the approach to building a vessel are easily discerned within the very language used by both cultures to describe ship parts in the discussed treatises. How vessels were designed and *supposed* to be built does not always align in examination of how ships were *actually* built. Some features in the treatises, however, such as Smith and Mainwayring's references to treenails in English construction, Witsen's instructions to join a keel of more than one piece with horizontal scarfs, and the illustrations of French double frames in *Album de*

Colbert, are all extent in the archaeological record. Thus, the two sources complement each other to a certain degree. The next two chapters discusses how the Corolla Wreck's features compare to both historical documents on ship construction and the archaeological record, as well as the results of archaeological field work.

CHAPTER SIX: Results & Analysis

Introduction

When compared to historic treatises, what do the features of the Corolla Wreck tell the maritime archaeologist? How does the Corolla Wreck compare, structurally, to contemporary shipwrecks in the archaeological record? Before Wreck CKB0022 was the focus of archaeological recording, it undertook its own journey, the first part spurred by forces of nature, the tide, waves, and storms that are the Outer Banks' soundtrack, the second the result of cultural disturbance and human interaction. The deposition and site formation of Wreck CKB0022 are discussed below, followed by the results and analysis of archaeological research and fieldwork, and lastly a discussion of the Corolla Wreck's structural features in the historical archaeological context of contemporary 17th-century treatises and shipwrecks.

CBK0022's Deposition and Site Formation

Since its appearance in 2008, Wreck CKB0022 has been an artifact trapped within a *systemic context*. The systemic context refers to artifacts participating in a human behavioral system (Schiffer 1987:3). At the same time, the Corolla Wreck has been subject to natural forces. An artifact that only interacts with the natural environment is in an *archaeological context* (Schiffer 1987:4). The combination of Wreck CKB0022's subjection to human activity and the natural environment is vital to understanding its present state and its significance as an artifact. A discussion on both influential factors of the Corolla Wreck's site formation processes follows below, first the cultural.

<u>Cultural Processes</u>

Cultural formation processes are essentially defined as human activity that affect an artifact (Hocker and Wendel 2006:146). In the case of the Corolla Wreck, this includes loss.

Fehon and Scholtz (1978:271) define loss as the unexpected “disassociation of an object from its user.” Schiffer (1987:76) defines loss as a, “depositional process that contributes artifacts to the archaeological record,” and reclamation processes (salvage, scavenging, and artifact collecting), as well as abandonment processes. The Oxford English Dictionary (OED 2013) defines the noun form of *find* as, “a discovery of something valuable, typically something of archaeological interest.” An historic ship find is considered a “macro-artifact,” giving it a very high pragmatic loss ratio, meaning the loss of a ship is usually a permanent one (Schiffer 1987:77-78). Retrieval of lost ships occurred throughout history in salvage attempts to reclaim cargo, expensive guns, even whole ships. Comparatively, a small number of wrecks have been archaeologically excavated, hull and all. The Corolla Wreck as an artifact that, along with the artifacts it retained after deposition, was subject to reclamation processes. Most influential were scavenging, collecting, and salvage.

Geography and coastal traditions played a large part in scavenging. Schiffer (1987:106) defines *scavenging processes* as the exploitation of previously deposited artifacts by a settlement’s inhabitants. Littoral populations have engaged in scavenging activities since humans first began using water transportation. Many residents of the Outer Banks are descended from shipwreck survivors, whose progeny, in turn, profited heartily from later shipwrecks as late as the early 19th century (Stick 1952:3-5). The location of the wreck’s discovery happens to be in the most populated part of the Outer Banks, an area visited by five million people each year (Learn NC 2013). Such a location presented Wreck CKB0022 with countless opportunities for human contact and interaction.

General Statues of North Carolina (NCGS) Chapter 121 prohibits the molestation of shipwrecks on land or within three miles of the shoreline (NCGS 1967:121-123). Despite state legislation, local residents and vacationers alike generally feel uninhibited in disturbing wreck remains, collecting artifacts and, in some instances, removing parts of shipwrecks. Gubernatorial decrees, as early as 1678, in the proprietary Carolinas restricted the pillaging of wrecked ships on the colonies' barrier islands. Residents of the Outer Banks (like most littoral populations) considered wrecked vessel as a personal boon (Stick 1952:3-5). Schiffer (1987:114) differentiates *collecting* as a subcategory of scavenging, in that collecting processes involve "the disturbance, removal, and transport of surface materials," something Outer Banks residents refer to as "beach combing." Schiffer considers metal-detecting akin to *pothunting,* collecting subsurface materials. Both are popular hobbies on the Outer Banks. Unlike treasure-salvors, metal-detectorists and collectors are not motivated by demands of the international antiquities trade. They regard relic hunting as a natural hobby, and few consider their activities harmful let alone destructive. Some even say it is in their blood (Outer Banks resident 2012 pers. comm.). Many believe they are saving what would be lost artifacts of historical value; in various forms and cases this is true. Residents and vacationers who either actively sought collectibles or happened to stumble across an object of interest collected the majority of material culture and photo archival material. Indirectly, and at times directly, collectors inflict damage on both the artifact and its archaeological context. Others have educated themselves about how to handle and treat artifacts (Roger Harris 2012 pers. comm.); a few even have their own homemade conservation labs and personal museums (Harold "Hubby" Blivens 2013 pers. comm.).

This collecting behavior is an amalgam of centuries of tradition, entitlement, and indifference towards unenforced and non-promoted state laws, as well as creative adaption to exploit local resources. Locals seeking to save a piece of history collected nearly all Corolla artifacts documented to this day (see FIGURE 78).

FIGURE 78. Local resident removing concretions with a hammer and hatchet. *The highlighted concretion to the right contained two French coins*. (Author's identity withheld, 2009)

More than 1,700 photographs taken of the wreck from 2008 to 2010 attest to how many people actually interacted with the Corolla Wreck. How many hands, booted or barefoot feet, and, in some cases, crowbars and hammers, touched the wreck is impossible to ascertain. Whether human activity contributed to the January 2010 breakup of the wreck is unclear. Other natural factors, discussed below, were definite contributors. Authorities recorded neither human nor nature-inflicted damage to the wreck. The removal of the wreck from its dynamic littoral context, however, is well documented.

The discussion now turns to salvage processes.

> SALVAGE, maritime law. This term originally meant the thing or goods saved from shipwreck or other loss; and in that sense it is generally to be understood in our old books. But it is at present more frequently understood to mean the compensation made to those by whose means the ship or goods have been saved from the effects of shipwreck, fire, pirates, enemies, or any other loss or misfortune (Bouvier:1856).

In admiralty or maritime law, *salvage* is the compensation allotted to persons who voluntarily save a ship or its cargo from impending danger (Hill and Hill 2005). Maritime salvage may also be property recovered from vessels that were shipwrecked, derelict, or recaptured. Thus, salvage as a *legal* concept typically concerns maritime salvage. Archaeologically, *salvage processes* are those activities of reclaiming artifacts (Schiffer 1987:104). The salvage of the Corolla Wreck is termed rescue archaeology. In 2010, to prevent further damage to the Corolla Wreck, local and state authorities removed it from the beach. As discussed above, authorities extracted the wreck from the beach after its energetic, several-mile jaunt up and down the coast. Following an agreement to house the artifact at GOAM, transportation authorities relocated the wreck there in July 2010. With few exceptions, the wreck ceased exposure to human interaction, entering into a pseudo-archaeological record on the back patio of GOAM. After covering it with a heavy plastic construction tarp and erecting a wire and wood-slat fence, concerned parties, essentially abandoned the wreck.

Abandonment processes are the ways in which a place, structure, or entire settlement (and its artifacts) are transformed to the archaeological context (Schiffer 1987:89). Abandonment can result as a normal occurrence after an object has reached its use-life; then it becomes *refuse.* Abandonment can also result from catastrophe. Thus, technically, an argument could be made that the wreck was abandoned both at its wrecking event and again after its recovery. The counter argument, however, is that it was officially on state property and under the care of a legally constituted body charged with the care and preservation of the wreck. That this entity did little to carry out its duty to preserve the wreck has dramatically affected the remains.

Shipwreck events are not always completely destructive; on the contrary, the encapsulation effect can preserve entire assemblages, even organics, *en situ*. Such was not the case with the Corolla Wreck. The only artifacts left in Hatteras are the timbers themselves. The wreck is no longer subject to active human interaction, though it is part of the historical (archaeologically speaking) record as an artifact at GOAM. Archaeologists revisited the wreck for further study in October 2010, late 2011, and early 2012. Beyond minor sampling, nothing else was effected that might change the natural environmental influences on the wreck. The plastic tarp and wooden slat fence put in place in 2010 were gone less than a year later. In a physical sense, no further plans exist to preserve the wreck. In this way it is partly trapped in an archaeological context, subject to many non-cultural or natural forces

Natural Processes

Natural processes are environmental forces that affect an artifact, usually contributing to deterioration, decay, and modification. Some environs, however, particularly underwater, can enhance preservation (Schiffer 1987:146; Bowen 2009:17). Chemical agents, in the form of oxygen, water, sunlight, and atmospheric pollutants can all react chemically with material culture, leading to corrosion and other chemical modifications (Schiffer 1987:148). Water, wind, and sunlight are among the principal physical agents that affect sites and deposits and modify artifacts (Schiffer 1987:149). Water by itself, even moving, does little damage (Björdal 2011:78). Water movement caused by wave action or strong currents, especially with sediment and particulate, result in much higher rates of decay (Björdal et al 2011:79, 108). Moisture also promotes other forms of deterioration, such as biological (Bjödal et al. 2011:65-79), whereas the wetting and drying of wood causes cracking along the grain (Schiffer 1987:154). After burial for an indeterminate time in the tidal zone, the Corolla Wreck once again became mobile. The wreck, as an exposed wooden structure, became subject to all the above factors.

The most influential factors, wind, water, and scouring by water and sediment are an inescapable presence in a coastal environment. The timbers neither exhibited the same deterioration or scouring of beached wrecks deposited 200 years later. In photographs from

2010, original squared edges are visible on frames, suggesting relatively good preservation before 2009. Neither did the Corolla Wreck show sign of teredo worm damage.

Teredo worms (*Terdindae*) are found worldwide with 66 known species comprising the family. *Teredo navalis* is one of six species that reproduces in the waters of Northern Europe, causing worm damage to wooden structures and vessels even in the Baltic. (Turner 1966 in Appelqvist 2011:57). The lack of teredo worm damage suggests Wreck CKB0022 may have once been a deep water wreck, or one buried in a stable anaerobic substrate (Appelqvist et al 2011:60-62,74-76,118-120). Teredo, or shipworms (see FIGURE 79), cause severe damage to wood (see FIGURE 80) in warm, temperate, and even some cold marine environs (Appelqvist 2011:61).

FIGURE 79. Shipworm (*Teredinidae*), also teredo worm, has caused damage to wooden vessels and submerged wooden structures for thousands of years. (Courtesy of Audubon.org, 2013)
FIGURE 80. Teredo worm borings in a modern wharf piling. (Photo by Mark Wilson, 2008)

Shipwrights battled the damage caused by shipworms for millennia until the advent of ferrous hulls and more modern chemical antifouling agents. Builders employed pine sheathing, lead sheathing, and eventually copper sheathing to combat the damage done to ships' hulls by shipworms and other wood boring marine organisms (McCarthy 2005:101-102). The undersides of CKB0022's hull planks did not exhibit any sign of sheathing. Ships destined for the Caribbean, Mediterranean, or East Indies often utilized some form of sheathing, but not always; vessels that trafficked in the northern extremes of the Atlantic or Baltic Sea did not require sheathing.

The wreck's mobile jaunt up and down the coast late 2009 to early 2010 might have worn evidence of boreholes away. The Corolla Wreck, however, did not display any evidence of shipworm infestation. So what protected the wreck from teredo worm attack during its deposition on the ocean floor? Teredo worms infest quickly, beginning at the larval phase of their life cycle. Even in cold water, the worms can do drastic damage, consuming eight inches (20cm) of wood in a single year in some studies. A myriad of factors affect teredo worm population distribution from year to year: temperature, dissolved oxygen levels, season, ocean currents, salinity, and the availability of wood substrate. (Turnery 1966 in Appelqvist 2011:57, Appelqvist 2011:58-62). Even if the wreck escaped worm damage to surviving frames, what protected the remains after being disturbed from the ocean floor and its journey to the shore? Two hypothetical site formation models might explain both the lack of worm damage and good state of preservation of the wreck's timbers.

In Model A (see FIGURE 81) the vessel is afloat (1); typically, this would render it vulnerable to teredo worm attack. (2) The wrecking event occurs. Depending on the violence of the event and how quickly it sank, the vessel remains would still be vulnerable, and previously unexposed internal timbers would also be available to shipworm attack. (3) The wreck comes to rest on the ocean floor; unless it came to rest in an oxygen-depleted environment, it may still be subject to worm attack. Research on teredo worms at depth remains untested, though extreme levels of salinity (levels above 8-10 psu)can be as lethal as anaerobic environments (Appelqvist 2011:61). (4) The wreck becomes covered with substrate, as little as 10cm can be effective protection; exposed timbers remain exposed to shipworm, and because of a variety of factors, collapse. (5) The wreck is buried in an anaerobic substrate; 50cm is enough to kill shipworms and arrest infestation and protect attack from most marine organisms (Gregory:1999:343-348; 2011:120). (6) Something dislodges the wreck and it re-enters the water column for an unknown amount of time, again, susceptible to teredo worms and other wood borers. Even in an anaerobic substrate, just the exposed ends of a timber can result in shipworm infestation (Jordan 2003; Björdal 2011:74). (7) The wreck is deposited in the tidal zone at an undetermined time and reburied where it remains protected from further worm damage.

This scenario suggests there ought to have been some teredo worm damage on the wreck remains. The lack of observable wormholes may reflect the damage to such evidence after deposition on the coast, as teredo-riddled wood is quite fragile, or that investigators missed such damage. At early stages, shipworms bore extremely small holes; 14-days old, larvae can bore holes at the size of 0.25mm (Appelqvist 2011:58). No worm damage is visible in the earliest photos of the wreck or at the time of recording. Another possibility could be the vessel departed during an extremely cold fall or winter and wrecked in the same season. In the Atlantic, teredo worms spawn from early summer to late fall. An unseasonably cool summer and fall could lower the teredo population. A simpler explanation can be found in another model.

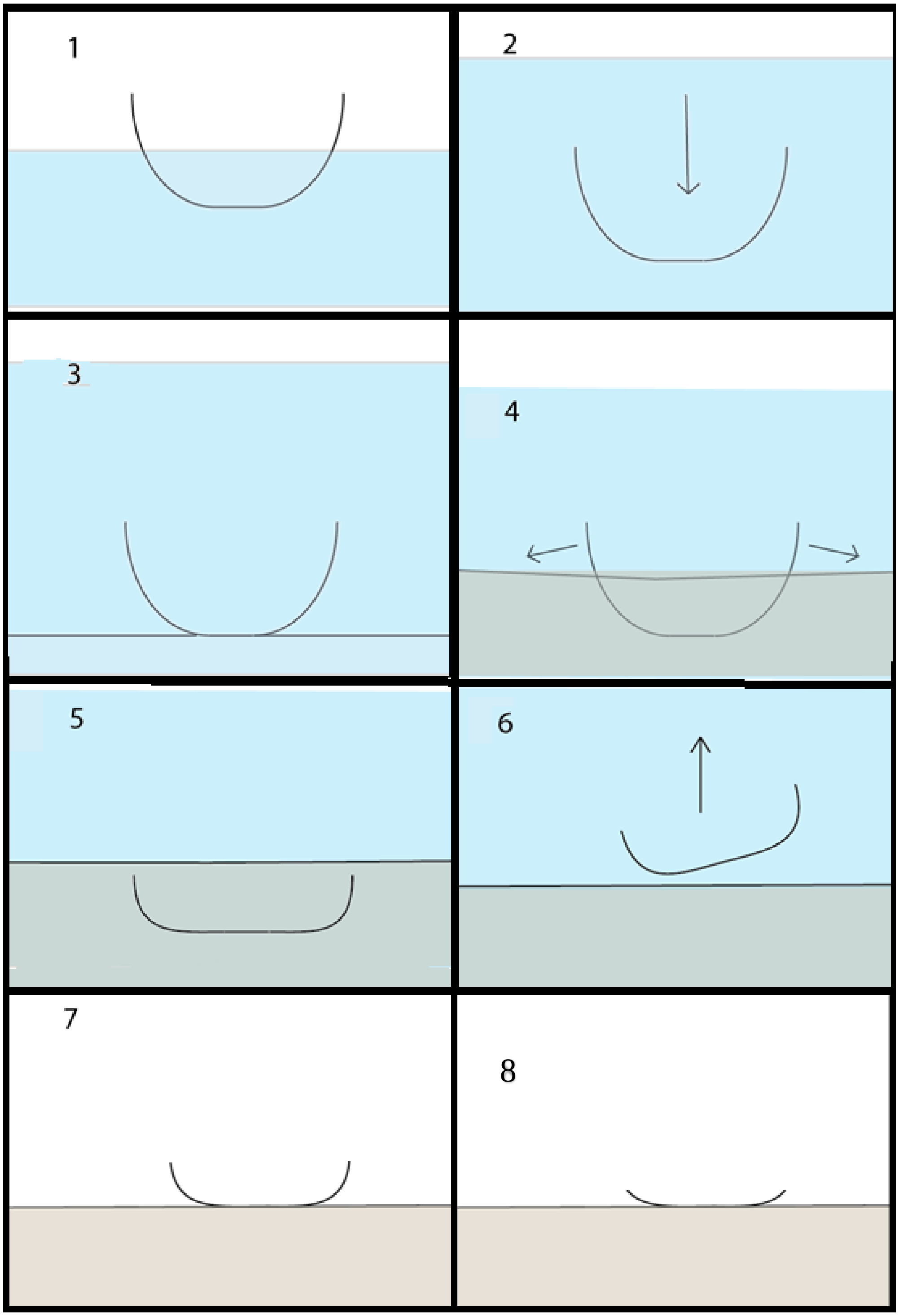

FIGURE 81. Site Formation Model A. (By author, 2013)

In Model B (see FIGURE 82) (1) the vessel is afloat, likely attacked by teredo worms, depending again on season, water temperature, and spawning success. (2) The vessel experiences a catastrophic wrecking event and is deposited on the shoreline, no longer susceptible to worm damage. (3) The wreck is buried in an anaerobic beach environment where it remains in good preservation until disturbed sometime in 2008. The beaching event could have removed evidence of worm damage to the hull and even a layer of sacrificial planking. The Corolla wreck's keel suggests a false keel was attached to the bottom, thus, sacrificial planking (a common practice for Atlantic vessels) remains a good possibility. The only contention with this theory would be that the Corolla Wreck, at its greatest documented extent, consisted of more than 40 feet of the *forward* section of a ship. When ships ground, damage to the keel and bow are usually evident. In fact, archaeologists rarely find bow sections of wrecked ships because of the rake of most keels, setting the aft end lower in the water, thereby leaving the bow higher up than the stern. In any substrate, this leaves the bow more vulnerable to marine organisms. The other possibility is the vessel foundered then righted and was cast ashore, the stern damaged or lost at some point; questions remain. Far more concrete evidence is available for the wreck's site formation following its discovery in 2008.

Wind, tides, and storms repeatedly re-buried and exposed the wreck, allowing its discovery in 2008, re-discovery in 2009, and its jaunt up and down the coast until more destructive disarticulation in 2010. Wind and water are not the only culprits that led to the Corolla Wreck's demise. All of these factors interacted, and continue to interact, as the wreck sits unprotected from the elements just 100s of yards from the ocean, directly affecting the material core elements of Wreck CKB0022, wood.

