1997

On the Wings of the Wind: Changes in English Shipbuilding, Navigation and Shipboard Life, 1485-1650

Anna Gibson Holloway
College of William & Mary - Arts & Sciences

ON THE WINGS OF THE WIND:

CHANGES IN ENGLISH SHIPBUILDING, NAVIGATION AND SHIPBOARD LIFE, 1485 - 1650

A Thesis

Presented to

The Faculty of the Department of History

The College of William and Mary in Virginia

In Partial Fulfillment

Of the Requirements for the Degree of

Master of Arts

---

by

Anna Gibson Holloway

1997

APPROVAL SHEET

This thesis is submitted in partial fulfillment of

the requirements for the degree of

Master of Arts

Author

Approved, May 1997

Dale Hoak

James P. Whittenburg

James Axtell

For Nannie

Table of Contents

Acknowledgements

There is no such thing as a solo project. More people than I have space to name have helped make this work possible. I would like to thank Professor Dale Hoak for his guidance and infinite patience while waiting for this thesis to become a reality. Likewise, Professors James Whittenburg and James Axtell have shared their talents and wisdom with me over the past several years, and I am the better person for it.

There are many people who have helped me chart my course towards this thesis. From Jamestown Settlement I would like to thank Stephen Furey-Moore for hiring me on as a cabin girl, Homer Lanier for keeping me employed for so many years despite the fact that I was a "@#&$! idiot," Captain Eric Speth for allowing me to sail, Jimmy and Jean Barger for turning me into a sailor and feeding me rum cake, and all of the crew of the *Susan Constant, Godspeed,* and *Discovery*. Fair winds, friends.

From Colonial Williamsburg I would like to thank Carson Hudson for giving me employment opportunities beyond my wildest dreams. Life is indeed a circus, Carson!

I'd also like to thank Addie Dinkins, Lexy Shaw and Melody Malone for keeping me on the proper side of sanity (whichever side that is).

Of course, the greatest support comes from family. I'd like to thank Duane and Pat Holloway for their love and friendship, and for accepting me into their brood. My grandmother, Edith Hartle has been wonderfully supportive in all my endeavors, as has my aunt, Ruby Sapp. Most of all I would like to thank my parents, Tom and Greta Gibson for - well, for absolutely everything. I would not have made it this far without them. They have gone above and beyond for me, and I hope I can someday return the favor.

Finally, I want to thank my husband Jim for loving me and the kitties. His patience, humor, and gourmet cooking have sustained me throughout my "gradual" school career. I can think of no one else with whom I would rather sail away.

Abstract

Before the fifteenth century, English maritime activity was largely confined to coastal work. English ships were small, slow, and limited in their use, built as they were with overlapping planks in the "clinker" fashion, and rigged with huge square sails. However, vessels captured from Mediterranean countries introduced flush planking and the triangular lateen sail to English shipwrights, who slowly incorporated these and other innovations into native shipwrightry.

This change in English vessel design coincided with an escalating interest in Atlantic travel, brought on in part by increasing knowledge of the Atlantic itself. This move by the English into the Atlantic was fueled also by the desire to find a route to the spice islands of the East Indies that was not monopolized by another European power. English mariners learned much from their Iberian counterparts, adapting such empirical knowledge to suit their particular needs in the North Atlantic. By the late sixteenth century, English mariners could be found not only in the Atlantic, but also in most parts of the known world.

This outward movement of the English was not merely a result of advanced shipwrightry and borrowed experience, however. English innovations in navigational technique and shipboard maintenance throughout the sixteenth and early seventeenth centuries insured that English ships would reach their destinations even as advances in shipboard hygiene and health care made it possible for more English sailors and passengers to arrive at those destinations alive.

This thesis will show how the English combined borrowed technologies and knowledge with native innovation in order to move away from their own coastline and into the waters of the world, becoming a formidable maritime nation by the mid-seventeenth century.

ON THE WINGS OF THE WIND:

CHANGES IN ENGLISH SHIPBUILDING, NAVIGATION,

AND SHIPBOARD LIFE, 1485 - 1650

Introduction

"To men the winds are as wings," wrote Francis Bacon in 1622. "For by them men are borne and fly, not through the air but over the sea; a vast gate of commerce is opened, and the whole world is rendered accessible."[1] By Bacon's time the wind *had* opened the world to the people of England by pushing their ships across vast oceans to foreign shores where they began England's bid for empire. Each successive voyage brought more information about the world home to England, which enabled the English to better formulate their plans for oceanic exploration. By gaining a thorough understanding of the forces of nature that conspired to make each voyage a success or a disaster, the English were better able to design their sailing vessels to withstand the rigors of trans-oceanic crossings; by constant improvement of navigational techniques and instruments, the English were able to travel more confidently away from the coastlines; and by observing shipboard conditions, sailors and passengers were better able to make such crossings bearable, if not yet comfortable. By the late seventeenth century,

[1]Francis Bacon, *The Works of Francis Bacon*, ed. James Spedding, Robert Ellis, and Douglas Heath, 14 vols. (New York: Garrett Press, 1968), 2: 19. "Venti humanae genti alas addiderunt, eorum enim dono feruntur homines et volant; non per aërem certe, sed per maria; atque ingens patet janua comercii, et fit mundus pervius."

the English had surpassed all other European nations in maritime prowess, having developed merchant and naval fleets that could serve the nation admirably in war as well as peace.