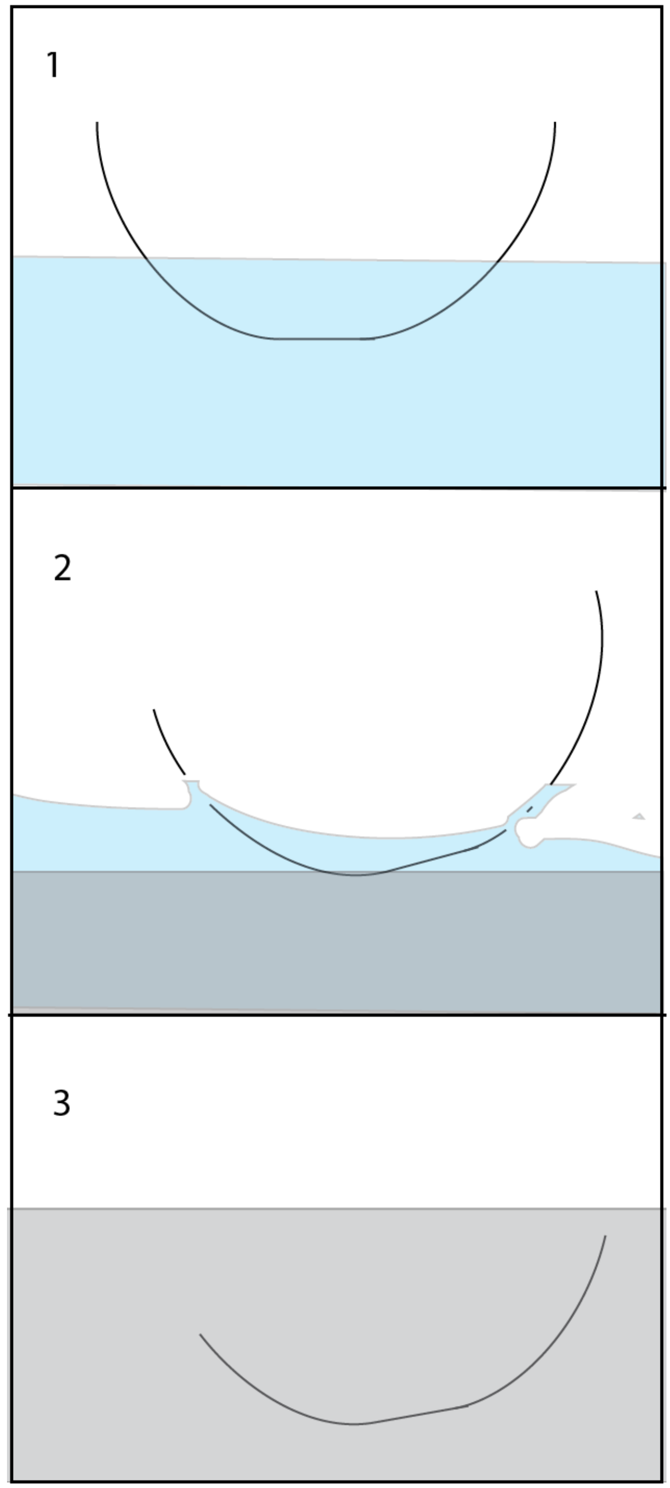

FIGURE 82. Site Formation Model B. (By author, 2013)

Wooden Artifacts & Wood Analysis

In his 2004 manual on archaeological conservation, Dr. Bradley Rodgers (2004:36) describes the microstructure of wood: “Wood cells are made of complex carbohydrate molecules.” Glucose molecules manufactured by photosynthesis chain together to form the complex polymer cellulose (Schiffer 1987:165). Cellulose makes most wood cells, joining together to make micro-fibrils and macro-fibrils that give wood its strength and durability (Rodgers 2004:36). Some woods, like oak, exhibit natural strength, is relatively waterproof, and retains a natural resistance to decay (mostly fungal) (Schiffer 1987:165-166; Rodgers 2004:35).The presence of water, depending on saturation levels, can easily undo natural resistance (Rodgers 2004:39). Seasoning, the drying of timbers at a slow rate reduces susceptibility to decay and ensures consistent shrinkage of wood cells. Dry timber contains approximately 15% to 20% water (compared to 30% at felling). In the right aquatic environment, wood immersed in water will undergo excellent preservation (Hickin 1963:23; Richardson 1978:32, in Schiffer 1987:167). Annual changes in moisture content result in seasonal collapse and shrinkage of wood across the gain at normal levels. Wood that has been seasoned will also shrink to a controlled and stable extent. Wood that has been substantially damaged, especially by waterlogging and dehydration, will shrink across the grain, more so tangentially (5% to 10%), to a lesser degree radially (2% to 6%); longitudinally, shrinkage is so slight as to usually be neglected (or go undetected at rates of 0.1% to 0.3%) (Walker et al 1993:595; Rodgers 2004:37-38,40). Waterlogged wood is defined as wood that contains little or no air in its cellular spaces. The cell walls weaken when the moisture content reaches saturation. Waterlogged-wood, upon dehydration, can experience cellular collapse with the rush of water from its cells. Water enables capillary tension, allowing cohesion between cells. When the water leaves saturated cells at a (microscopically) rapid rate, it pulls at the walls causing collapse, like the demolition of a firewall in a house. Wood scientists call this capillary tension collapse (CTC), and even wet or damp wood will undergo CTC if not constantly saturated with water (Rodgers 2004:39). Hence, the structural break down of the Corolla Wreck. CTC can begin rapidly, and then slow its pace, but once begun, is irreversible. Further dehydration leads to shrinkage of the cell walls and further distortion of dried waterlogged-wood. Continual wetting and drying of damaged wood, left exposed to the elements, eventually leads to disintegration (Rodgers 2004:38-40). What caused the structural disarticulation of the wreck in January 2010 was not dehydration, but CTC. While in the tidal zone, the timbers of the Corolla Wreck remained saturated with seawater, to what extent remains unknown.

Photographs of the wreck show it intact on 31 December 2009 (see FIGURE 83). Then, photographed just five days later, the stem, apron, and keel lay disarticulated on the port side of the wreck, one ceiling plank barely visible in the background (see FIGURE 84). There are two possibilities that could evoke such violent disarticulation on CKB0022. The first could be cultural; vandalism is a common crime. To undo the stem and keel assembly, however, would require more brute force than a single individual could muster with most tools. Chains and a tow hitch might suffice to wrest the keel from its fasteners, given the corroded state of the iron bolts and the cellular collapse of the treenails. It is possible someone might have attempted to drag the wreck from the beach, viewing it as a vehicle hazard. Vehicles with permits are allowed to drive on the beach in North Carolina. Certainly CTC played a role in the destabilization of timbers and fasteners as wood cells continued to weaken and collapse. It is possible that just as temperatures began to plummet, the structural integrity of the rusted bolts and water logged treenails literally reached a breaking point. No storms were reported in the meteorological data in early January, but perhaps violent surf was enough to do the damage. Unfortunately, no diagnostic images of the break were found among the 1,700 plus photographic archive. What exactly caused the sudden breakup of the bow assemblage remains one of the unsolved mysteries surrounding the Corolla Wreck.

FIGURE 83. CKB0022 photographed on 31 December 2009. (By John Aylor)

FIGURE 84. CKB0022 photographed on 3 January 2010. Stem, apron and keel (*not shown*) lay to the right of the wreck; the detached ceiling plank is in the left background. (By Roger Harris)

Shortly after removing the wreck from the sands near Corolla, UAB sent six wood samples to the University of Pennsylvania's Department of Anthropology for analysis. The results determined that all samples were of the white oak anatomical group. Samples were taken from the keel, floor, lower futtock or half-frame, garboard strake, and two treenails. The first four samples were the same species of sessile oak, also known as "durmast oak, Cornish, and Welsh Oak," native to most of Europe into Anatolia (see FIGURE 85 and FIGURE 86) (Newsom 2010:1). Sessile oak (*Quercus petraea*) is a large, deciduous tree peaking at 66 to 130 feet (20-40m) tall, occurring in upland areas close to 1000 feet (over 300 m) above sea level, with higher rainfall and shallow, acidic, sandy soils (Rushforth 1999:1075).

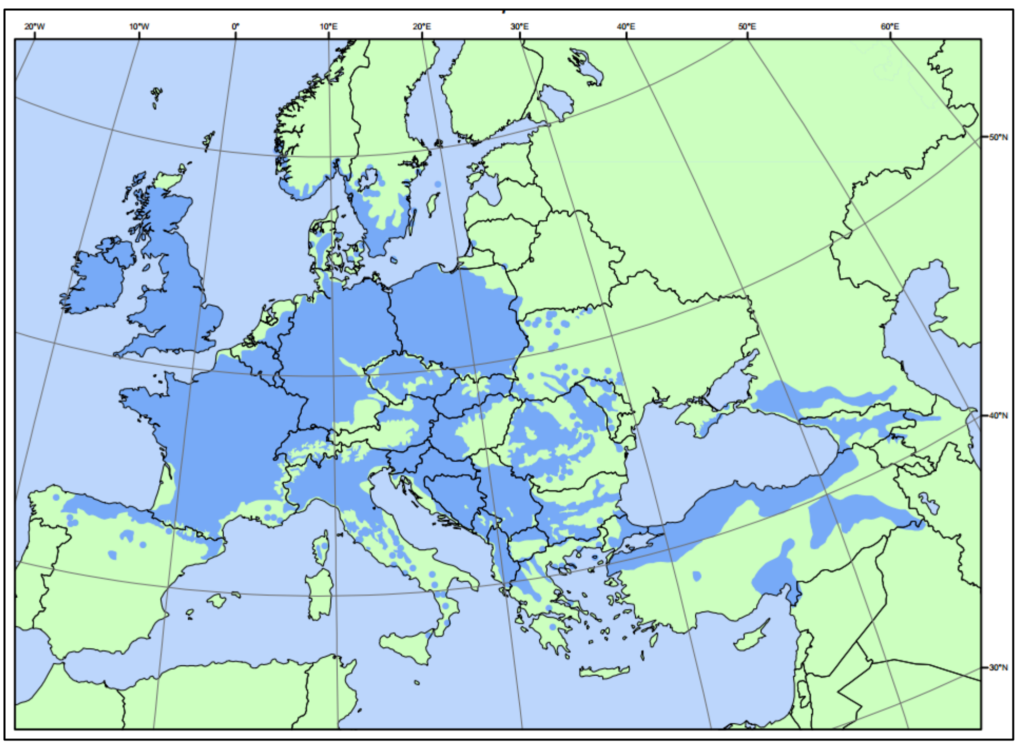

FIGURE 85. Distribution map, dark blue area showing the natural distribution of *Quercus petraea*. (Compiled by EUROGEN 2009)

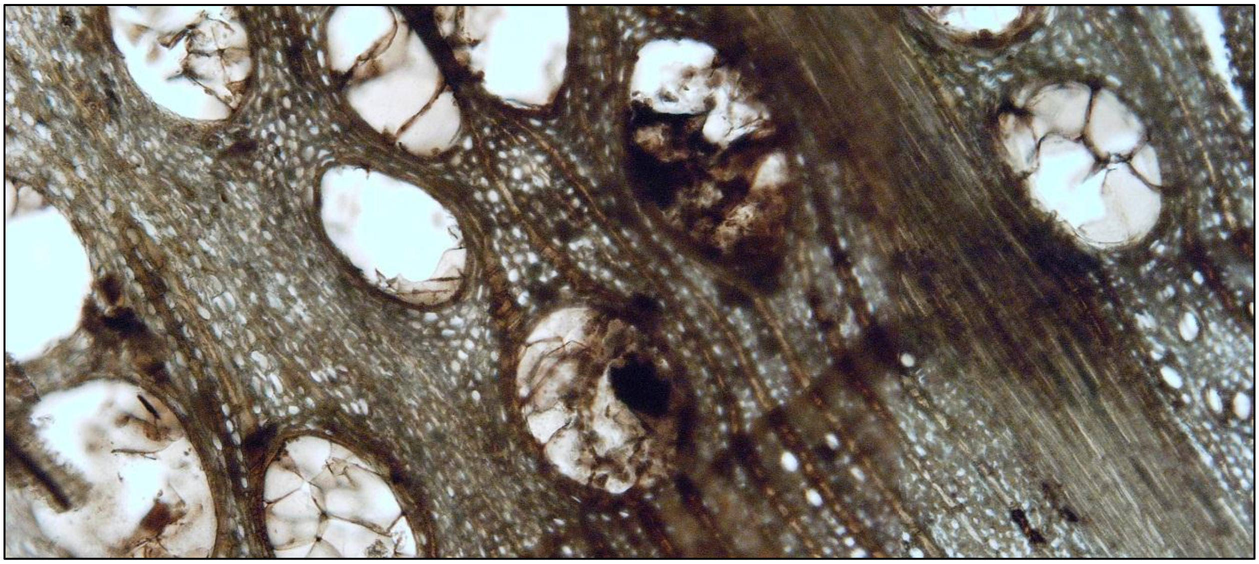

FIGURE 86. Slide from one of CKB0022's oak floors showing trachieds. (By Newsom, 2010)

The two treenails were also white oak (but neither *Quercus petraea* nor *Quercus robur*, "penduculate" or "English Oak") (Newsom 2010:1). English Oak grows in deeper, rich soils at lower altitude (Rushforth 1999:1091). Thus, European white oak rules out New World or North American origins. This, unfortunately, does not narrow possibilities of where in Europe the timber came from. Seventeenth-century colonists, especially the Iberians, did build vessels abroad, usually with locally hewn or salvaged timbers from their own ships (see *Sea Venture* above). Further dendrochronological analysis could go far to date the felling and origin of the timber used to construct the vessel CKB0022 represents. Unfortunately, no proper samples were taken at the time of removal from the littoral zone or since. Various experts have suggested there may be little information left given the continued state of disintegration and collapse of the surviving hull. An experienced or trained scientist should attempt proper dendrochronological samples. Such an opportunity may unfortunately, have passed.

Archaeology of Site CKB0022

Traditionally, a shipwreck's artifact assemblage aids archaeologists in determining the vessel's cargo, its use, cultural makeup of the crew, and even the origin of the vessel and year of the wrecking event. Unfortunately, collectors, both avid hunters and curious visitors, picked up most material culture from CKB0022 without any scientific documentation and little provenience. The mobile proclivity of the wreck further complicated verifying testimony of where certain artifacts were found in relation to the wreck. A small number of artifacts were donated to UAB; and a few others collected during subsequent observations of the wreck. Most of the material collected is in possession of two Outer Banks residents, Ray Midgett and Roger Harris. Though not every artifact they affiliate with the Corolla Wreck reflects a 17th-century origin, much of the material culture does appear to be from the 17th century. No artifacts were recorded *en situ*. Careful photographic sifting, however, established an actual provenience for two diagnostic artifacts. Fortunately, both Midgett and Harris were enthusiastically cooperative in allowing the photographic recording of their collections and assisted the team in the documentation process. Harris even purchased a book on conservation and attempted basic electrolysis to preserve a round of 6-pound shot and some rigging elements he recovered. Closer inspection of the collections revealed several artifacts, in particular English, French, and Spanish coins, all dated from the early-to-mid 17th century.

<u>Artifactual Analysis</u>

The most numerous artifacts in both collections consist of lead shot and brass pins (see FIGURE 87 and FIGURE 88). Unfortunately, dating a pin is nearly impossible, with little, if any difference between pins manufactured between the 15th and late 18th centuries. American efforts to manufacture pins failed to take off, and Americans imported pins from England well into the middle of the 19th century (Beaudry 2006:19,21,40). Analysis of the lead shot may provide more information; unfortunately, such analysis required time and resources not at the author's disposal. A concreted bag of hail shot was the most interesting sample of munitions from either collection (see FIGURE 89). Hail shot was similar to cluster or grape-shot, except that it included iron dice for added anti-personnel effect. Hail shot is first noted on the manifest of *Harry Grace a Dieu,* ca. 1520, under the heading "Shot of iron" listed as "Dice of iron for hail shot" (Hattendorf et al.1993:119).

FIGURE 87. Brass pins Harris found within concretions from the Wreck CKB0022. (Photo by Author, 2012)

FIGURE 88. Lead shot Midgett removed from concretions from the Wreck CKB0022. (Photo by Author, 2012)

FIGURE 89. Hail shot from Roger Harris's collection (*note the iron dice*). (Photo by Author, 2012)

The rest of Midgett and Harris's collections reflect a variety of artifacts with a consistent 17th-century context. Included are several copper alloy objects, including a rose-shaped ring, rose style button, dividers, a gunlock, French lead seals, a Spanish spur, and an English pennyweight (see FIGURE 90 through FIGURE 97).

FIGURE 90. Spanish style brass spur recovered by Harris from Site CKB0022. (Photo by Author, 2012) FIGURE 91. Dividers recovered from Wreck CKB0022 by Midgett. (Photo by Author, 2012)

FIGURE 92. Gunlock recovered by Midgett from Wreck CKB0022. (Photo by Author, 2012)

FIGURE 93. Rose ring recovered by Midgett from Wreck CKB0022. (Photo by Author, 2012)

FIGURE 94. Copper alloy seal "M T" recovered by Harris from CKB0022. (Photo by Roger Harris, 2012)

FIGURE 95. English pennyweight manufactured after 1602, recovered by Midgett from CKB0022. (Photo by Author, 2012)

FIGURE 96. Rose button recovered by Midgett from CKB0022. (Photo by Author, 2012)

FIGURE 97. French lead seals recovered by Midgett from Wreck CKB0022. (Photo by Author, 2012)

Two deadeyes are part of the Harris collection; one was recovered in vicinity of the wreck, the other reportedly from the hull remains (Roger Harris pers. comm. 2012). The former appeared to be lathe-turned lignum vitae, late 18th century at most (Fred Hocker 2013 elec. comm.). The latter, however, looked early 17th century, very similar to *Vasa's* deadeyes, narrower at the ends and thicker in the middle, like those described by R. C. Anderson (1955:51,56) (see FIGURE 98 and FIGURE 99).

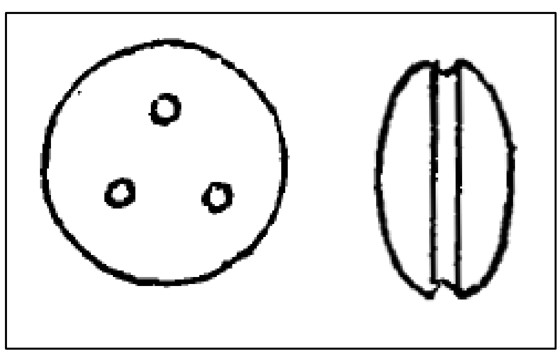

FIGURE 98. From R. C. Anderson's *The Rigging of 17th-Century Ships*.

FIGURE 99. One of Harris's deadeyes, very reminiscent of a *Vasa* deadeye, ca. 1610-1640. (Photo by Author, 2012)

Among the most diagnostic artifacts recovered from Site CKB0022 are seven coins ca. the late 16th century and early-to-mid 17th century. They include several Spanish *maravedis* (see FIGURE 100 through FIGURE 104), one English coin from the reign of Charles I just six years before his execution (see FIGURE 105), and two French *double tournois* from the reign of Louis XIII, both dating to late his in rule (see FIGURE 106, FIGURE 1067, and FIGURE 108).

FIGURE 100 and FIGURE 101. Undated Spanish *maravedis* recovered by Midgett near the Corolla Wreck. (Photo by Author, 2012)

FIGURE 102. Undated Spanish *maravedi* ca. Phillip II (reign 1554-1598) recovered by Midgett from Site CKB0022. (Photo by Author, 2012)

FIGURE 103. Undated Spanish *maravedi* ca. Phillip III (1598-1621) recovered by Midgett from Site CKB0022. (Photo by Author, 2012)

FIGURE 104. Spanish *marvedi* dated 1603 from the reign of Phillip III (1598-1621) recovered by Midgett from Site CKB0022. (Photo by Author, 2012)

FIGURE 105. English coin dated 1643 from the reign of Charles I (1625-1649) recovered by Midgett from Site CKB0022. (Photo by Author, 2012)

FIGURE 106. Harris's French *double tournois* ca. Louis XIII dated 164_, and the concretion he removed from a plank of the Corolla Wreck. (Photo by Roger Harris, 2009); FIGURE 107. The same coin photographed in 2012. (Photo by Author).

FIGURE 108. . A less preserved French *double tournois* ca. Louis XIII (reign 1610-1643) recovered by Harris from a concretion taken from the Corolla Wreck. (Photo by Author, 2012)
FIGURE 109. An excellently preserved example of a French *double tournois* of the same period dated 1643. (Courtesy of www.cgb.fr, 2013)

When Ray Midgett and Roger Harris first reported these artifacts, UAB archaeologists considered them key evidence dating the Corolla Wreck to the early half of the 17th century. Coinage from Spain, England, and France recovered from or near the wreck caused some confusion. A vessel carrying mixed currencies, however, would not have been an anomaly in the 17th century, as merchants and sailors used whatever currency they had available—it was an oft bemoaned complaint of the shortage of cash in the American colonies, the exception being New Spain. That the coins range from the late 16th century to the 1640s is no surprise either—coins were hard currency and remained in circulation (as they do today) decades after minting. The lack of *en situ* recording posed a few challenges to utilizing both collections in that only the two French coins have a solid provenience, in dated photographs, showing the ceiling plank that became disarticulated from the wreck in early 2010, later removed by Harris and Midgett, from which Harris removed a fist sized concretion containing the two *double tournois*. The more preserved coin, with a clear date of 164_ could only have been minted between 1640 and 1643 before the death of King Louis XIII of France. This provides the wreck with a definite *terminus post quem* of 1640, confirming a mid-17th-century context at the earliest for the wrecking event of the vessel remains CKB0022. Aside from the Midgett and Harris collections, Henry Blivens of Manteo has a pewter spoon and a copper alloy finial his sons recovered from the wreck when it was still in the surf in 2008 (see FIGURE 110 and FIGURE 111).

FIGURE 110. Pewter spoons recovered from the Corolla Wreck in 2008. (Photo by Author, 2012)

FIGURE 111. Copper alloy finial recovered from the Corolla Wreck in 2008. (Photo by Author, 2012)

The author has not seen the video of this recovery to confirm the provenience of these two artifacts. The lack of *in situ* documentation of these and other artifacts as well as the coins, however, is buffered by the astronomical statistical chance of so many 17th-century artifacts being found near or on a single wooden vessel. The vessel's structural elements also suggest an origin around the middle of the 17th century.

Structural Analysis

Though material culture remains the best dating tool available for dating a wreck site, archaeologists can turn to the wreck for possible answers as to the origin and broader date of shipwreck remains. Nathan Henry and Richard Lawrence from North Carolina's Underwater Archaeology Branch (UAB) conducted the earliest archaeological recording of the ambulatory wreck in January 2010. Lawrence observed that the use of treenails as the primary fastener holding the planks and frames together suggested it was far older than the 19th-century wrecks typically encountered in the shifting dunes of the Outer Banks. Unfortunately, no recording of the wreck occurred before its catastrophic break up just before the UAB encounter in January 2010.

The UAB survey recorded a piece of a vessel's hull measuring 28 feet 9 inches (8.76 m) by 17 feet 2 inches (5.23 m). A total of 10 frames consisting of 10 floor timbers with 14 associated framing timbers, five on one side, nine on the other. Measured photographs from the UAB recordings show a joint in the keel where the stem was scarfed, along with a section of the apron (see FIGURE 112). According to Lawrence and Henry, the stem section measured 9 feet 8 inches (2.95 m) long, joined by a vertical scarf to a 44 foot 1 inch (13.45 m) length of keel. Photographs taken before the UAB recording show far greater extant wreck remains. By using the below profile as a scale (see FIGURE 112), it is possible to estimate the original 2008 length to approximately 40 feet (12.19 m). Several forward timbers and aft floors, as well as ceiling planks and stringers, were lost before any archaeological recording. As mentioned in the introductory chapter, students and faculty from East Carolina University carried out far more extensive recording of the salvaged wreck in late May and early June 2010.

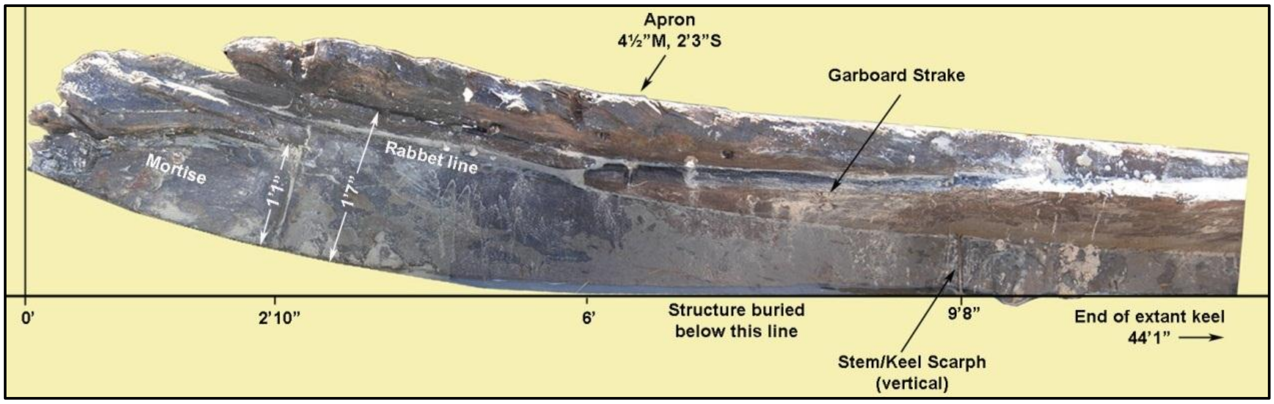

FIGURE 112. Measured photo profile of the disarticulated stem *in situ*. (By Lawrence and Henry, 2010, Courtesy NCUAB)

Nathan Richards conducted a preliminary survey of the Corolla Wreck with two crew chiefs on 8 May 2010. The primary investigators decided to include the remains as part of the multi-wreck field school they were conducting later that month with graduate students from East Carolina University's (ECU) Program in Maritime Studies (PMS). Additional recording resumed between 25 through 28 May 2010. Recording included additional photographs, scaled drawings of all timbers, fasteners, tool marks, repairs, all drawn in plan view, as well as frame profiles later drafted onto a sight plan (see FIGURE 113 and FIGURE 114). A piece of the ship's apron, photographed in 2008 and 2009, was also recorded, as well as a piece of the keel. The good state of preservation both in the photographs and after a month of dehydrating in the hot late spring weather suggested to Rodgers that this was not a beached wreck.

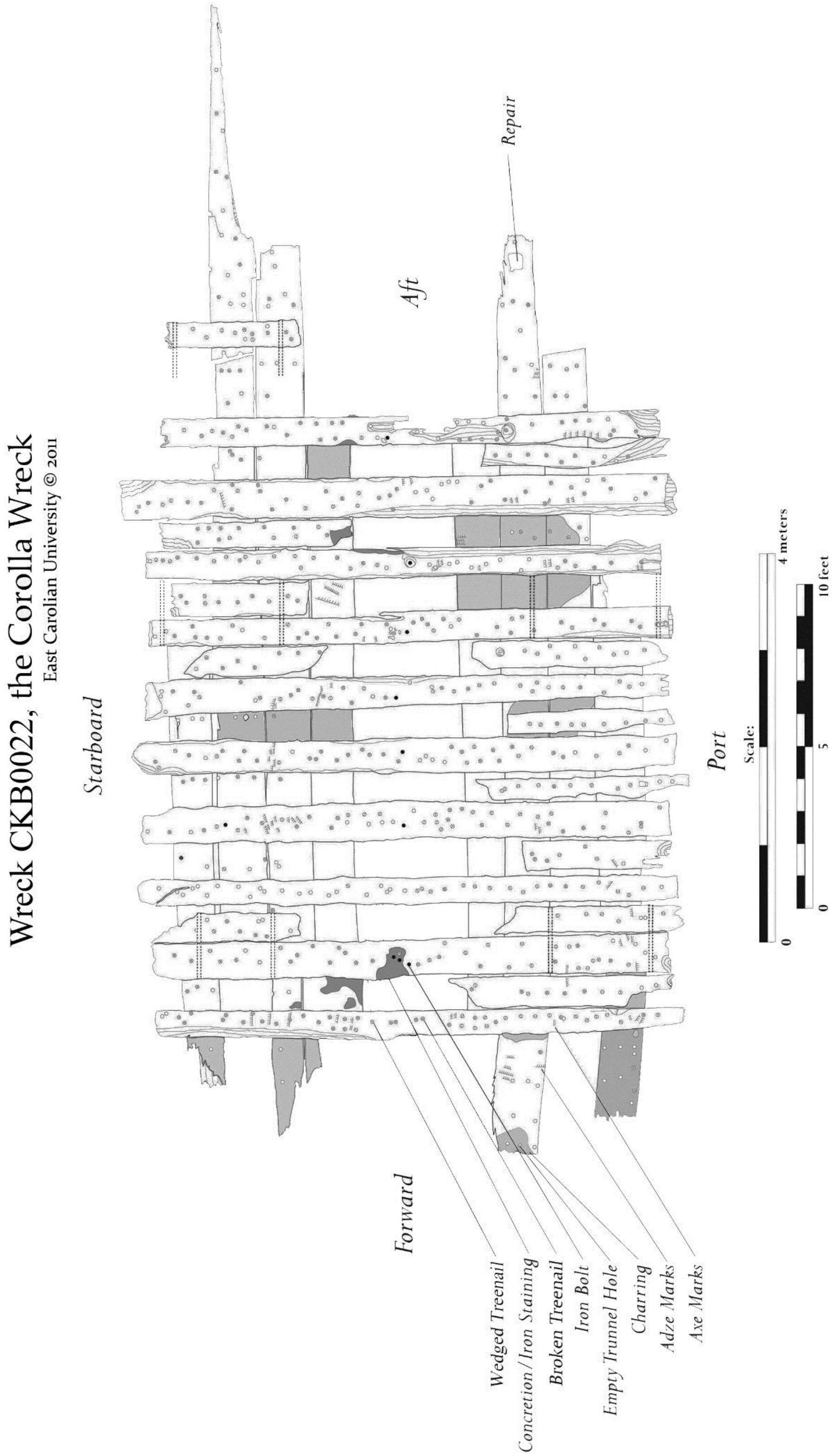

FIGURE 113. Wreck CKB0022’s scaled site plan. (© East Carolina University, 2010)

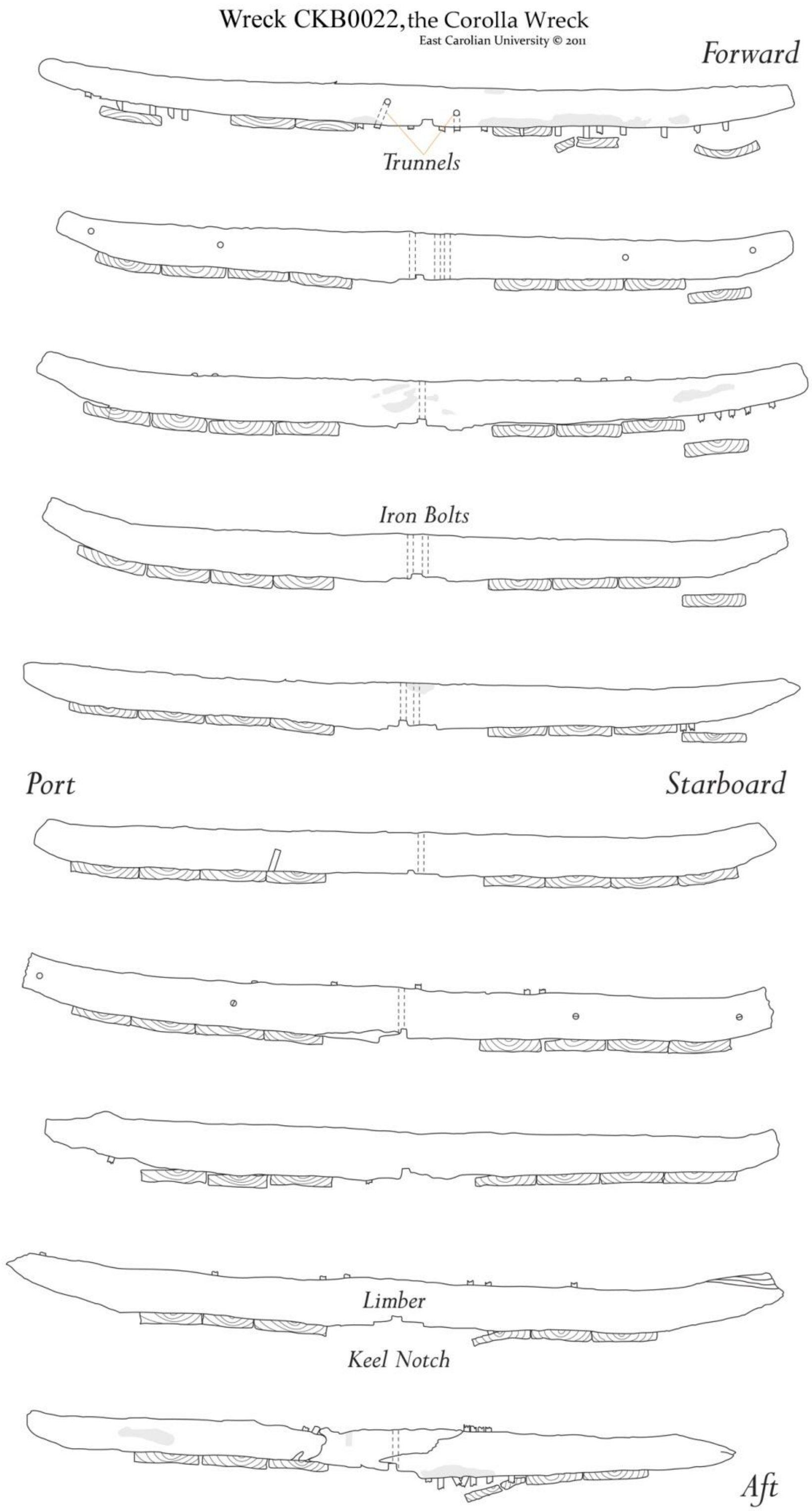

FIGURE 114. Frame profiles from Wreck CKB0022. (© East Carolina University, 2010)

The ECU recording resulted in more specific dimensions of 10 floor timbers and 14 futtocks and filling pieces recorded by UAB, as well as the locations and number of all fasteners and fastener holes. Of the fasteners recorded, only nine were iron, all of them along the centerline of floors where the keelson would have been located before disarticulation. The staggered location of the iron fasteners and photographic evidence of iron bolts protruding from frames along the centerline suggest a very wide keelson with a fairly shallow molded dimension. The rest were wooden fasteners, or treenails, fastened through hull planking into frames (see FIGURE 115); some are wedged but most are shorn. Observation of timbers and fasteners revealed a pattern of 1 to 2 wedged treenails fastened through frames and, along with 2, 3, or 4 treenails fastened through hull, frames, and ceiling planking (shown as shorn on the site plan as all ceiling planks were disarticulated). Treenails are staggered, averaging 2 to 3 per strake on futtocks and 3 to 4 per strake (many along strake seams) on frames, depending on the sided dimension of the frame. Among these are five treenails and an additional five treenail holes running fore-and-aft, denoting five fore-and-aft (longitudinally) fastened frames (two treenails each) and indicated a sixth where a port-side futtock and central floor were missing. These longitudinal fasteners are usually found on master frames, and shaping, or tail-frames (see Chapter 4), where the floors and lower futtocks were preassembled to provide frame shapes between master frames and perpendiculars, usually with one or more sets of ribbands that gave the carpenter the shape of frames yet added.

In the latter half of the 17th century, shipwrights used transversely fastened treenails on vessels built with double or composite frames (Batchvarov 2002) (see FIGURE 116). Combined with chocks, this frame style added to the strength of the vessel, required less compass timber, and provided more space between frames for air circulation, helping to decrease wood rot.

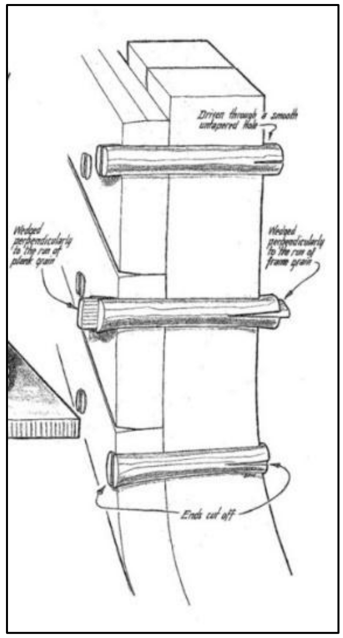

FIGURE 115. Treenails and their function. (By Sam Manning, in Greenhill 1988)

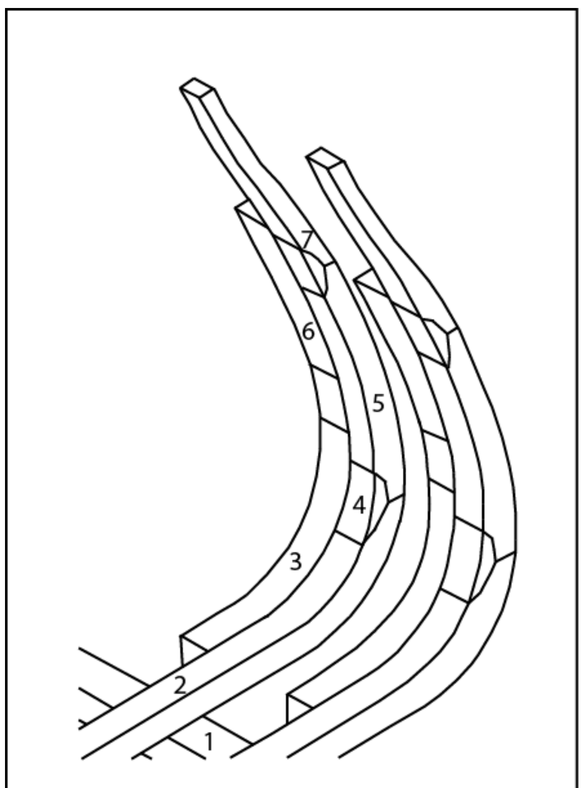

FIGURE 116. A composite frame: keel (1), floor (2), first futtock (3), chock (4), second futtock (5), third futtock (6), top-timber (7). (By Author 2013, after Batchvarov, 2002)

The Corolla Wreck's frames, despite some lateral fasteners, are of an older style of construction (see FIGURE 117). Room-and-space (space occupied by a floor and the empty space between it and the next frame) is occupied by lower futtocks, and if the upper ends reached the railing, created a solid wall of timber. Even if they only passed the turn of the bilge, this solid band of timber provided great strength to the hull, but did not allow for the circulation of air or water beyond the limber holes. Such framing is resonant of late 16th-century and earlier 17th-century origins when compass timber was more readily available (Church 2008:59) and before greater demands of increasing numbers of larger vessels with more numerous and larger guns that appeared in the latter half of the 17th century.

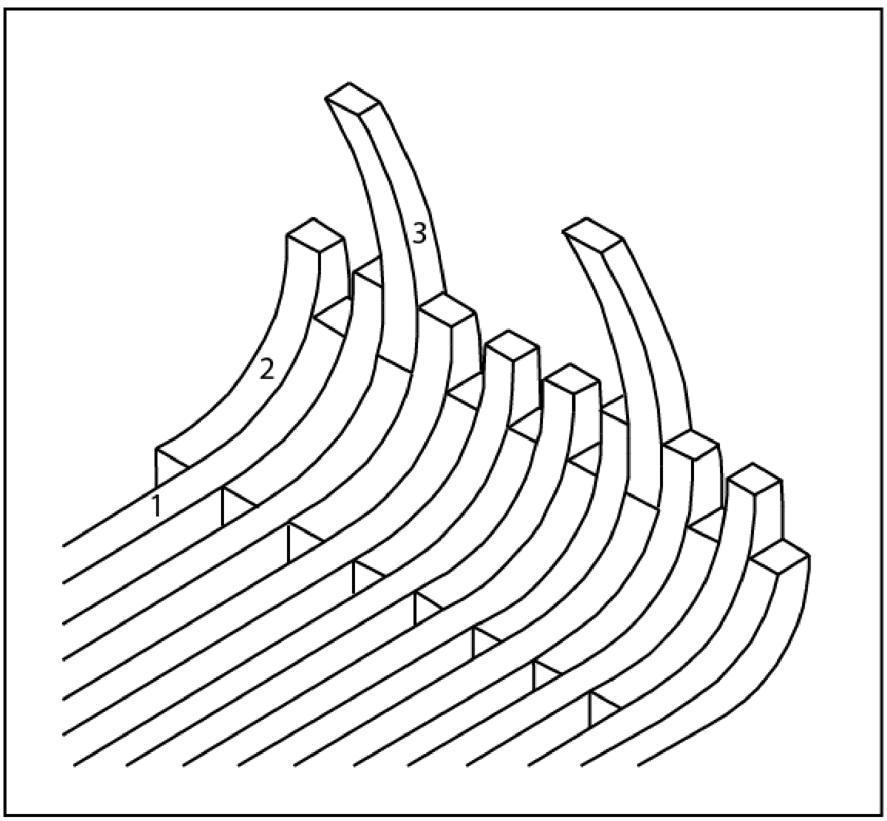

FIGURE 117. The solid band of timber between floors (1), lower (2), and upper (3) half-frames. (By Author 2013, after Batchvarov)

The regularity of the framing, the average squared dimensions of the floors (12 inches or 30 cm), the predominant use of treenails, and the striking resemblance to the remains of *Sea Venture*, led Rodgers to believe the Corolla Wreck likely had English origins. Could this be the remains of English vessel built in the late 16th to early 17th century? Historical research, artifacts, timber species analysis, and certain structural features support such a theory.

Among first features to stand out to Rodgers during the ECU recording, after transverse treenails, was the square-pegged wedges first noted on the outer ends of treenails lodged in the underside of the apron. Further inspection of the keel and hull planking found many more examples (see FIGURE 118 and FIGURE 119). Unfortunately, because of time constraints and the presence of poison ivy (and a few snakes), no recording of the outboard face of hull planking or treenails occurred.