Although there have been many works that have focused on various aspects of European maritime history of the sixteenth and seventeenth centuries, there is as yet no study that focuses entirely on England and combines English scientific and technological advances with the social history of English ships of this period.[2] This thesis will show that it was the combination of technological advancements in shipbuilding and navigation along with the gradual improvement of shipboard conditions that allowed the English to gain supremacy at sea by the late seventeenth

---

[2]Samuel Eliot Morison's works on North American explorers, *The European Discovery of America : The Northern Voyages 500-1600* (New York: Oxford University Press, 1971), and *The Southern Voyages 1492-1616* (New York: Oxford University Press, 1974), as well as his biography of Columbus, *Admiral of the Ocean Sea: A Life of Christopher Columbus* (Boston: Little, Brown, and Company, 1942), all contain useful chapters on life at sea for various European sailors. Peter Kemp's *The British Sailor: A Social History of the Lower Deck* (London: J.M. Dent & Sons, Ltd, 1970) and Christopher Lloyd's *The British Seaman 1200-1860: A Social Survey* (Rutherford, N.J.: Fairleigh-Dickinson University Press, 1970) both contain excellent information on the life of a sailor, but do not discuss the ramifications of technological change for the seaman. David Beers Quinn's *England and the Discovery of America, 1481-1620* (New York: Alfred A. Knopf, 1974) also includes a chapter on the life of a sailor as well as chapters on some technological change, but is not comprehensive. J.H. Parry's *The Age of Reconnaissance: Discovery, Exploration and Settlement, 1450 to 1650*, (New York: Praeger Publishers, 1969) has excellent chapters on both life at sea and on technological change, but does not focus solely on the English.

century. This work will begin by examining the background to England's great age of exploration, focusing upon European knowledge of the forces at work in the Atlantic before the middle of the sixteenth century. This will be followed by an examination of the English response to such knowledge primarily in the latter half of that century. Changes in hull design, sail plan and preventive maintenance as well as advances in pilotage and navigation will be outlined for the entire Tudor period, focusing primarily on the reign of Elizabeth, as well as changes made during the reign of the early Stuarts. Finally, this work will move within the wooden walls of England's sailing fleet and observe shipboard conditions for the hundreds of men (and later women and children) who challenged the world's oceans in English ships during the sixteenth and seventeenth centuries.

Chapter One

Early Explorations and Knowledge of the Wind

Though it has been fashionable in the years following the quincentennial of Columbus's first voyage to malign that explorer for his deeds in the Caribbean, it cannot be denied that he provided invaluable information to mariners when he discovered the prevailing wind pattern of north-easterlies in the Atlantic. However, centuries of discovery and observations of wind patterns came before 1492 aided both Columbus and the English explorers who followed hard upon his heels in succeeding years.

Aristotle's *Meteorologica* was the primary source for wind theory in fifteenth and sixteenth-century Europe.[1] Drawing on the writings of Hippocrates, Aristotle presented the view that both wind and rain were aspects of air, which was an exhalation of the earth. To define the origin of wind, Aristotle postulated that winds are formed by "the gradual collection of small quantities of exhalation, in the same way that rivers form when the earth is wet."[2] Furthermore, "Winds blow horizontally; for though the

---

[1]Harold L. Burstyn, "Theories of Winds and Ocean Currents From the Discoveries to the End of the Seventeenth Century," *Terrae Incognitae* 3 (1971): 8.

[2]Burstyn, "Theories of Wind," 173.

exhalation rises vertically, the winds blow round the earth because the whole body of air surrounding the earth follows the motion of the heavens."[3] There was no better explanation until Torricelli's experiments with air pressure in 1644, coupled with Newton's theory of motion, disproved Aristotle's logic.[4]

But it was not the question of *where* winds came from that captivated mariners. *How* a wind behaved was of more immediate concern. Yet even here, Aristotle provided answers in the sixteenth and seventeenth centuries. Aristotle believed that the world was divided into several zones, only two of which were habitable. The northern habitable zone, which included the known world, stretched from the Tropic of Cancer north to the Arctic Circle. Believing the earth to be symmetrical, Aristotle assumed that there would be a corresponding habitable zone to the south, stretching from the Tropic of Capricorn to the southern Antarctic zone. The zones between the tropics and the polar regions were too hot or too cold to be inhabitable. Therefore, "since . . . there must be a region which bears to the other pole the same relation as that which we inhabit bears to our pole," wrote Aristotle, "it is

---

[3]Aristotle, *Meteorologica*, trans. H.D.P. Lee, Loeb Classical Library (Cambridge: Harvard University Press, 1952), 171.