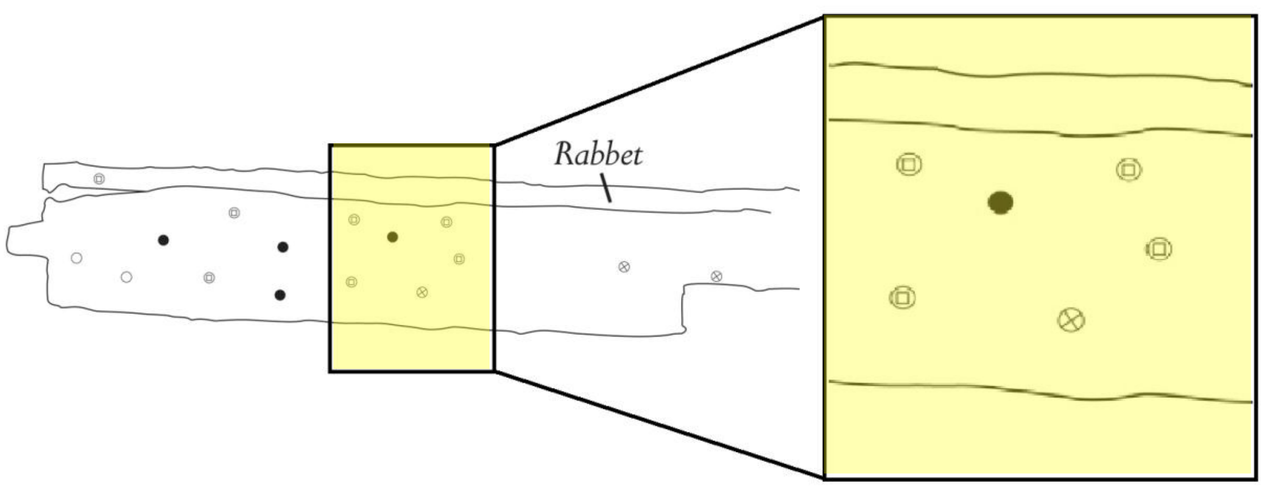

FIGURE 118. Detail of square-pegged treenails from the keel drawing. (By Author 2013, after ECU, 2010)

FIGURE 119. Square-pegged treenail from a hull plank on CKB0022. (Photo by Bradley Rodgers, 2010)

The square-pegged treenails, however, were thought to be a strictly 17th-century technique utilized by Dutch shipwrights, like those found on *Batavia*, the Dutch-built *Vasa*, and some of the Christianshaven Wrecks (see FIGURE 120and FIGURE 121). Strictly Dutch, however, turned not to be the case.

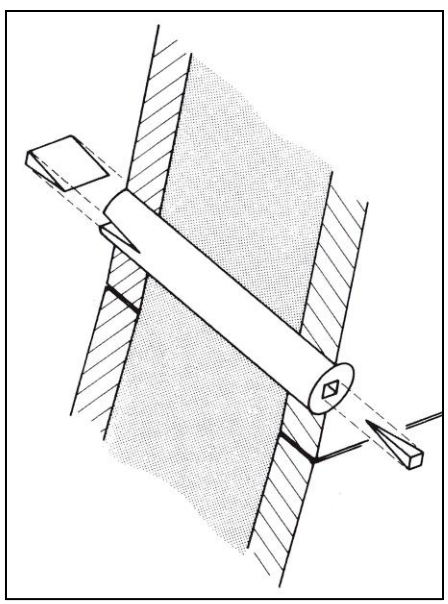

FIGURE 120. Drawing of a square-pegged treenail. (By A.J. Hoving, 1994)

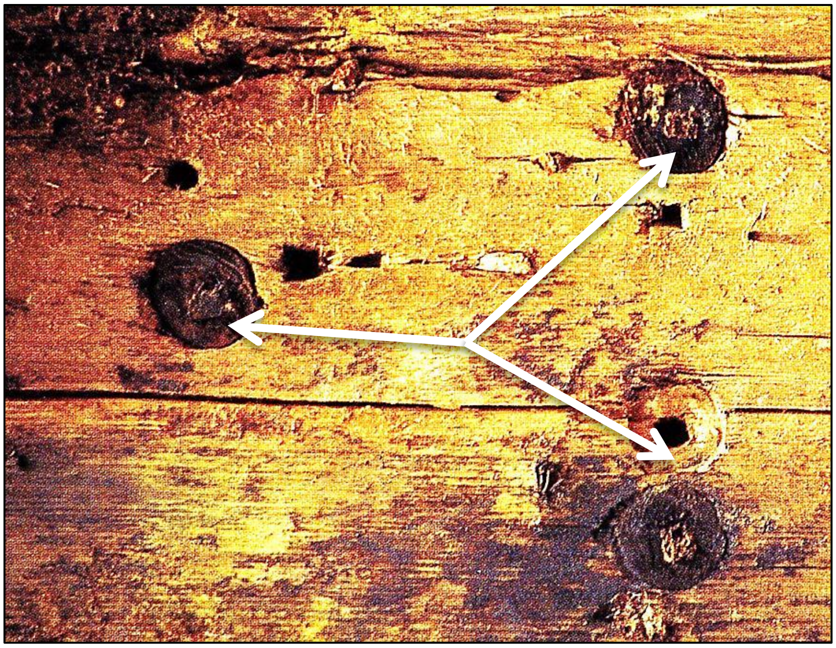

FIGURE 121. Square-pegged treenails on planking of Christianshaven Wreck B&W2 (*the other square holes are spike holes from cleats used to hold planks before framing*). (Photo by Christian Lemée, 2006)

Scholars know that shipwrights used square-pegged treenails on 18th-and 19th-century North American built vessels (see Albright and Steffy 1979). When English shipyards began using square-pegs was unknown until very recently. Square-pegged treenails do show up on one confirmed early English vessel, *Warwick* (Adams SHA 2013). With its double-hull, pine sheathing, and square pegs, it is clear some early 17th-century English shipyards employed square treenail wedges as well. That trade and migration between Holland and England resulted in cultural and technological exchange is well known. It is entirely possible English shipwrights began using square-pegged treenails at the same time or before Dutch examples. Given the mobile nature of ships and their builders, tracing the date of English shipyards employing square-pegged treenails will require more pre-17th-century archaeological finds.

The Corolla Wreck's treenails are diagnostic in other ways. The practice of doubling treenails and placing them between plank seems was found on *Sea Venture*, *Dartmouth*, *Vasa*, other Dutch-built vessels, and the Corolla Wreck. Initially thought to be repairs or poor craftsmanship, such a practice actually reinforced existing fasteners as the treenails would expand once wet. Discerning between when such instances are deliberate or accidental can be difficult to determine. On the Corolla Wreck, however, treenails between plank seams show a pattern consistent across frames, and double-treenails appear in a somewhat regular pattern to suggest they were deliberate and not mistakes or repairs (see FIGURE 122). Another puzzling feature found on *Dartmouth* was the apparently random placing of angled treenails through frames into the keel (see FIGURE 123 and FIGURE 124). Later analysis revealed that alternating some treenails at an angle would actually create a stronger hull thanks to the variation in fastener and grain direction (Adams 2003).

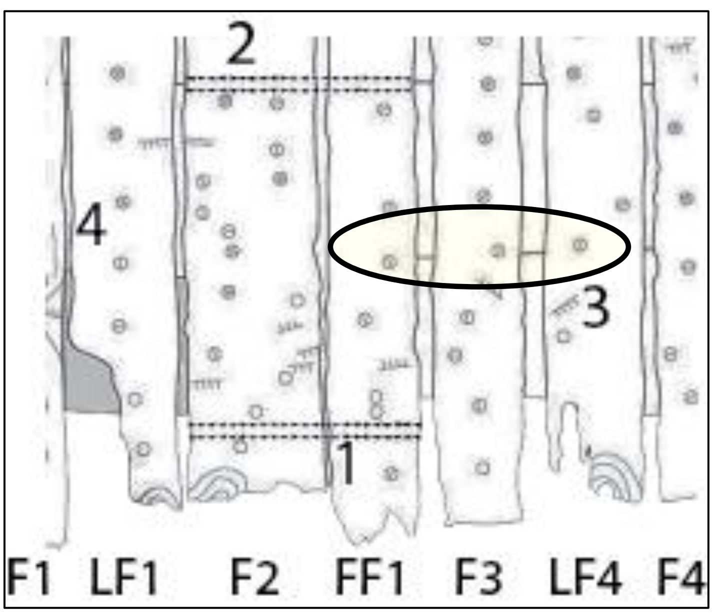

FIGURE 122. Detail of the ECU site plan (*note the treenails between plank seams on FF1, F3, and LF4*). (By author, 2013, after ECU 2010)

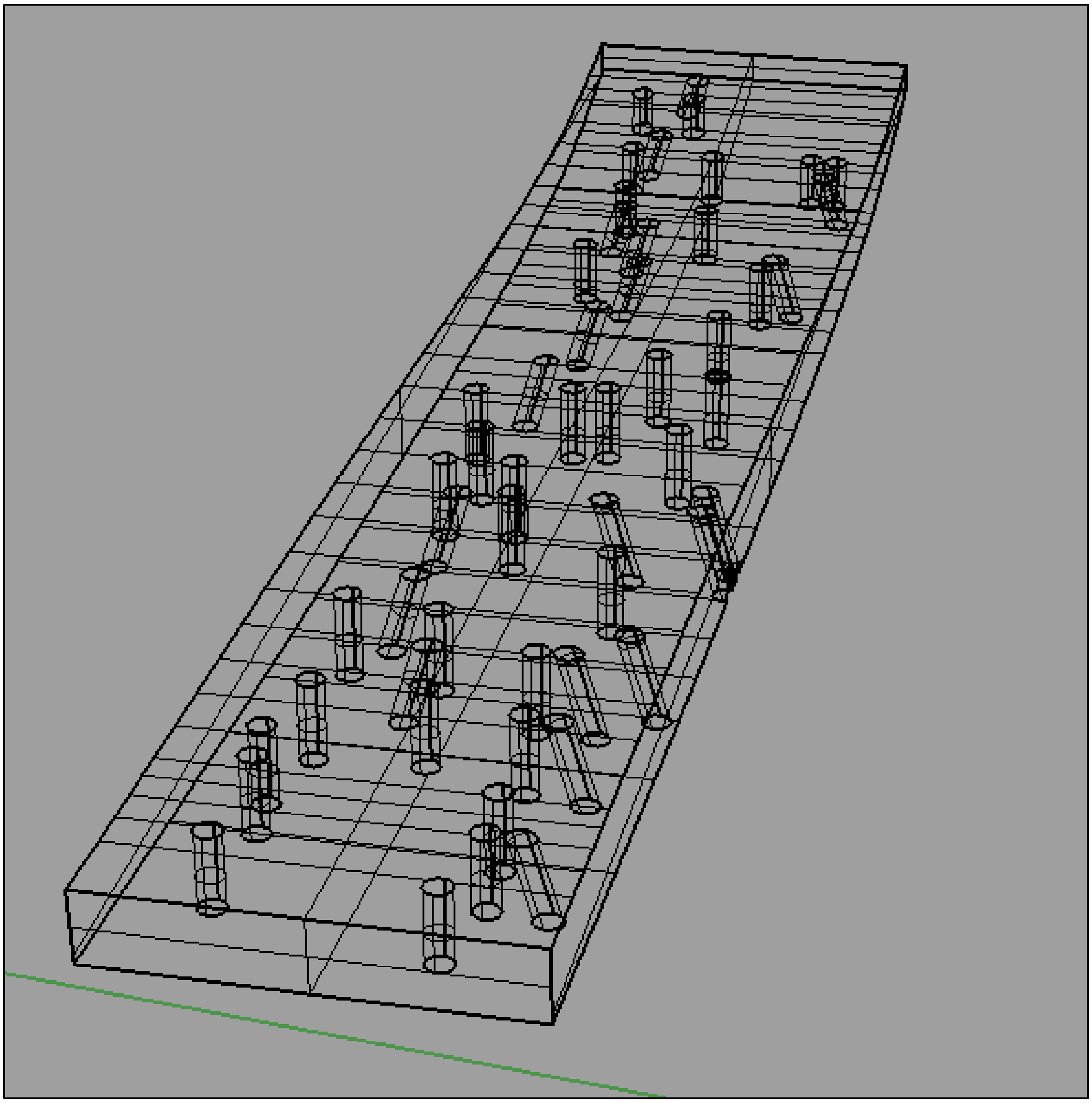

FIGURE 123. Digital drawing of Corolla's apron with fastener holes (*note the angled treenails through the garboard*). (By Author, 2011)

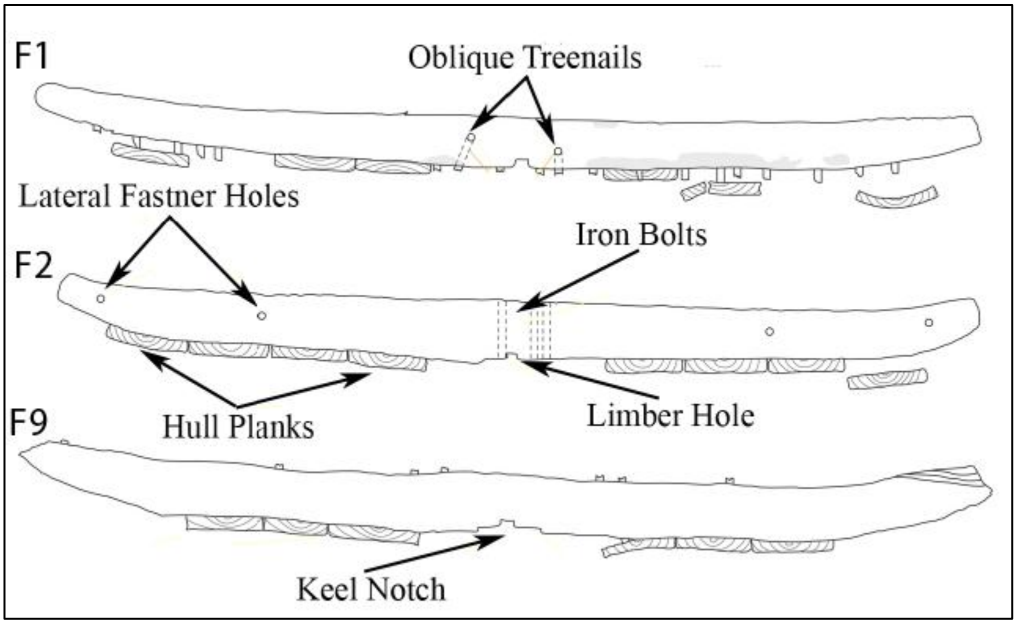

FIGURE 124. Detail of Floors 1, 2, and 9 (*note the fastener details and single limber hole*). (By Nathan Richards et al. 2011)

As discussed in chapter 4, English and Southern Dutch vessels were built in the frame-based tradition. The keel and frames were primary to the strength of the vessel; the planking was secondary. Every English wreck covered in chapter 5 employed a multi-piece keel joined with vertical scarfs; several of them were hook scarfs (like *Dartmouth*). The keel piece associated with CKB0022 has the remnants of such a scarf. The keel section's end is coked-and-nibbed, and the surface of the scarf was stepped and notched to receive its mirrored partner (see FIGURE 125, FIGURE 126, and FIGURE 127).

FIGURE 125. Photomosaic of the Corolla Wreck's keel piece. (Image by Author, 2012)

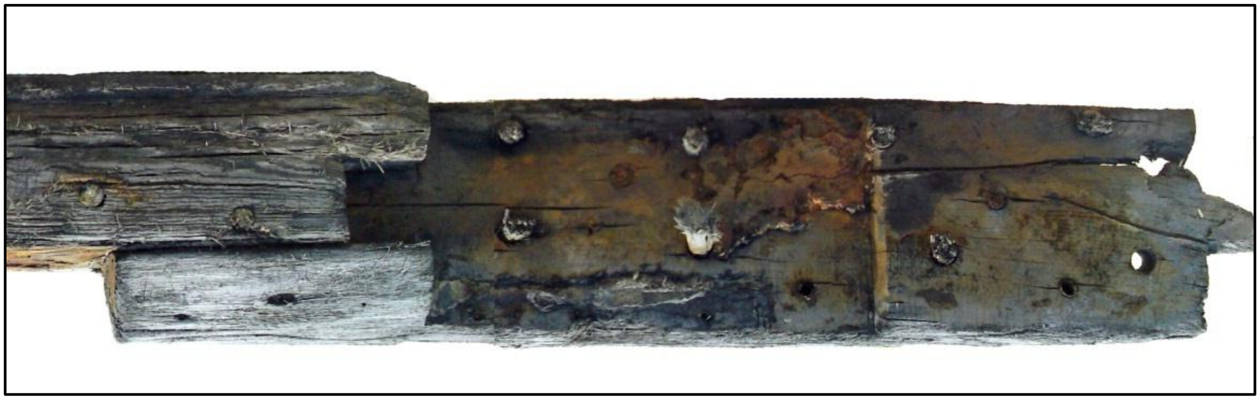

FIGURE 126. Keel scarf on CKB0022’s keel. (Image by Author, 2012)

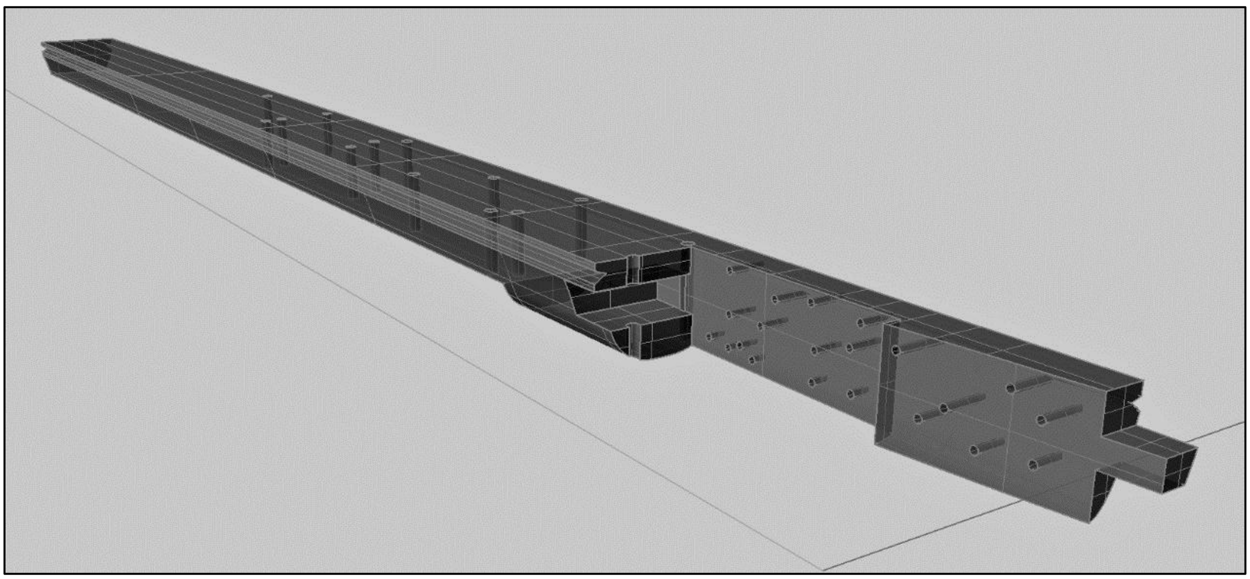

FIGURE 127. Digital schematic of Corolla's keel scarf; the depth of the notch is exaggerated to show function. (By Author 2011)

Nine horizontally fastened iron bolts and nine treenails secured the scarf (six of the seven extent treenails are wedged with square pegs). The rabbet is readily apparent on the same face as the scarf, less so on the opposite side. The keel’s bottom surface is stepped for what was likely a false keel,(see FIGURE 129) with visible tool marks about the middle. Six bolts and eight treenails remain as well as a hole for another bolt and two large flat concretions. In addition, there are three empty holes absent of iron stains indicating missing treenails. On the top surface, only three through bolts are visible and 12 through treenails, all shorn, plus two empty holes; the difference of two treenails is because their bottom surface is hidden by concretions. Further examination revealed nail holes on the upper surface along the scarf seam (see FIGURE 128); these are left over from the wood strip that would be caulked and nailed over the scarf seam The keel, therefore, appears quite English.

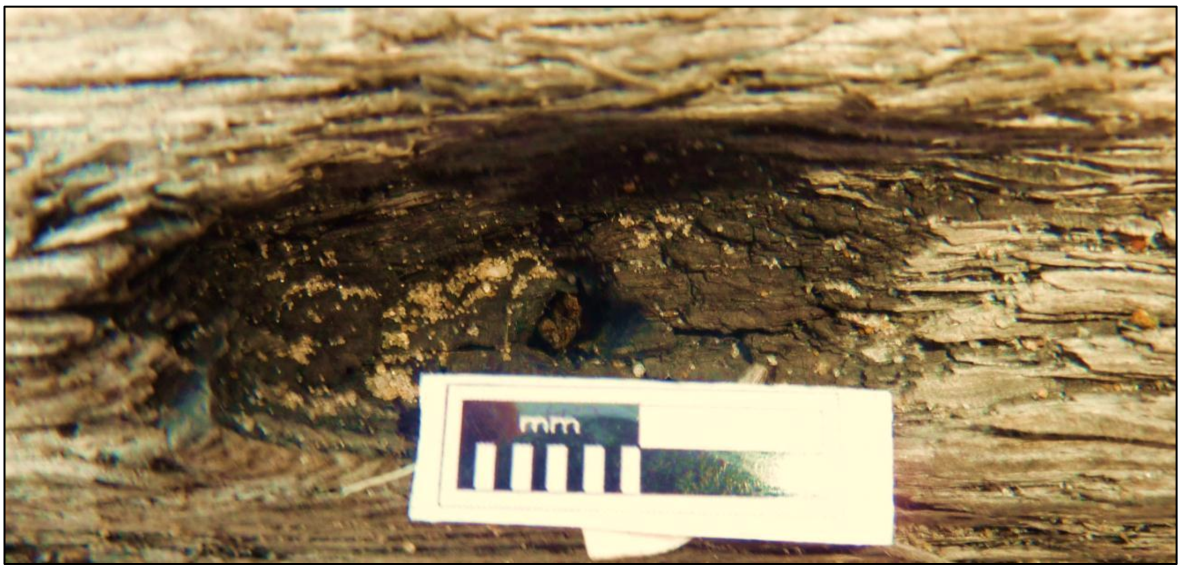

FIGURE 128. Close up detail of previously missed nail hole. (Photo by Author, 2010)

The central limber hole, mentioned in chapter 5 as both an Iberian and earlier English feature, is prominent on each of the Corolla Wreck's frames. This feature also suggests English, over Dutch origins. The historic description of the Dutch *tingle* or fillet and evidence of such in the archaeological record, such as the Old Spanish Vessel in Bermuda (actually Dutch), would not have required any notching in the actual floors, as is found on CKB00222 (see FIGURE 130, FIGURE 131, and FIGURE 132).

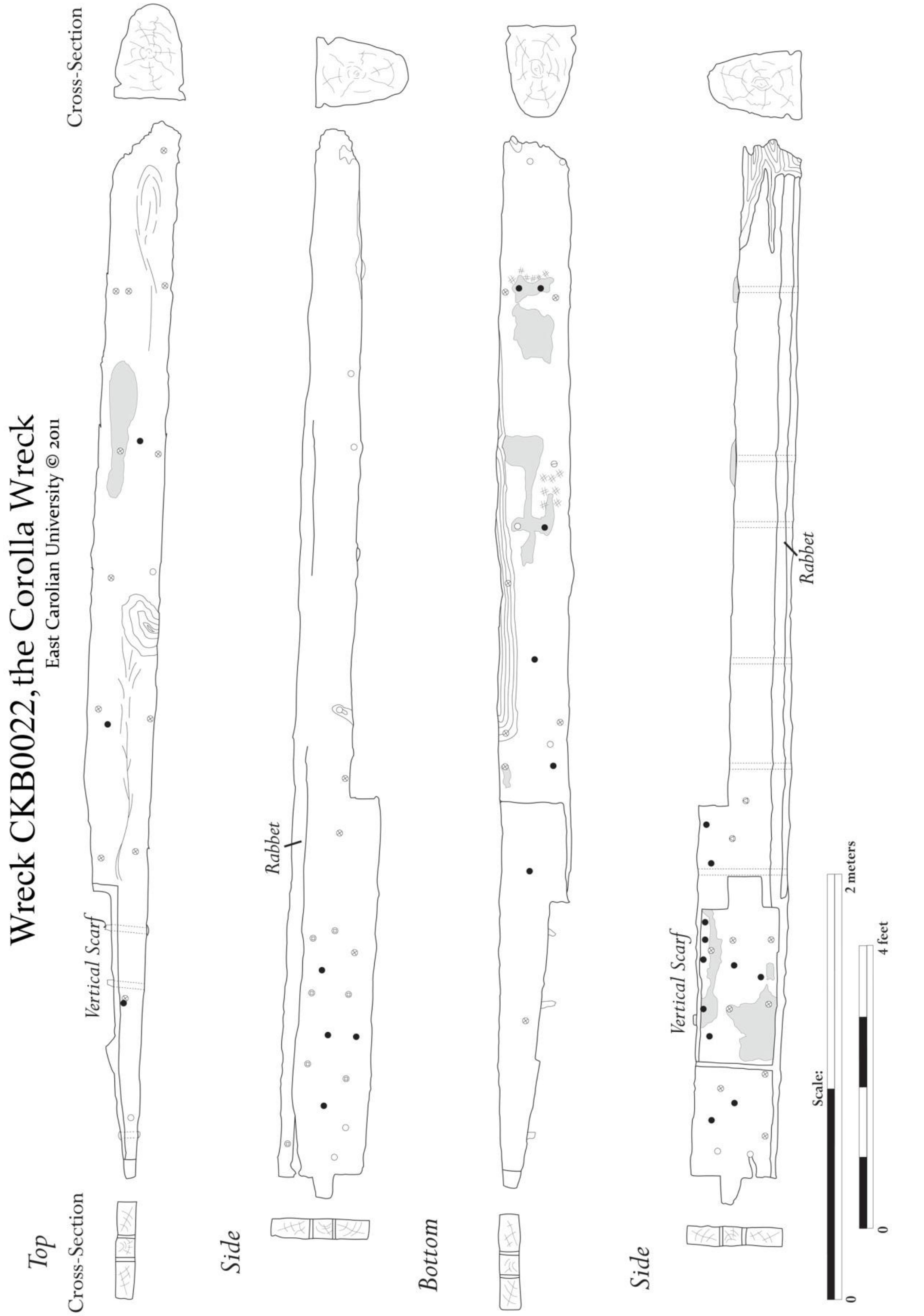

FIGURE 129. Keel recording of Wreck CKB0022. (© East Carolina University 2010)

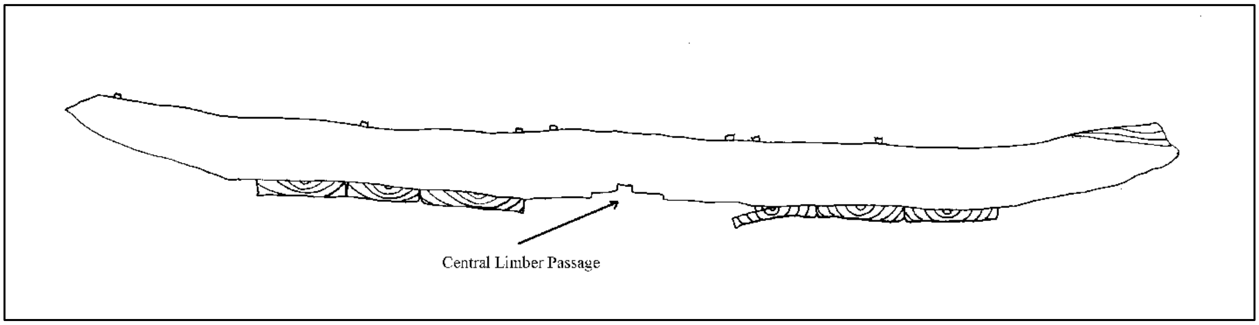

FIGURE 130. Frame profile from CKB0022. (Image courtesy of ECU 2010)

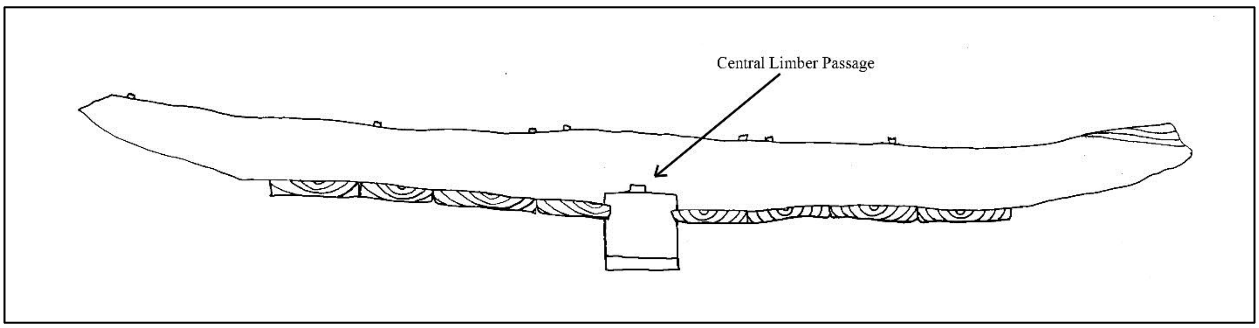

FIGURE 131. Corolla frame profile with reconstructed keel and garboard. (Image by Author, 2013)

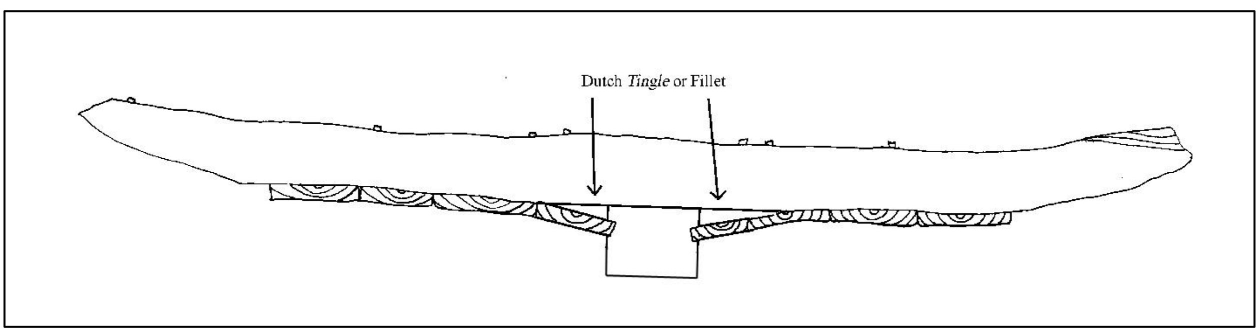

FIGURE 132. Typical 17th-century Dutch keel and tingle arrangement. (Image by Author, 2013)

Conclusion

Locals dubbed Wreck CKB0022 the “peg wreck” for a short time because of protruding treenails. Photographs show people standing on, poking, and prodding the wreck. What appears a mass of old timbers to an onlooker contains a wealth of information to the nautical archaeologist’s carefully trained eye. Yet, mishandling of archaeological material by professionals is equally detrimental as damage inflicted by uninformed enthusiasts. At the same time, the curiosity aroused by the wreck supplied researchers with over one thousand photographs— photographs that contained data that would have otherwise been lost. The true identity, ownership, command, port of origin, and destination of the vessel that is now the Corolla Wreck will likely never be known. Yet enough evidence exists to speculate when and where the vessel was built, when and where it wrecked, as well as what it was doing at the time of the wreck event. Such theorizing is not without bias owing to the scant amount of scientific evidence available. After thorough scrutinizing of every inch of the surviving timbers that make up the Corolla Wreck, the more than 20 artifacts collected by Ray Midgett, Roger Harris, and others provide the most definitive evidence of when the wooden ship that is now a mass of rotting timbers met its demise. More information may be revealed by X-raying concretions in state and private possession, as well as an attempt at dendrochronology of the wreck’s more solid timbers.

That researchers extracted information from the Corolla Wreck, despite damage from its treatment and salvage, is a testament to the value of maritime archaeology. Analysis of the site formation processes that affected CKB0022 disclosed the interaction and impact of both natural and cultural influences on the wreck and its, at times, mobile context. Through environmental and human contrived stresses, the macro-artifact that is the Corolla Wreck has transformed from a partially preserved bow section of a 17th-century wooden ship to a mass of shrinking timbers. Pre-2008 site formation and deposition questions, and the curious lack of teredo worm damage, remain inconclusive. Some beached wrecks appear to stay in a mild state of preservation whereas others from the same century seem riddled with soft rot and are extremely fragile. More research into the ecological littoral conditions that hasten or prevent degradation of wooden wrecks may help to solve this riddle.

The author believes that the Corolla Wreck hails from the 17th century, somewhere around the middle of the century or earlier. Analysis of its structure combined with analysis of its associated artifacts confirm this. The dominant presence of treenails, frame-on-keel construction, stringers and heavy ceiling planking all suggest English or Southern Dutch origins. Certain features like the central limber hole could suggest English; features like the wide flat keelson appear more Dutch. The presence of Spanish and French artifacts and one English coin suggest it may even have been a French ship or loyalist ally vessel. That a squadron was sent to Virginia to bring colonists in line with Parliamentarian rule in 1652 (Hepper 1994:1) may suggest what trade was carried out in the English colonies was with Loyalist merchants and their foreign counterparts. The 1652 loss of a former merchant vessel, HMS *John*, purchased by the English navy in 1646 and rated a (comparatively small at 367 tons and 28 guns) 4th-rate warship, provide one of the few historical candidates for the identity of the Corolla Wreck. Not enough evidence exists as yet to corroborate the wreck as HMS *John*, but neither is there enough evidence to say it is not this ship, "Wrecked on the coast of Virginia," which in 1652 could include the northern extent of the Carolinas. A summation of why the Corolla Wreck likely has a Northern European origin follows with final analysis and conclusions, as well as suggested routes of future research.

CHAPTER SEVEN: Conclusions and Future Research

Introduction

The purpose of this thesis has been to analyze and attempt to identify the origin of the remains of a wooden ship discovered in the surf near Corolla, North Carolina, in 2008. The text demonstrates that 17th-century European Atlantic trade and colonization patterns can provide the context for a systematic comparison of 17th-century ship construction treatises along with contemporary examples of wrecks in the archaeological record. As such, this thesis seeks to provide a broader analysis to undiscovered wrecks. In the case of the Corolla Wreck, a precise port of origin and destination of the original vessel is not feasible, but analysis suggests the origin is northern European, possibly English, southern Dutch, or French, mid- 17th century. Bradley Rodgers proposes that European population distribution should be proportional to the number of ships supporting European colonies and thereby provide a list of best possible candidate nations of ownership (if not origin). Variables include colony self-sufficiency, distances from the Outer Banks, and ship sizes, to name just a few. Seventeenth-century European navigation laws required a country's commerce be carried out exclusively by that country's flagged vessels. This ought to support the idea of population proportion to traffic, but these laws were difficult to enforce and regularly flaunted by interlopers of all nations. North American English colonies strove for self-sufficiency and population expansion. The French focused solely on the fur trade, with more outposts than towns or cities. The Dutch regularly traded in colonies other than their own, and quite profitably too. The Dutch focus on trade over colonization makes population ethnicity somewhat problematic as an indicator of origin. Artifactual analysis suggests the vessel was involved in French or English commerce, possibly Spanish earlier in the century. Structural analysis suggests southern Dutch or English merchant construction, but the lack of comparative archaeological data from the middle of the 17th century, especially the dearth of French vessels, makes pinpointing national origin problematic. There is, however, sufficient evidence for multiple working hypotheses. Below are three tables outlining the archaeological evidence: the structural features of the wreck (TABLE 12), itself considered a macro-artifact, the material culture associated with the Corolla Wreck (TABLE 13), and 17th-century colonial North American population figures (TABLE 14).

TABLE 12. THE COROLLA WRECK'S CONSTRUCTION FEATURES

Feature	**Detail**	**Significance**
Frames	vary between unevenly sided and molded floors, averaging 11 inches (27.6cm) sided and 10 inches (26.4cm) molded. Futtocks average a little over 8 inches (21.3cm) sided. 3 pre-erected frames longitudinally fastened with treenails	English foot = 12 inches, Dutch foot = 11 inches, French foot = 13 inches. English aligned frames 90 degrees to the keel Dutch shipwrights used a variety of sized frame elements, usually smaller and more abundant than English frames. Spain and France were known to use more iron fasteners in attaching frame elements.
Keelson	Photographic evidence and iron fastener pattern suggest a very wide keelson before disarticulation	English keelsons were usually heavy and squared. Dutch shipwrights employed wider keelsons with a lesser molded dimension.
Longitudinal timbers	thick stuff and stringers overlapping wrungheads of floors	English shipwrights used both heavy transverse and longitudinal timbers. Dutch construction usually featured heavy ceiling of even thickness, often without stringers or thick stuff.
Keel Scarfs	vertical tabled hook scarf with luting	Vertical joints appear specific to English shipwrecks in the archaeological record. Dutch keel joints usually have horizontal tables.
Limber	centrally cut hole in floors	Found in 16th-century Iberian and English vessels, replaced mid-17th century by the two limber system. Dutch limber holes were cut either side of the keel or augmented by fillets.
Fasteners	wedged oak treenails, double treenails, oblique treenails, treenails between	English and Dutch shipwrights both relied on wooden fasteners over iron fasteners, double treenails and treenails between seams lock

	plank seams, minimal iron fasteners	timbers tighter together.
Planking	uniform, equally thick ceiling and hull	Both English and Dutch vessels utilized thick ceiling planking with equally thick hull planking sandwiching heavy timbers that provided hull strength.
Tool Marks	adze marks, charring	Charring consistent with 17th-century techniques to bend timbers and planks as well as dubbing of frames, typically northern European.
Wood Species	two varieties of oak native to England	Timbers identified as Cornish or Welsh Oak, treenails European white oak. Both varieties of oak are found throughout northern Europe, eliminating North America as a timber source.

Henry VIII's influence on English shipbuilding can still be found in the archaeological record of the early 17th century. Heavy, squared timbers for frames supported the (at times) excessive armament the king demanded (e.g. guns that fired 60-pound shot). Ships' structures also reflect English tradition of the Cinque Ports, and reliance on merchantmen to supplement naval force is reflected in as well. Ships were built to move goods, but also served to function as mobile gun platforms. Thus, even English merchantmen were heavily built to accommodate the burden of ships' guns. In fact, charters usually specified that cargo ships were required to carry ordnance (Oppenheim 1896:171). Part of the structure to support guns was "thick stuff," stringers, or foot-wales, employed on the inside of the ship. These longitudinal timbers reinforced frames where floors and futtocks overlapped, just as equally thick ceiling and hull planking contributed to the hull's stiffness. Heavy riders (transverse timbers) contributed even greater strength to purpose-built, more heavily armed warships. Dutch fluyts were generally not armed and thus were lighter built, carried less sail, and required smaller crews. Yet, the Dutch built armed merchantmen as well; such vessels exhibited heavier construction than fluyts, such as Witsen's 134-foot pinnace (1671:23). As mentioned above, the English preference to limber holes over fillets (in Dutch a *tingel*) is consistent in the archaeological record. The absence of iron fasteners in the pre-erected frames and the predominance of wooden treenails as the primary fastener also reflect Northern European traditions employed by both the English and the Dutch. The species of wood used in the timbers could be English but could also be from anywhere in northern Europe. This does not rule out Dutch origins since the Dutch imported most of their timber from the Baltic and Germany; it does eliminate the Americas as a timber source. Many features suggest English merchant or southern Dutch construction in the middle of the 17th century; the lack of any evidence of riders and inconsistent floors and spacing do not reflect more stringent English naval construction. Yet, HMS *John*, purchased by the English navy in 1646 was a 367-ton merchant vessel refitted as a comparatively small fourth-rate with only 28-guns.

Structural evidence points towards northern European construction, either English, southern Dutch, or French. The material culture (see TABLE 13) allows for further speculation.

TABLE 13. ASSOCIATED ARTIFACT ASSEMBLAGE

Artifact	**Description**
hail shot	first noted in English Admiralty records 1520
lead shot	small caliber drop shot
brass pins	ubiquitous and non-diagnostic
copper alloy finial	Elizabethan style collar on cherub head
deadeye	1610-1640, flat face, round-three-hole *Vasa* style
French coins	Louis XIII *double tournois* minted between dating 1640s
English half crown	Charles I 1643
Spanish *maravedis*	from Phillip II and Phillip III, 1598 to1603
French lead bale seal	17th century in style and marking
Spanish spur rowel	well preserved Iberian style rowel from a spur
Pewter spoon	requires further analysis to be considered diagnostic
dividers	non-diagnostic, changed little from the 15th to 19th centuries
caulking	animal hair fibers, other organic material

Scientific investigation into contemporary wrecks, compared with historical evidence in the form of commerce and construction treatises, allows for greater conclusions. Theoretically, a colony's need of supplies reflected population size and therefore 17th-century traffic along the Eastern Seaboard. TABLE 14 does not necessarily mean the Corolla Wreck is a given nationality, only that it has a predictable chance of being from a given nationality, for a certain period.

TABLE 14. NORTH AMERICAN COLONY POPULATION DISTRIBUTION 1630-1650

Source: Bureau of the Census, US Department of Commerce, from *1998 World Almanac and Book of Facts,* 378.