[4]Burstyn, "Theories of Wind," 9; Hugh Kearney, *Science and Change, 1500 - 1700* (New York: World University Library, 1971), 149.

clear that this region will be analogous to ours in the disposition of winds. . . ."[5] Such knowledge would serve mariners well as they sailed into the unknown.

The ancients provided other sources of information on the winds that influenced the natural philosophers of the sixteenth century. As early as the fourteenth century, the English had access to copies of the Roman work, *De Ventis*, written by Theophrastus around 300 B.C. In 1538, the Spaniard Pedro de Medina drew directly from *De Ventis* in his *Libro de Cosmographia*. Echoing Theophrastus, Medina wrote that wind is made up of "great movements [of air] continuously carried by the waters from one place to another. And so we see that over the sea and near it, there are stronger and more continuous winds than on other parts of the earth."[6] Medina's work was available in English translation by 1581 and was generally accepted in scientific circles. However, even at that late date, the nature of the wind was still a matter of question to the landsman. Oxford don Richard Madox wondered in 1582 "whether the winds are attracted to some end and whether, fearing something hostile, they are driven out from some place and flee or

---

[5]Aristotle, *Meteorologica*, 183.

[6]Pedro de Medina, *A Navigator's Universe : The Libro de Cosmographia of 1538*, trans. Ursula Lamb (Chicago: University of Chicago Press, 1972), 191. "Lo mas cierto es quel viento se hage de los grandes movimientos que contin otra en las mares de una parte a otra. Cassi vemos que en la mare cerca della ay mas Regios e continuos vientos que en otras partes de la tierra."

whether by some kind of presentiment, they seek out some quiet place congruent to their nature."[7]

One thing was certain. The winds blew consistently out of certain quarters at certain times of the year. The ancient Greeks named such prevailing winds for geographic features that lay in the direction of such winds - hence Thracian winds from the northwest and Hellespontian winds from the east-northeast. The Romans borrowed that system, substituting Latin place-names and geographical features for the Greek. People from the far north, the Norsemen, also developed a system of eight winds corresponding to their home geography.

The ancients and the Norse drew circular representations of the winds which in time became the well-known wind rose. Pliny noted that the "ancients noticed four winds in all, corresponding to the four quarters of the world." But he as well as the ancients found this a "dull-witted system," which was slightly improved upon by adding eight more winds. This, according to Pliny, was "too subtle and meticulous" for most, so "their successors adopted a compromise, adding to the short list four winds from the long one." Thus it was decided that there would be "two

---

[7]Elizabeth Story Donno, ed., *An Elizabethan in 1582: The Diary of Richard Madox, Fellow of All Souls*, Hakluyt Society Publications, 2d ser. 147 (London, 1976), 259-60.

winds in each of the four quarters of the heavens."[8]

In 1240 A.D., the English cartographer Matthew Paris first developed the subdivision of the preferred eight-fold system into sixteen for use in England.[9] But the standard thirty-two-point system, which appeared on *portolani* from the thirteenth century, did not appear in England until about 1391; apparently the twelve-fold system and its subdivisions were still being used on land at this time. In his *Treatise on the Astrolabe*, the poet Geoffrey Chaucer wrote: "Now is the horizon departed in 24 parts by the azimuth, in signification of the 24 parts of the world; albeit so that shipmen reckon the same parts in 32."[10] Sixty-four-point wind roses, although used by the Italians, failed to accommodate the needs of the common mariner, for as Martin Cortés wrote in 1561, "In the cardes that they have, the confusion of lynes is greater then the profite that maye bee taken thereby."[11]

---

[8]Pliny, *Natural History*, trans. W.H. Rackham, Loeb Classical Library (Cambridge: Harvard University Press, 1938), 1: 261. The windrose of Aristotle and Theophrastus display the twelve-fold system.

[9]E.G.R. Taylor, *The Haven-Finding Art* (London: Hollis and Carter, 1956), 8.

[10]*The Student's Chaucer*, ed. Walter W. Skeat (Oxford: Clarendon Press, 1929), 411. "Now is thyn orisonte departed in 24 parties by thy azimutz, in significacion of 24 partiez of the world; al-be-it so that shipmen rikne thilke partiez in 32."

[11]Martin Cortés, *The Art of Navigation*, trans. Richard Eden (London: R. Jugge, 1561), fol. 55v.