North American Colonies	**1630 Pop.**	**Total %**	**1650 Pop.**	**Total %**
English (Virginia and NE)	4,300	83.3%	46,000	87.9%
New France	458	8.8%	2,000	3.8%
New Amsterdam (Dutch)	400	7.7%	4,100	7.8%
New Sweden	0	0%	200	0.4%
Total	**5,158**	**99.8%**	**52,300**	**99.9%**

Specific figures on shipping are not easy to locate for the first half of the 17th century. Before successful settlement of an English colony, contributions from English customs increased from £24,000 in 1586, to £50,000 in 1590, and to £127,000 in 1603 when James I ascended the English throne (Oppenheim 1896:171). Historical research has demonstrated the marked increase in maritime traffic in the Atlantic after 1620 when Virginia tobacco prices fell and the market expanded rapidly (Menard 1976:404-440). It can be surmised that the Corolla Wreck was likely an English or Dutch merchantman engaged in Atlantic trade, possibly in transit to or from Jamestown at the time when it wrecked, perhaps en route from French Huguenot settlements in present day South Carolina (given the presence of 17th-century French artifacts). With the exception of interruptions in English trade caused by the English Civil War and the first Anglo-Dutch War, transatlantic commerce steadily increased following the success of Jamestown and later, the New England and Caribbean colonies. By the outbreak of the English Civil War, England boasted New World 14 colonies. Expansion slowed but continued, increasing again in the 1650s in the Caribbean during Cromwell's Protectorate and increased again after Charles II's Restoration to the throne in 1660. Expanding English trade meant burgeoning shipyards. The same was true for England's rivals, despite Spain's decline and France's minimal commitment to North American colonization until the latter half of the 17th century. Examination of other building traditions reinforces the conclusion of an English or southern Dutch origin for the Corolla Wreck.

Divergent European Shipbuilding Traditions

The first established cultural tradition identified among historic shipwrecks in the New World was Iberian. Spanish and Portuguese hulls featured meticulous notching and joinery, such as dovetailed mortise-and-tenon scarfs in frames. Iberian builders also relied predominantly on iron fasteners. On the opposite spectrum, only four 17th-century French ships have been documented, all from the latter end of the century, leaving what French vessels looked like in the 17th century a mystery if not for the *Album de Colbert*. Pre-assembled paired frames on the wreck are a physical manifestation of the carefully illustrated plates from *Colbert*. A northern Dutch origin can be dismissed in the lack of temporary fasteners and presence of at least two pre-assembled frames (possible tail frames). Dutch shipwrights did not employ squared-timbers, or timbers aligned perpendicularly to the keel with even room-and-space (Steffy 1994:271). Dutch frames had consistent molded dimensions but not sided (Batchvarov ISBSA 2012). The Corolla Wreck's floors range from 8.5 to 12 inches (22-30cm) molded, averaging 10.5 inches (26.4cm). Dutch frames were not as heavy as English frames and being smaller, they used more of them (Maarleveld 2013:353). Thijs Maarleveld has demonstrated a ratio to the number of frames in meter measurements along the keel that differ on English and Dutch ships. Dutch vessels in

Maarleveld's study retained a ratio of 18 to 23 frames per four meters, whereas English vessels displayed a ratio of 14 to 16 frames per four meters (2013:354-355). On the Corolla Wreck, the number is 13 counting a missing frame, leaning further towards English construction. Another small but critical difference is in the way shipwrights dealt with standing water in the bilge. By the 18th century, composite frames allowed more airflow and had two limber holes either side of the keel. English vessels built in the earlier 17th century exhibited a single central limber hole for bilge water to drain to the lowest point of the hull at the pump. On flat-floored hulls, Dutch shipwrights cut a pair of limber holes either side of the keel, or angled the first strake from the rabbet to the floor; this allowed for better sailing and created two channels for bilge water to drain. These channels also obviated the need to notch, and therefore, weaken the frames. In English construction, this feature is called a *filet*, in Dutch, a *tingel*. Witsen defined it in his treatise as "a piece of wood between the keel and the first plank on the keel wherein a hole is made so water may go through" (Witsen 1690:96). Mainwayring referred to the method as a "standing strake… most used amongst the Flemmings" (Mainwayring 1667:102).

Of the two Dutch traditions, *Noorderkwartier* (northern) is easier to identify and distinguish in the archaeological record. Multiple layers of hull planking, square pegged treenails, wooden plugs used to fill the holes made by temporary cleats, and impressions left by clamps are all indicative of a bottom-based Amsterdam-style built vessel, though by the latter half of the 17th century, this tradition had phased out in favor of frame-based construction. *Maaskant* (southern) is somewhat harder to distinguish from an English vessel built in the frame-based tradition. Both countries preferred wooden treenails to iron bolts, wedged or square pegged, at times overlapping or between seams, as well as equally thick hull and ceiling planking. Structural features such as stringers, thick stuff, and heavy wales are typically an

English tradition. On English wrecks, two are common and deliberate. Doubling treenails through frames and oblique treenails through the keel reflect the northern European philosophical approach of locking large timbers tightly together from multiple angles. The practice is also seen on English and Dutch ships from the period, again making it difficult to differentiate between traditions. Angling treenails in a different direction provides additional strength. Doubling treenails only makes them tighter, as does placing treenails between plank seams. This may appear to weaken a seam, but on the contrary, an additional treenail between planks will force those same two planks tighter against adjacent planks. English shipwrights were also keen on larger square-frames; frames were usually sided and molded an English foot, aligned 90 degrees to the keel. There is also, of course the Dutch *tingel,* used in both southern and northern Netherlands, as opposed to a single central limber hole on English ships. The most distinguishing feature is the joint used to assemble the multi-piece keel. Witsen instructed his readers to use a horizontal flat scarf; Van Yk described a similar scarf seam (Hoving 2012:40) and this joint is seen in the archaeological record as either a flat scar or a hook scarf. English treatises say nothing about the keel scarf, but every English wreck discussed in chapter 5 utilized an often intricate vertical scarf.

Conclusion

Northern European traditions approached hull construction by locking frames between equally thick and structurally important hull and ceiling planking with wooden fasteners, treenails. This is why the term ceiling was originally spelled *sealing.* The use of multiple stringers, thick stuff, and wales, and most importantly on warships, riders, are typically English techniques that result in compression, tension, and significant hull strength that could bear many great guns. Since both an English or Dutch shipwright would add additional strength by placing oblique treenails through frames into the keel, the direction of the scarf is insignificant. The Corolla Wreck exhibits a carefully cut vertical tabled hook scarf sealed with luting (a combination of moss, hair, and tar); the nail holes for the stop-water cap and animal hair can still be found on the keel scarf. Treenails observed in the keel scarf were all transverse on the Corolla Wreck, but some treenails recorded in the keel, apron, and one floor were angled. Also, very similar treenail patterns and keel joints were found on the early 17th-century *Sea Venture* and mid-17th-century *Dartmouth*. The Corolla Wreck's structure is remarkably similar to *Sea Venture*, dating from 1609, and its flat bluff shaped hull even more reminiscent of the Old Spanish Vessel in Bermuda. Yet three very similar structures do not make a typology. Maritime archaeology has often been reproached for being historically particular (Gould 1983:4), yet wooden ships were just that, particular. As Witsen put it, "two ships and two people are never exactly identical" (1691:23).

The Corolla Wreck's construction features appear a mix of English merchant and southern Dutch. Given the survey of contemporary English and Dutch wrecks in the archaeological record, it is possible to assemble a list of mid-17th-century English diagnostic features (the last two criteria, while not uniquely English, are consistent on 17th-century English wrecks):

1. The use of large, regular (approximately one foot sided and molded), squared and centered floors of consistent sided dimension.
2. A centrally cut limber hole in floors.
3. The keel is assembled with vertical table-scarfs.
4. The use of thick stuff and stringers overlapping the wrungheads of floors and ends of futtocks to longitudinally strengthen the hull.

5. The presences of pre-erected frames assembled with longitudinal treenails and not iron fasteners, as would be expected on French or Iberian hulls.

6. The presence of uniformly thick ceiling and hull planking.

7. The predominant use of treenails and minimal use of iron fasteners to secure frames to hull and ceiling planking, treenails between seams, and oblique treenails through frames into the keel.

The list is not comprehensive, nor can a single feature be considered diagnostic. Not every English wreck discussed in this thesis reflects all seven features, but they are consistent with most. The list as a whole can be diagnostic, applied to unrecorded wrecks, and enhanced by future recordings. In this way, the results of research conducted on the Corolla Wreck may serve to help interpret future historic wrecks.

Future Research

Beyond the scope of this thesis are further research questions that might contribute to the understanding of the Corolla Wreck and the mid-17th century. More research into the wreck's deposition in the tidal zone may contribute to knowledge of wrecking patterns, especially if paired with previous research on how wooden vessel's remains are distributed on the Outer Banks. Larger questions remain; how does the geomorphology of the Outer Banks affect historic wrecks? Do the turbulent waters of North Carolina's coast really pose a threat to historic wrecks, as reported with the Beaufort Inlet Wreck? The North Carolina coast is certainly dynamic. Inlets close and open, vessels might be buried in what was once an inlet, and buried vessels may be revealed at the opening of new inlets. Like the ones created after Hurricanes Irene and Sandy. What is North Carolina to do if another rare historic wreck is uncovered by another fierce storm?

As a case management study, the Corolla Wreck is unfortunately a classic example of failed site management and proves that archaeologists and cultural resource managers are not always up to the task of protecting every site. What led to this debacle, this road paved with good intentions that ultimately robbed archaeology of precious contextual evidence, all for the sake of saving an artifact only to let it rot (see

FIGURE 133)? Cultural perceptions of historic wrecks by residents and homeowners on the Outer Banks may reveal information that could be used to bridge the gap between the archaeological community and the local community in the future.

FIGURE 133. Entire frames have collapsed and continue to disintegrate without any protection from the elements. (Photo by Author, 2012)

Studies on outreach, wreck disturbance and vandalism, treasure hunting, beach combing, outright looting of historic wrecks, collecting behaviors, and the like, might help archaeologists better understand activities on the Outer Banks that affect cultural resources. Another vein of continued research concerns the artifacts and timbers. Initial wood samples identified the species as a member of the white oak family, Durmast or Sessile Oak. Dendrochronological analysis may provide a narrower location of the timber source and reveal the felling date of the wood, giving a much smaller window for the vessel's construction. Samples should be large and varied given the wreck's current state of decomposition. Having the few surviving concretions X-rayed may reveal more diagnostic artifacts than ubiquitous brass pins.

Analysis of the lead shot similar to that done on the lead shot found on *Mary Rose*, may better corroborate the ship's origin, or at least, that of its cargo. Following up on Henry Bliven's claim to have video footage of a spoon and clothing hook found on the wreck may add more to the artifact assemblage interpretation. Reportedly, there are better preserved timbers in private possession. Investigation of the organic substance that appears to be animal hair may reveal the species and location of that animal, similar to the caulking analysis done for *Warwick.* The concreted caulk itself may retain chemical information that could provide even more evidence of origin. Archaeoentomological examination of dirt and detritus, whatever was not removed by fire hoses, may also contribute to answer just where exactly the ship that became the Corolla Wreck was built.

Most interesting of all to the author, and unfortunately beyond the scope of this thesis, is the possibility of reconstructing lines for the Corolla Wreck. Preliminary calculations and observations suggest the Corolla Wreck was a vessel 70 to 80 feet (21.3 to 24.3 meters) long on the keel, with a 25 to 30 foot (7.6 to 9.1 meters) beam, and a draft of 10 to 13 feet (3 to 4 meters). This would yield a vessel roughly 225 to 315 tons burden. A vessel of this size lost, even in the early 17th century, would not have gone missing unnoticed. Future archival research in England, France, or Holland may yet turn up more candidates for the elusive Corolla Wreck.

More wrecks remain to be recorded. Wrecks currently under study mean that more data will soon be available to add to this minimal sampling of the archaeological record. The author hopes that this thesis serves as a nominal test of J. Richard Steffy's 1994 proposal: that in the future, in the absence of diagnostic material culture, the ethnic origin of ship remains might be identified by structural components alone. This work is a reminder to current and future nautical archaeologists of the importance of working towards building a compendium of culturally diagnostic vessel structures. The Corolla Wreck is representative of just one of those structures: the evidence suggests mid-17th-century northern European, most likely English, southern Dutch, or possibly French. Only future research will tell.

APPENDIX I: Locations, Distance Traveled, and Elevations of CKB0022, 2008 to 2010

TABLE 15. LOCATIONS OF CKB0022 FROM 2008 TO 2010.

Date	N	W	Elevation (feet)	Elevation (centimeters)	Change (miles)	Change (meters)	Heading (Degrees)
2008.10.03	36.222578	75.492287	3	91.44			
2009.12.22	36.223377	75.492509	2	60.96	0.16	252.73	346.98
2009.12.30	36.220983	75.493397	2	60.96	0.7	1127.96	348.35
2010.01.02	36.222001	75.49216	4	121.92	0.98	1570.46	168.74
2010.01.30	36.213342	75.490984	5	152.4	0.91	1464.79	168.51
2010.02.06	36.359251	75.81913	0	0	0.92	1475.19	167.59
2010.02.11	36.349084	75.816113	4	121.92	0.72	1161.15	166.53
2010.03.11	36.3386518	75.8134018	5	152.4	0.73	1182.02	168.2
2010.03.23	36.201897	75.484811	7	213.36	1.46	2356.81	166.78
2010.04.06	36.355358	75.818188	4	121.92	1.18	1902.55	346.96
2010.04.07	36.224003	75.495165	6	182.88	1.95	3141.88	
2010.08.05	35.122324	75.421569	8	243.84	94.77	152514.28	

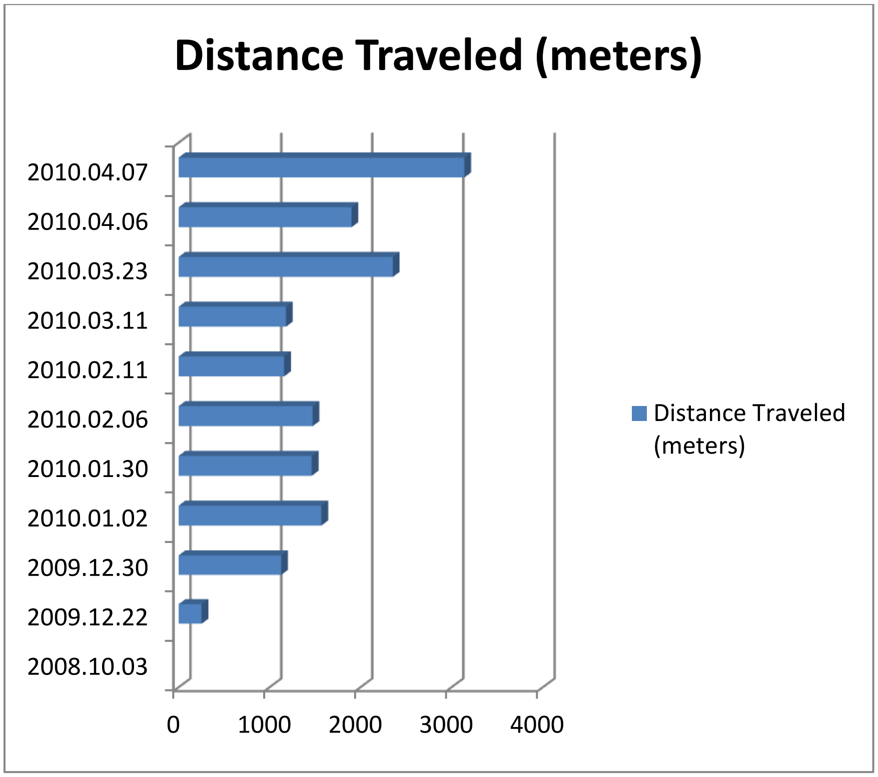

FIGURE 134. Distance CKB0022 moved, 2008 to 2010.

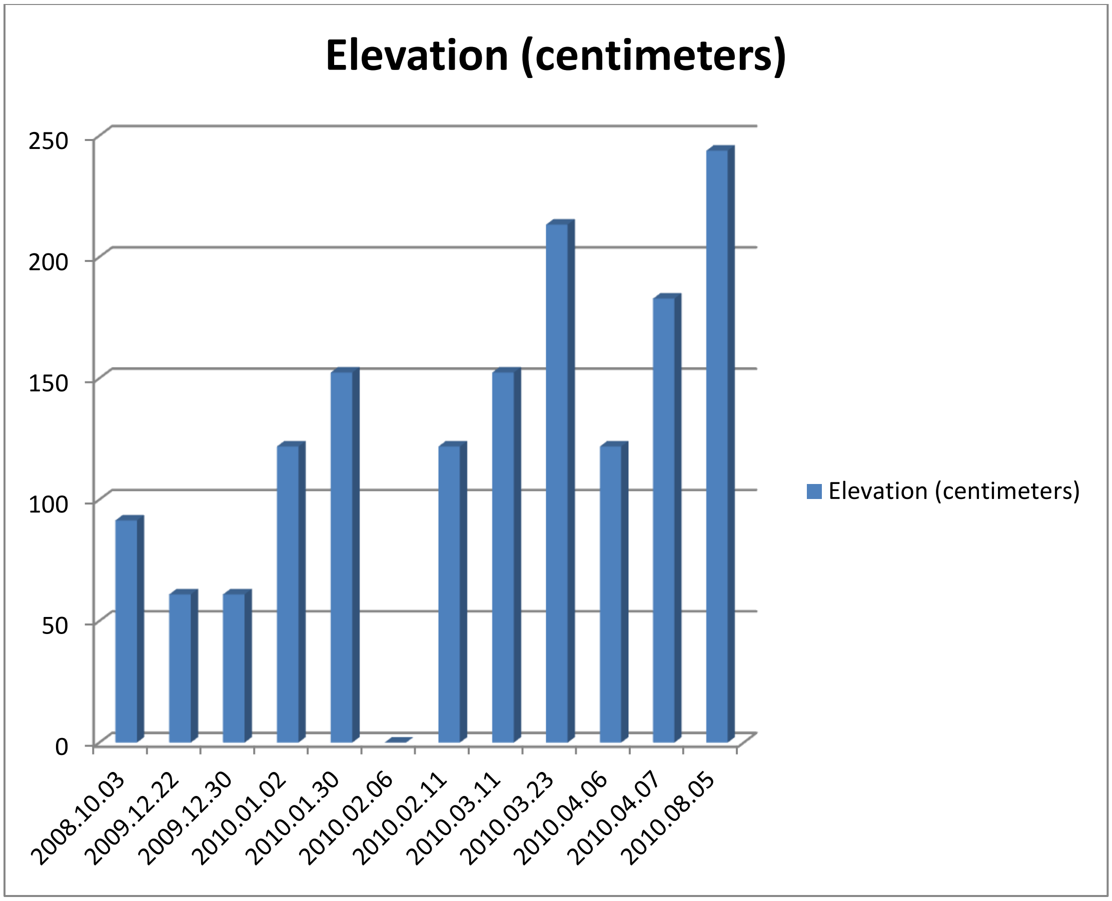

FIGURE 135. Changes in CKB0022's elevation, 2008 to 2010.

APPENDIX II: Table of Cameras and Authors of Photographs

The author utilized the table below to assign authorship and date to hundreds of the massive 1,700 photo archive.

TABLE 16 CAMERA MAKES, MODELS, AND CORRESPONDING AUTHORS..

Camera Make	Model	Author
Nikon	D90	UAB
Nikon	Cool Pix P4	UAB
Nikon	D80	Ayer, J
Nikon	D50	Browne, George
Nikon	Cool Pix L20	Moxey, Mike
Canon	Powershot SD750	Browne, George
Canon	EOS Digital Rebel XSi	Harris, Roger
Canon	EOS 40D	Unknown
Canon	Powershot SD850 IS	Adam
Canon	Powershot G5	Unknown
Olympus	SP510UZ	Unknown
LG	VX1000	Unknown
Canon	Powershot A550	Browne, George

APPENDIX III: A Chronology of Photos

Early images of the wreck in the surf helped establish the presence of more frames than was realized during the 2010 field season. Ceiling plank roughly the thickness of recorded hull planks was also identified along with a bilge stringer. Dimensions of the stem were recovered by a combination of photographic evidence and scaled drawings made during the site recording in 2010. Unfortunately, uniform dimensions for scantling on English ships were not established until the early 18th century. Below are just samples of the more diagnostic photos of the wreck.

FIGURE 136. The Corolla Wreck in October 2008. (Photo by Ray Midgett)

FIGURE 137. The Corolla Wreck in December 2009. (Photo by Roger Harris)

FIGURE 138. Corolla Wreck in the surf, December 2009. (Photo by Roger Harris)

FIGURE 139. The Corolla Wreck's stem and apron, New Year's Eve 2009. (Photo by John Aylor)

FIGURE 140. The Corolla Wreck January 3, 2010. (Photo by Roger Harris)

FIGURE 141. UAB archaeologists conducting a preliminary Phase II survey in January 2010. (Photo by Megan Agresto)

FIGURE 142. Corolla's frames uncovered, January 2010. (Photo by Megan Agresto)

FIGURE 143. Vertical scarf on Corolla's keel, January 2010. (Courtesy UAB)

FIGURE 144. Exposed hull planking on the day of recovery, April 2010. (Photo by Roger Harris)

FIGURE 145. The Corolla Wreck near Currituck Light on recovery day, April 2010 (note the rapidly drying timbers). (Courtesy UAB)

FIGURE 146. A joggled plank seem, 1 day after removal, April 2010. (Courtesy UAB)

FIGURE 147. Square-wedged treenail. (Photo by Roger Harris, 2010)

FIGURE 148. Another square-wedged treenail. (Photo by Brad Rodgers, 2010)

FIGURE 149. Photo mosaic of the Corolla Wreck's keel piece recovered 15 miles south. (Image by Author, 2012)

FIGURE 150. Detail of the Corolla Wreck’s intricate vertical scarf. (Photo by Author, 2012)

FIGURE 151. Photo mosaic of the collapsing frames. (Image by Author, 2012)

FIGURE 152. The aft most frame has completely collapsed and continues to disintegrate. (Photo by Author 2012)

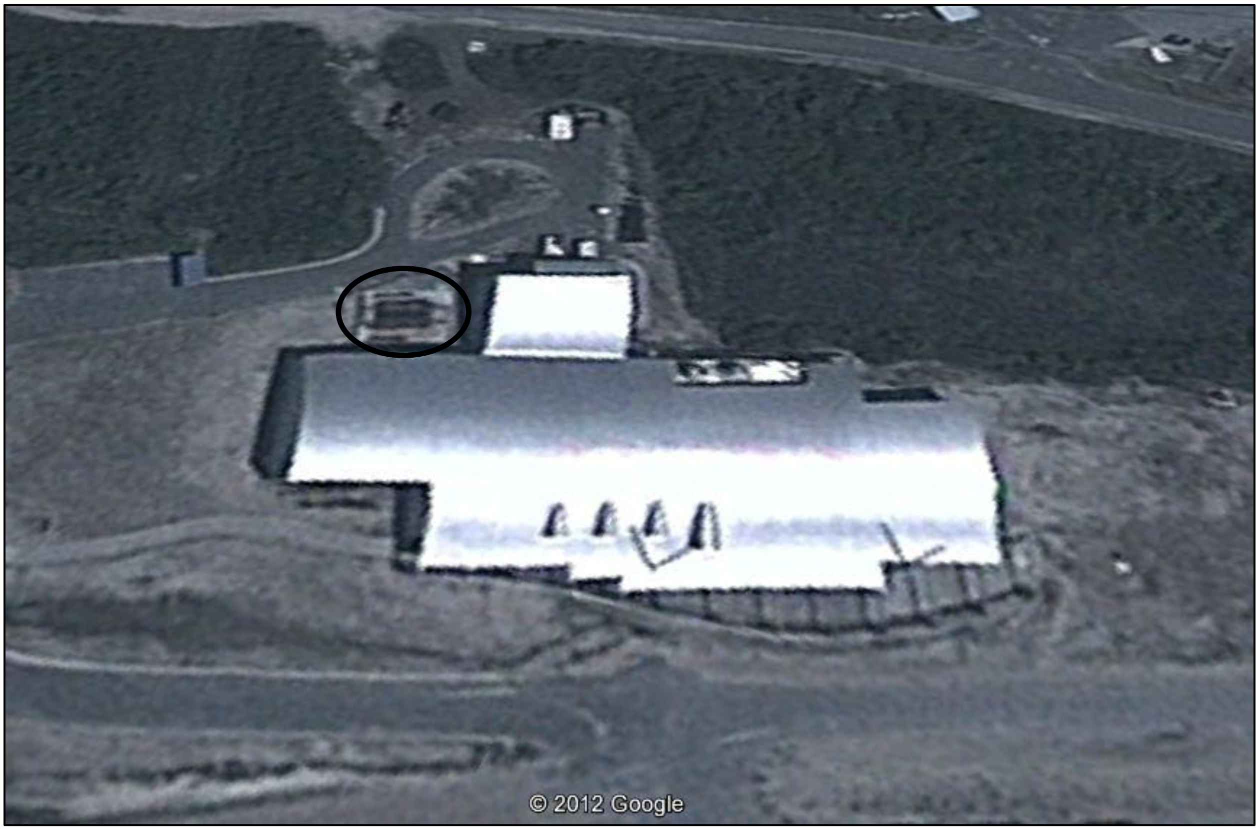

FIGURE 153. The Corolla Wreck's final resting place, behind the Grave Yard of the Atlantic Museum in Hatteras, North Carolina; museum access only. (Courtesy Google Earth, 2012)

REFERENCES

Adams, Jonathan

1985 *Sea Venture*: a second interim report--part 1. *The International Journal of Nautical Archaeology and Underwater Exploration* 14(4):275-229.

2001 Ships and Boats as Archaeological Source Material. *World Archaeology* 32(3):292-310.

2003 *Ships, Innovation and Social Change: Aspects of Carvel Shipbuilding in Northern Europe*. Doctoral Dissertation, Department of Archaeology, Stockholm University, Sweden.

Adams, Jonathan and David Gibbins

2001 Shipwrecks and Maritime Archaeology. *World Archaeology* 32(3):279-291.

Allen, Julie Gardiner and Michael J., ed

2005 *The Archaeology of the* Mary Rose. Vol. 4, *Before the Mast: Life and Death Aboard the* Mary Rose, Julie Gardener and Peter Crossman, editors. Mary Rose Trust, Portsmouth, England.

Anderson, R. C.

1955 *Seventeenth Century Rigging.* Model and Allied Publications, Hertfordshire, England.

Appelqvist, Christin

2011 Wood Degraders in the Baltic Sea. In *Wreck Protect: Decay and Protection of Archaeological Wooden Shipwrecks,*Charlotte Gjelstrup Björdal and David Gregory, editors, pp.57-72. Archaeopress, Oxford, England.

Arnade, Charles W.

1961 Cattle Raising in Spanish Florida, 1513-1763. *Agricultural History* 35 (3):116-124.

Arnold, Jay Rosloff and J. Barto

1984 The keel of the San Esteban (1554): continued analysis. *The International Journal of Nautical Archaeology and Underwater Exploration* 13(4):287-296.

Arnold, J. Barto III.

1996 The Texas Historical Commission's Underwater Achaeological Survey of 1995 and the Preliminary Report on the Belle, Lasalle's Shipwreck of 1686. *Historical Archaeology* 30(4):66-87.

Aritinaño y de Galdácano, Gervasio de

1917 *Histori del comercio con las Indias durante el dominio de los Austrias.* Oliva de Vilanova, Barcelona, Spain.

Auer, Jens and Antony Firth
2007 The Gresham Ship: An Interim Report on a 16th-century Wreck from Princes Channel, Thames Estuary. *Post-Medieval Archaeology* 41 (2):222-241.

Babits, Lawrence E. and Hans van Tilburg
1998 The Technical Importance of Shipwreck Archaeology, by Matthew Baker. Reprinted in *Maritime Archaeology: A Reader of Substantive and Theoretical Contributions*, 17-21. Plenum, New York, NY.

Baker, Matthew
1586 *Fragments of English Shipwrightery.* Madgalene College, Cambridge University, England.

Baker, William A.
1955 The Arrangment and Construction of Early Seventeenth-Century Ships. *American Neptune* 15(1):259-286.

1958 *The New* Mayflower, *Her Design and Construction.* Barre Publishing, Barre, PA.

Bang, N. E.
1906 *Tabeller over Skibsfart og Varetransport Gennem Oresund, 1497-1660*. Fondation de Carlsberg, Copenhagen, Denmark.

Barbour, Violet
1930 Dutch and English Merchant Shipping in the Seventeenth Century. *Economic History Review* 2(2):261-290.

1940 Rigidities Affecting Business in the Sixteenth and Seventeenth Century. *American Economic Review* 30(1):290-297.

Barker, Richard
1994 A Manuscript on Shipbuilding, ca. 1600, copied by Newton. *Mariner's Mirror* 80(1):16-29.

Batavia Yard
2009 Batavia Werf, Development & Realization PM Webdesign, Swifterbant <http://www.bataviawerf.nl/>.

Batchvarov, Kroum N.
2002 *The Framing of Seventeenth-Century Men-of-War in England and Other Northern European Countries.* Masters thesis, Department of Anthropology, Texas A&M University, College Station.

2007 Dartmouth Revisited. *The International Journal of Nautical Archaeology and Underwater Exploration* 36(2):344-352.

2009 *The Kitten Shipwreck: Archaeology and Reconstruction of a Black Sea Merchantman*. Doctoral dissertation, Department of Anthropology, Texas A&M University, College Station.

2012 The Hidden Structure of *Vasa.* Recording the Frames. *International Symposium on Ship and Boat Archaeology*, Amsterdam, Netherlands.

Beaudry, Mary C.
2006 *Findings: The Material Culture of Needlework and Sewing*. Yale University Press, New Haven, CT.

Belmessous, Saliha
2005 Assimilation and Racialism in Seventeenth- and Eighteenth-Century French Colonial Policy. *American Historical Review* 110(2):322-349.

Bergin, Joseph
2001 *The Seventeenth Century: Europe 1598-1715*. Oxford University Press, Oxford, England.

Berti, Hubert
1988 *Album de Colbert 1670*. Editions Omega, Nice, France.

Billings, Warren M.
1996 Sir William Berkley and the Diversification of the Virginia Economy. *Virginia Magazine of History and Biography* 104(4):434-454.

1975 *The Old Dominion in the Seventeenth Century: A Documentary History of Virginia 1606-1689.* University of North Carolina Press, Chapel Hill.

Björdal, Charlotte Gjelstrup and David Gregory
2011 *Wreck Protect: Decay and Protection of Archaeological Wooden Shipwrecks.* Archaeopress, Oxford.

Bojakowski, Piotr and Katie Bojakowski
2012 *The Warwick: New Archaeological Research on the 17th-century English Galleon.* Report on the First Season of Excavation June 19th to July 23rd, Bermuda Maritime Museum. National Museum of Bermuda, Sandys.

2011 The *Warwick*: Results of the Survey of an Early 17th-Century Virginia Company Ship. *Post-Medieval Archaeology* 45(1):41-53.

Boorstin, Daniel J.
1985 *The Discoverers.* Vintage Books, New York, NY.

Bouvier, John
1856 *A Law Dictionary*. Childs and Peterson, Philadelphia, PA.

Bowens, Amanda
2009 *Underwater Archaeology: The NAS Guide to Principles and Practices*. The Nautical Archaeology Society, Portsmouth, England.

Boxer, C. R.
1965 *The Dutch Seaborne Empre: 1600-1800.* Alfred A. Knopf, New York, NY.

Bradford, William
1626 On the Wreck of the Sparrow Hawk. Pilgrim Hall Museum, 2005, (http://www.pilgrimhallmuseum.org/pdf/Wreck_Sparrow_Hawk.pdf, accessed May 1, 2012).

Broadwater, John D., Robert M. Adams and Marcie Renner
1985 The Yorktown Shipwreck Archaeological Project: An interim report on the excavation of shipwreck 44Y088. *International Journal of Nautical Archeology and Underwater Exploration,* 14(4):301-314.

Brouwer, Adriaen.
Peasants of Moerdyck. Private Collection.
Smoking Men. Metropolitan Museum of Art, New York, NY.

Brown, Alexander
1891 *The Genesis of the United States: A Series of Historical Manuscripts.* Vol. 1. Riverside Press, Cambridge, MA.

1901 *The Genesis of the United States: A Series of Historical Manuscripts.* Vol. 2. . Riverside Press, Cambridge, MA.

Bruce, Philip Alexander
1895 *Economic History of Virginia in the seventeenth Century.* Vol. 2. From 1935 edition. Peter Smith, New York, NY.

1895 *Institutional History of Virginia in the Seventeenth Century: An Inquiry into the Religious, Moral, Educational, Legal, Military, and Political Condition of the People, Based on Original and Contemporaneous Records.* Vol. 1. From 1964 edition. P. Smith, Gloucester, MA.

1910 *Institutional History of Virginia in the Seventeenth Century: An Inquiry into the Religious, Moral, Educational, Legal, Military, and Political Condition of the People, Based on Original and Contemporaneous Records.* Vol. 2. From 1964 edition. P. Smith, Gloucester, MA.

Burrage, Henry S., ed.
1906 *Early English and French Voyages: Chiefly from Kaluyt 1534-1608.* From 1959 edtition. Barne’s and Noble, New York.

Bushnell, Edmund
1669 *The Complete Shipwright.* Third Edition. George Hurlock, London.

Cano, Tomé
1611 *Arte para fabricar y aparejar naos*. Edited by Enrique Marco Dorta, 1964. Instituto de Estudios Canarios, La Laguna, Canary Islands.

Castro, Filipe
2001 *The Pepper Wreck: A Portuguese Inidiaman at the Mouth of the Tagus River.* Doctoral dissertation, Department of Anthropology. Texas A&M University, College Station.

Chapelle, Howard Irving
1949 *The History of the American Sailing Navy.* Bonanza, New York, NY.

Chilcote, Ronald H.
1963 Spain's Iron and Steel: Renovation of an Old Industry. *Geographical Review* 53(2):247-262 .

Christensen, Arne Emil
1996 Proto-Viking, Viking and Norse Craft. In *The Earliest Ships,* edited by Robert Gardiner, 72-88. Conway Maritime Press, London, England.

Church, Robert A.
2008 *Depletion of the Sylvan Sea: Seventeenth-Century English Shipbuilding.* PAST Foundation, Columbus, OH.

Clayton, Lawrence A.
1976 Ships and Empire: The Case of Spain. *Mariners Mirror* 62(3):235-247.

Clifford, Sheila Alicia
1993 An Analysis of the Port Royal Shipwreck and its Role in the Maritime History of Seventeenth-Century Port Royal, Jamaica. Master’s thesis, Department of Anthropology. Texas A&M University, College Station.

Condon, Thomas J.
1968 *New York Beginnings: The Commercial Origins of New Netherland.* New York University Press, New York, NY.

Cooper, J. P.
1970 Sea Power, *The New Cambridge Modern History*, IV, J.P. Cooper editor, *The Decline of Spain and the Thirty Years War, 1609-48/59,* 226-238. Cambridge University Press, Cambridge, England.

Crisman, Kevin James
1984 The Eagle: An American Brig on Lake Champlain During the War of 1812. Master's thesis, Department of Anthropology. Texas A&M University, College Station.
Crumlin-Pedersen, Ole.
2004 Nordic Clinker Construction. In *The Philosphy of Wooden Ships*, edited by Frederick M. Hocker, & Cheryl A. Ward, 37-63. Texas A&M University Press, College Station.

Davies, J D.
2008 *Pepys's Navy: Ships, Men and Warfare 1649-1689.* Seaforth Publishing, Greenwich, England.

Davis, Ralph
1972 *The Rise of the English Shipping Industry In the Seventeenth and Eighteenth Centuries.* Second Edition: David and Charles, Devon, England.

Dunn, Richard S.
1972 *Sugar and Slaves: The Rise of the Planter Class in the English West Indies, 1624-1713.* University of North Carolina Press, Chapel Hill.

Edmundson, George
1911 *Anglo-Dutch Rivalry During the First Half of the Seventeenth Century.* Clarendon Press, Oxford, England.

Einarsson, Lars
1990 *Kronan* – Underwater Archaeological Investigations of a17th-Century Man-of-War. The Nature, Aims, and Development of a Maritime Cultural Project. *International Journal of Nautical Archaeology and Underwater Exploration* 19(4):279-297.

Elbl, Martin Malcolm
1985 *The Portuguese Caravel and European Shipbuilding: Phases of Development and Diversity.* Universidade de Coimbra, Coimbra,Portugal.

Elliot, H. H.
2009 *Spain, Europe and the Wider World, 1500-1800.* Yale University Press, New Haven, CT.

Emmer, Peter C.
2003 The First Global War: The Dutch versus Iberia in Asia, Africa and the New World, 1590-1609. *Journal of Portuguese History* 1(1):1-13.

Endsor, Richard
2005 A Drawing of the Midship Bend of the Hampshire 1653. *Mariner's Mirror* 91(1):67-82.

2009 *The Restoration Warship: The Design, Construction and Career of a Third Rate of Charles II's Navy.* Naval Institute Press, Annapolis, MD.

Eriksson, Niklas
2010 Between Clinker and Carvel: Aspects of Hulls Built with Mixed Planking in Scandinavia between 1550 and 1900. *Archaeoligia Baltica: Underwater Archaeology in the Baltic Region* 14:77-887.

2012 The Lion Wreck: A Survey of a 17th-Century Dutch Merchant Ship--An Interim Report. *International Journal of Nautical Archaeology and Underwater Exploration* 41(1):17-25.

Exquemelin, Alexander O.
1678 *The Buccaneers of America*, translated by Alexis Brown 1969. Dover Publications, Mineola, NY.

Famighetti, Robert
1997 *1998 World Almanac and Book of Facts*. St. Martins Press, New York, NY.

Fiset, Richard and Gilles Samson
2009 Charlesbourg-Royal and France-Royal (1541-43): France’s First Colonization Attempt in the Americas. *Post-Medieval Archaeology* 43(1):48-70.

Firth, Jens Auer and Antony
2007 The 'Gresham Ship': An Interim Report on a 16th-Century Wreck from Princes Channel, Thames Estuary. *Post-Medieval Archaeology* 41(2):221-241.

Friends of the Newport Ship
2013 “The Newport Ship's Discovery.” (http://www.newportship.org/the-ship.aspx, accessed September 2013).

Galloway, April and Christine Scott
2010 “Eco-Tourism in the Outer Banks of North Carolina.” LEARN North Carolina. http://www.learnnc.org/lp/pages/1963 (accessed April 4 2013).

Gardiner, Robert
1994 *Cogs, Caravels and Galleons,* editor. Conway Maritime Press, London, England.

1996 *The Earliest Ships.* Conway Maritime Press, London, England.

Garrigus, John
1993 Blue and Brown: Contraband Indigo and the Rise of a Free Colored Planter Class in French Saint-Domingue. *The Americas*, Vol. 50, No. 2 (Oct., 1993), pp. 233-263.

Gentleman, Tobias
1614 *Englands Way to Win Wealth, and to Employ Ships and Mariners: or, A Plain Description of What Great Profit it will Bring into the Common Wealth of England by the Erecting, Building, and Adventuring of Busses to Sea, a Fishing.* Nathaniel Bytter, London, England.

Goslinga, Cornelis
1971 *The Dutch in the Caribbean and on the Wild Coast 1580-1680.* University of Florida Press, Gainesville.

Gregory, David J.
1999 Re-Burial of Timbers in the Marine Environment as a Means of the Long-Term Storage: Experimental Studies in Lynæs Sands, Denmark. *International Journal of Nautical Archaeology* 27.4:343-348.

Gregory, David and Martijn Manders
2011 *In-Situ* Preservation of a Wreck Site. In *Wreck Protect: Decay and Protection of Archaeological Wooden Shipwrecks*,Charlotte Gjelstrup Björdal and David Gregory, editors. Archaeoepress, Oxford, England.

Greico, Glenn
2003 Modeling *La Belle*: A Reconstruction of a Seventeenth-Century Light Frigate. Master's thesis, Department of Anthropology, Texas A&M University, College Station.

Gould, Richard
1983 "Looking Below the Surface: Shipwreck Archaeology as Anthropology*." Shipwreck Anthropology,* p. 3-22. University of New Mexico Press, Santa Fe.

Hall, Jerome Lynn
1996 *A Seventeenth-Century Northern European Merchant Shipwreck in Monte Christi Bay, Dominican Republic.* Doctoral dissertation, Department of Anthropology. Texas A&M University, College Station.

Hallet, C. F. E. Hollis, ed.
2007 *Butlers's History of the Bermudas*. Bermuda Maritime Museum Press, The Keep, Old Royal Naval Dockyard, Bermuda.

Hatch, Charles E.
1991 *The First Seventeen Years, Virginia 1607-1624*, 10th edition. University Press of Virginia, Charlottesville.

Hatfield, April Lee
2004 *Atlantic Virginia: Intercolnial Relations in the Seventeenth Century.* University of Pennsylvania Press, Philadelphia.

Hattendorf, John B., R. J. B. Knight, A. W. H. Pearsall, N. A. M. Rodger, & Geoffrey Till, eds.
1993 *British Naval Documents 1204-1960.* Navy Records Society, Cambridge.

Hazlett, Alexander
2007 Appendix C: *Livro Nautico,* translated by Alexander Hazlett, in The *Nau* Of The *Livro Nautico*:Reconstructing A Sixteenth-Century Indiaman From Texts. Dissertation, Department of Anthropology, Texas A&M University, College Station.

Hening, William Waller, ed.
1823 *The Statutes at Large; Being a Collection of all the Laws of Virginia, from the first Session of theLegislature in the Year 1619.* George Cochran, Richmond.

Hepper, David J.
1994 *British Warship Losses in the Age of Sail 1650-1859*. Jean Boudriot Publications, East Sussex.

Hocker, Frederick M. and John M. McManon
2006 Mediavel Shipbuilding in the Mediterranean and Wirren Culture at Venice. *Mediterranean Historical Review* 21(1):1-37.

Hocker, Frederick M., and Cheryl A. Ward
2004 *The Philosophy of Shipbuilding.* Texas A&M University Press, College Station.

Horn, James
1994 *Adapting to a New World: English Society in the Seventeenth Century Chesapeake.* University of North Carolina Press, Chapel Hill.

2007 Imperfect Understandings: Rumor, Knowledge, and Uncertainty in Early Virginia. In *The Atlantic World and Virginia, 1550-1624,* edited by Peter C. Mancall, 513-540. University of North Carolina Press, Chapel Hill.

Hoving, A. J.
1988 A 17th-Century Dutch 134-Foot Pinas, Part 1: A Reconstruction After Aeloude en Hedendaegse Scheepsbouw en Bestier by Nicolaes Witsen 1671. *International Journal of Nautical Archaeology and Underwater Exploration* 17(3):211-222.

1988 A 17th-Century Dutch 134-Foot Pinas: II. A Reconstruction After Aeloude en Hedendaegse Scheepsbouw en Bestier by Nicolaes Witsen 1671. *International Journal of Nautical Archaeology and Underwater Exploration* 17(4):331-338.

2012 *Nicolaes Witsen and Shipbuilding in the Dutch Golden Age*. Translated by Alan Lemers. Texas A&M University Press, College Station.

Israel, Jonathan
1995 *The Dutch Republic: Its Rise, Greatness, and Fall 1477-1806*. Clarendon Press, Oxford, England.

Jaenen, Cornelius J.
2001 French Expansion in North America. *History Teacher* 34 (February):155-164.

Kammen, Michael.
1975 *Colonial New York: A History*, 2nd edition. KTO Press, White Plains, England.

Keeble, N. H.
2002 *The Restoration: England in the 1660s.* Blackwell Publishing, Cornwall, England.
Kingsbury, Susan Myra, ed.
1906 *The Records of the Virginia Company.* Vols. 1-5. Government Printing Office, Washington, D. C..

Kirsch, Peter
1990 *The Galleon.* English Translation, Conway Maritime Press, London, England.

Klein, Herbert S.
1988 *African Slavery in Latin America and the Caribbean*. Oxford University Press, Oxford, England.

Kupp, Jan
1973 Dutch Noarial Acts Relating to the Tobacco Trade of Virginia, 1608-1653. *William and Mary Quarterly* 3 (October):653-655.

Kupperman, Karen Ordahl
2007 *The Jamestown Project.* Belknap Press of Harvard University Press, Cambridge, MA.

Larn, Richard, ed.
1985 The Wreck of the Dutch East Indiaman *Campen* on the Needles Rocks, Isle of Wight, 1627--Part 1. *International Journal of Nautical Archaeology and Underwater Exploration* 14(1):1-31.

Lavery, Brian
1981 *Deane's Doctrine of Naval Architecture, 1670.* Edited by Brian Lavery. Conway Maritme Press, London.

1991 *Building the Wooden Walls: The Design and Construction of the 74-Gun Ship Valiant.*, Naval Institute Press, Annapolis, MD.

L'Hour M, and L. Long
1990 The Wreck of an "Experimental' Ship of the "Oost-Indische Companie": The *Mauritius* (1609). *International Journal of Nautical Archaeology and Underwater Exploration* 19.1: 63-73

Loades, C. S. Knighton and David
2002 *Letters from the Mary Rose.*Sutton Publishing, Portsmouth, England.

Loades, David
2000 *England's Maritime Empire: Seapower, Commerce and Policy 1490-1690.* Pearson Education Limited, Essex, England.

Lyon, David
1993 *The Sailing List: All the Ships of the Royal Navy - Built, Purchased and Captured, 1688-1855.* Conway Maritime Press, Oxford, England.

Maarvleveld, Thijs
2012 "*Aanloop Mongat.* A Maritime Archaeological Mileston." *International Symposium on Ship and Boat Archaeology,* Amsterdam, Netherlands.

Mainwayring, Sir Henry
1667 *The Sea-Man's Dictionary: or, An Exposition and Demonstration of all the Parts and Things belonging to a Ship. Together with An Explanation of all the Termes and Phrases used in the Practice of Navigation,* 3rd edition. W. Godbid, London.

Maland, David
1980 *Europe at War, 1600-1650.* Rowman and Littlefield, Totowa, NJ.

Marsden, Peter and David Lyon
1977 A Wreck Believed to be the Warship *Anne,* Lost in 1690. *International Journal of Nautical Archaeology and Underwater Exploration* 6(1):9-20.

Marsden, Peter, ed.
2003 *The Archaeology of the* Mary Rose. Vol 1. *Sealed by Time: The Loss and Recovery of the* Mary Rose. Julie Gardener and Peter Crossman, editors. Mary Rose Trust, Portsmouth, England.

Martin, Colin J. M.
1978 The *Dartmouth*, a British Frigate Wrecked off Mull, 1690. *International Journal of Nautical Archaeology and Underwater Exploration* 7(1):29-58.

Mather, Ian Roderick
1990 The Royal Navy Advice Boat *Swift* and the Potential of Unrated Warships. Master's thesis, Department of History. East Carolina University, Greenville, NC.

McCarthy, Michael
2005 *Ships' Fastenings: From Sewn Boat to Steamship.* Texas A&M University Press, College Station.

Mello, Ulysses Pernambucano de
1979 The Shipwreck of the Galleon *Sacramento*--1668 off Brazil. *International Journal of Nautical Archaeology and Underwater Exploration* 8(3):211-223.

Menard, Russel R.
1976 A Note on Chesapeake Tobacco Prices, 1618-1660. *Virginia Magazine of History and Biography* 84(4):401-410.

Middleton, Arthur Pierce
1946 The Chesapeake Convoy System, 1662-1763. *The William and Mary Quarterly,* 3rd series 3(2):182-207.

Mitchell, Robert D.
1983 American Origins and Regional Institutions: The Seventeenth-Century Chesapeake. *Annals of the Association of American Geographers* 73(3):404-420.

Moogk, Peter N.
1989 Reluctant Exiles: Emigrants from France in Canada before 1760. *William and Mary Quarterly,* 3rd series 46(3):463-505.

Moore, James and James Dodds
1984 *Building the Wooden Fighting Ship.* Facts on File Publications, New York, NY.

Morgan, Edmund S.
1971 The First American Boom: Virginia 1618 to 1630. *William and Mary Quarterly,* 3rd series 28(2):169-198.

1975 *American Slavery, American Freedom: The Ordeal of Colonial Virginia.*W. W. Norton & Company, New York, NY.

Muckelroy, Keith
1978a Introducing Maritmie Archeology. Reprinted in 1998 *Maritime Archaeology: A Reader of Substantive and Theoretical Contributions*, edited by Lawrence E. Babits, & Hans Van Tilburg, 23-37. Plenum, New York, NY.

1978b The Archaeology of Shipwrecks. Reprinted in 1998 *Maritime Archaeology: A Reader of Substantive and Theoretical Contributions,* edited by Lawrence E. Babits, & Hans Van Tilburg, 267-290. Plenum, New York, NY.

Munroe, John A.
1978 *Colonial Delaware.* KTO Press, New York, NY.

Nash, Robert C.
1982 The English and Scottish Tobacco Trades in the Seventeenth and Eighteenth Centuries: Legal and Illagal Trade. *Economic History Review* 35(3)354-372.

2001 The Economy. In *The Seventeenth Century: Europe 1598-1715*, Joseph Bergin, editor. Oxford University Press, Oxford, England.

Nelson, Arthur
2001 *The Tudor Navy: The Ships, Men and Organization 1485-1603.* Naval Institute Press, Annapolis, MD.

Newell, Samuel W.
1987 A Maritime History of Ocracoke Inlet, 1584-1783. Master's thesis, Department of History. East Carolina University, Greenville, NC.

Newsome, Lee
2010 CKB0022-Corolla Wreck: Wood Species Analysis. Manuscript, Underwater Archaeology Branch, Kurre Beach, NC.

OED Online.
2012. Oxford University Press. http://www.oed.com/view/Entry/99553?redirectedFrom=iron+sick& (accessed January 22, 2013).

Oertling, Thomas J.
1989a The Molasses Reff wreck hull analysis: Final report. *International Journal of Nautical Archaeology and Underwater Exploration* 18(3) 229-243.

1989b The Highborn Cay wreck: The 1986 field season. *International Journal of Nautical Archaeology and Underwater Exploration* 18(3)244-253.

2001 The concept of the Atlantic Vessel. *International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition.* IGES Par, Libson, Portugal. 233-240.

Oppenheim, M., ed.
1896 *A History of the Administration of the Royal Navy and of Merchant Shipping in Relation to the Navy from 1509 to 1660 with an Introduction Treating of the Preceding Period,* 1988 edition. Temple Smith, Hants.

1902 *The Naval Tracts of Sir William Monson in Six Books.* Vol. I. Navy Records Society, London.

1913 Oppenheim, M., ed. *The Naval Tracts of Sir William Monson in Six Books.* Vol. 4. Navy Records Society, London.

1914 Oppenheim, M., ed. *The Naval Tracts of Sir William Monson in Six Books.* Vol. 5. Navy Records Society, London.

Owen, Norman C.
1988 HMS Hardous Wrecked 1706. Pre-Disturbance Survey Report 1987. *International Journal of Nautical Archaeology and Underwater Exploration* 17(4):285-293.

1991 *Hazardous* 1990-1991 Interim Report. *International Journal of Nautical Archaeology and Underwater Exploration* 20(4):325-334.

Pagan, John R.
1982 Dutch Maritime and Commercial Activity in Mid-Seventeenth Century Virginia. *Virginia Magazine of History and Biography* 90(4):485-501.

Palm, Franklin Charles
1924 Mercantilism as a Factor in Richelieu's Policy of National Interests. *Political Science Quarterly* 39(4):650-664.

Parks, George Bruner
1961 *Richard Hakluyt and the English Voyages.* Second Edition. Edited by James A. Williamson. Frederick Ungar Publishing, New York, NY.

Parr, Charles McKew
1964 *Jan van Linschoten: The Dutch Marco Polo.* Thomas Y. Crowell Company, New York, NY.

Parry, J. H.
1967 Transport and Trade Routes, in E. E. Rich and C. H. Wilson editors, *Cambridge Economic History Europe. IV: The Economy of Expanding Europe in the Sixteenth and Seventeenth Centuries.* Cambridge University Press, Cambridge, England, 155-219.

Pepys, Samuel
2010 *Memoires of the Royal Navy 1690.* Naval Institute Press, Annapolis, MD.

Pérez-Mallaína, Pablo E.
1998 *Spain's Men of the Sea: Daily Life on the Indies Fleets in the Sixteenth Century*, Carla Rahn Phillips translator. Johns Hopkins University Press, Baltimore, MD.

Perrin, W. G., ed.
1918 *The Autobiography of Phineas Pett.* Navy Records Society, London, England.

Phillips, Carla Rahn
1986 *Six Galleons for the King of Spain: Imperial Defense in the Early Seventeenth Century*. John's Hopkins University Press, Baltimore, MD.

Postma, Johannes
1972 The Dimension of the Dutch Slave Trade from West Africa. *Journal of African History* 13 (2):237-248.

Quinn, Alison M. Quinn and David B., ed.
1973 *Virginia Voyages from Hakluyt.* Oxford University Press, London, England.

1982 *The First Colonists: Documents on the Planing of the First English Settlements in North America 1584-1590.* North Carolina Division of Archinves and History, Raleigh.

Quinn, D. B. and A. N. Ryan
1983 *England's Sea Empire.* Allen and Unwin, Boston, MA.
Rabb, Theodore K.
1967 *Enterprise and Empire: Merchant and Gentry Investment in the Expansion of England, 1575-1630.* Harvard University Press, Cambridge, MA.

Reinder, Reinders and Paul Kees, ed.
1991 Carvel Construciton Technique. *Fifth International Symposium on Boat and Ship Archaeology, Amsterdam 1988.* Oxbow Books, Oxford, England.

Reiss, Warren Curtis
1980 The HIstory of, and Search for, the Seventeenth Century Bristol Merchantman *Angel Gabriel.* Master's thesis, Department of Anthropology. Texas A&M University, College Station.

Reps, John W.
1963 The Tidewater Colonies: Town Planning in the Seventeenth Century. *Town Planning Review* 34(1):27-38.

Rink, Olivar A.
1986 *Holland on the Hudson: An Economic and Social History of Dutch New York.* Cornell University Press, Ithaca, NY.

Robinson, Peter J.
2005 *North Carolina Weather and Climate*. University of North Carolina Press, Chapel Hill.

Rodgers, Bradley
2004 *The Archaeologist's Manual for Conservation: A Guide to Non-Toxic, Minimal Intervention Artifact Stabilization.* Plenum Publishers, New York, NY.

2011 The Seventeenth Century. *American Maritime Material Culture.* East Carolina University, Greenville, NC, February 8.

Rushforth, Keith
1999 *Collins Wildlife Trust Guide Trees: A Photographic Guide to the Trees of Britain and Europe.* Harper and Collins, London, England.

Scammell, G. V.
1989 *The First Imperial Age: European Overseas Expansion c. 1400-1715*: Unwin Hyman, London, England.

Schiffer, Michael B.
1983 Toward the Identification of Formation Processes. *American Antiquity* 48(4):675-706.

1987 *Formation Processes of the Archaeological Record*. University of Mexico Press, Albuquerque. Reprinted 1996.

1988 The Structure of Archaeological Theory. *American Antiquity* 53(3):461-485.

Schwarz, George
2010 J. Richard Steffy Ship Reconstruction Laboratory: *Livro de Traças de Carpintaria*, by Manoel Fernandez.http://nautarch.tamu.edu/shiplab/01George/Fernandez.htm, (accessed September 6, 2012).

2010 J. Richard Steffy Ship Reconstruction Laboratory: *O Liuro da Fábrica das Naus*, by Fernando Oliveira, http://nautarch.tamu.edu/shiplab/01George/Oliveira.htm, (accessed September 6, 2012).

Skowronek, Russell K.
1992 Empire and Ceramics: The Changing Role of Illicit Trade in Spanish America. *Historical Archaeology* 26 (1):109-188.

Smith, Frederick H.
2005 *Caribbean Rum: A Social and Economic Hisotry.* University Press of Florida, Jacksonville.

Smith, John
1627 *A Sea Grammar, With the Plaine Expsotion of Smith's Accidence for young Sea-men, enlarged.* John Haviland, London. 1969 reprint, Da Capo Press, New York.

Spence, Craig
1995 *Archaeological Site Manual.* Department of Urban Archaeology, Museum of London, London, England.

Steele, Ian K.
1986 *The English Atlantic, 1675-1740: An Exploration of Communication and Community*. Oxford University Press, New York, NY.

Steffy, J. Richard
1994 *Wooden Ship Building and the Interpretation of Shipwrecks.* Texas A&M University Press, College Station.

Stick, David
1952 *Graveyard of the Atlantic*: *Shipwrecks of the North Carolina Coast.* University of North Carolina Press, Chapel Hill.

1958 *The Outer Banks of North Carolina*. University of North Carolina Press, Chapel Hill.

Sturdy, David J.
2002 *Fractured Europe: 1600-1721*. Blackwell Publishers, Oxford, England.

Strachey, William
1610 *A true reportory of the wracke, and redemption of Sir* THOMAS GATES *Knight; vpon, and from the Ilands of the* Bermudas: *his comming to* Virginia, *and the estate of that Colonie then, and after, vnder the gouernment of the Lord* LA WARRRE. Reprinted in *Purchas, Samuel. Hakluytus posthumus; or, Purchas his pilgrimes,* by William Stansby, London, England,1625, vol. IV.

Taylor, A. H.
1950 Carrack into Galleon. *Mariner's Mirror* 36(2): 145-151.

Thompson, John M., ed.
2007 *The Journals of Captain John Smith.* National Geographic Society, Washington, D.C.

Unger, Richard
1978 *Dutch Shipbuilding Before 1800.* Van Gorcum, Amsterdam, the Netherlands.

1980 Dutch Herring, Technology, and International Trade in the Seventeenth Century. *Journal of Economic History* 40(2):253-280.

Usher, Abbott Payton
1932 Spanish Ships and Shipping in the 16th and 17th Centuries. *Facts and Factors in Economic History.* Harvard University Press, Cambridge, MA.

Usherwood, Stephen and Elizabeth Usherwood
1983 *The Counter-Armada, 1596: The Journal of the* 'Mary Rose'. Naval Institute Press, Annapolis, MD.

Van Duivenvoorde, Wendy
2008. *The Batavia shipwreck: An Archaeolgical Study of an Early Seventeenth-Ccentury Dutch East Indiaman.* Doctoral dissertation, Department of Anthropology, Texas A&M University, College Station.

2009 More than Just Bits of Hull: Expensive Oak, Laminate Construction, and Goat Hair: New Insights on Batavia's Archaeological Hull Remains. *Tijdschrift voor Zeegescheidenis* 2(January):59-68.

2012 "Batavia's Timbers and Rembrandt's Panels: A Perfect Match." *Annual Conference of the Society for Historical Archaeology,* Baltimore, MD.

Van Yk, Cornelis
1697 *De Nederlandsche Scheepsbouwkunst Open Gestalt*. Andries Voorstád, Delft, the Netherlands.

Veitia Linaje, José de
1702 *The Spanish Rule of Trade to the West Indies*. Translated by John Stevens. Samuel Crouch, London, England.

Waddell, Peter J. A.
1986 The disassembly of a 16th century galleon. *The International Journal of Nautical Archaeology and Underwater Exploration* 15(2):137-148.

Walker, J.C.F., Butterfield, B.G., Langrish, T.A.G., Harris, J.M. and Uprichard, J.M. Primary
1993 *Wood Processing*. Chapman and Hall, London, England.

Walsh, Lorena S.
1989 Plantation Management in the Chesapeake, 1620-1820. *Journal of Economic History* 49(2):393-406.

Walton, James F. and Gary M. Shepherd
1972 *Shipping, Maritime Trade and the Economic Development of Colonial North America.* Cambridge University Press, Cambridge, England.

Watkins-Kenney, Sara and Nathan Henry
2010 Corolla Wreck: Emails. Manuscript, Underwater Archaeology Branch, Kurre Beach, NC.

Watkins-Kenney, Sara
2010 Crisis at Corolla: Rescue of a Colonial Era Shipwreck: A Case Study in Crisis Management. Manuscript, East Carolina University, Greenville, North Carolina.

Watts, Gordon P.
1993 The Western Ledge Reef wreck: a preliminary report on investigation of the remains of a 16th-century shipwreck in Bermuda. *International Journal of Nautical Archaeology* 22(2):103-124.

Wilson, William E.
1961 Spain's Restless Golden Age – The Collapse of a Dream. *Hispania* 44 (3):409-414.

Witsen, Nicolaes
1690 *Aeloude en Hedendaegsche Scheeps-bouw en Bestier*. Reprint, Peter and Joan Blaeu, Amsterdam, the Netherlands.

Wright, Irene A.
1932 *Documents Concerning English Voyages to the Spanish Main 1569-1580,* 1967 reprint by Hakluyt Society, London, England.

Wheatley, Henry B., ed.
1952 *The Diary of Samuel Pepys.* Vols. 1-6. G. Bells and Sons, London, England.

Williams, Neville
1960 *The British Public Record Office: History, Description, Record Groups, Finding Aids, and Materials for American History with Special Reference to Virginia.* Special Report, Virginia State Library, Richmond, VA.

Wingwood, Allan J.
1982 *Sea Venture*: An Interim Report on an Early 17th-Century Shipwreck Lost in 1609. *International Journal of Nautical Archaeology and Underwater Exploration* 11(4):333-347.

1986 *Sea Venture* Second Interim Report--Part 2: The Artefacts. *International Journal of Nautical Archaeology and Underwater Exploration* 15(2):149-159.

Wyckoff, Stanly Gray and V. J.
1940 The International Tobacco Trade in the Seventeenth Century. *Southern Economic Journal* 7(1):1-26.