The thirty-two-point wind rose became the object by which mariners were able to plot their courses. By incorporating the wind rose into his charts in an intricate interweaving of rhumb lines, a mariner could then use these "rhumbs of the winds" to determine his heading.[12] Martin Cortés wrote that the wind roses would be added to the completed chart by first drawing a "hidden circle," which the cartographer then divided into thirty-two points. This would define the positions of either sixteen or thirty-two intersections (depending on the size of the chart), each drawn as a colorful wind rose. The eight principal winds were drawn in black, the half-winds in azure or blue and the quarter-winds in red.[13] By using a pair of dividers, the pilot could read off his course. With the widespread use of the magnetic compass at sea from the twelfth century onward, the rhumb lines began to be less associated with the winds and more indicative of compass direction when the magnetized needle of the compass was attached to a colorful card depicting the wind rose. With the winds thus controlled on paper, explorers on both land and sea had a better notion of wind patterns within the known world. But by the early fifteenth century, Europeans had begun to venture into the unknown.

---

[12]David W. Waters, *The Art of Navigation in England in Elizabethan and Early Stuart Times* (New Haven: Yale University Press, 1958), 21.

[13]Cortés, *Art of Navigation*, fol. 56v.

The *Polychronicon* of Ranulf Higden and *De proprietatibus rerum* by Bartholomeus Anglicus, both English works written in Latin, had been translated into English by 1398. Caxton had published the latter in 1482 and Wynkyn de Worde printed both in 1495.[14] These works, along with Jean d'Outremeuse's *The Travels of Sir John Mandeville*, all contained descriptions of the known world and its peoples, and anyone who could read had access to them by the late-fifteenth century. All drew on ancient texts for their information, along with some contemporary sources. Higden and Bartholomeus, however, both gave proof that the area known as Vinland in North America, settled by Norsemen in 1000 A.D., was already familiar to English scholars, in name at least, if not in position. Higden wrote:

> Vinland, that island, is by west Denmark, and is a barren land and of men misbelieved; they worship mawmetry, and sell wind to shipmen, that sail to their havens, as it were enclosed under knots of thread; and as the knots are unknit, the wind waxes at her own will.[15]

---

[14]Franklin T. McCann, *English Discovery of America to 1585* (New York: King's Crown Press, 1952), 4.

[15]Ranulf Higden, *Polychronicon Ranulphi Higden Monachi Cestrensis Together with the English Translations of John Trevisa and of an Unknown Writer of the Fifteenth Century*. vol. I, *Rerum Britannicarum Medii Aevi Scriptores (Rolls Series)*, vol. 41, ed. Churchill Babington, (London: Longman Green, 1865), 323-27. "Wyntlandya, þat ilond, is by west Denmark, and is a barayne lond and of men mysbyleued; þei worschippeþ mawmetrie, and selleþ wynd to schipmen, þat seilleþ to hire hauenes, as it were i-closed vnder knottis of þrede; and as þe knottes beeþ vnknette, þe wynde wexeþ at her wone wille. Islond, þat ilond, haþ in þe est side Norþwey, in þe north þe froren see, mare congelatum . . . þat ilond is from Irlond and from Bretayne þre dayes

Bartholomeus related the same story about the selling of wind, and concurred that "Wynlandia [was] a countree besydes the mountayns of Norway towarde the east."[16] Therefore, it is probable that the English already knew of the existence of Vinland, although they were ignorant of its importance, and it was apparent that there had already been contact between the English and the Norse colonists in Iceland, with whom the English built up a fishing trade. Thus the English had early access to knowledge of the North Atlantic. But because the climate changed for the worse in the north during the twelfth century, the colonies in Greenland ceased to exist, and since Greenland was the link between Europe and Vinland, all knowledge of that place passed from the realm of fact into the realm of legend; the Icelanders even forgot it, and Higden and Bartholomeus's accounts of wind-selling natives substantiated the myth. Only the experience of Bristol mariners who sailed to Iceland to trade for fish in the mid-fifteenth century proved that anything other than a supernatural wind blew in those waters. The English encounter with North America in 1497, then, appeared to them to be a new discovery.

The early-fifteenth century brought many new

---

seillynge. Tile is þe vttermost ylond of occean . . . and wel fewe men knoweþ þat ilond . . . Noþeles Tyle is sixe dayes seillynge out of Bretayne . . ."

[16]Robert Steel, *Mediæval Lore From Bartholomew Anglicus* (New York: Cooper Square Publishers, 1966), 100.

discoveries (and rediscoveries) of islands which lay several miles outward to the west of Europe and Africa. The Canaries had been rediscovered in the thirteenth century and had been colonized by 1402, so the existence of island groups in the Atlantic that were not merely cloud-banks and the stuff of dreams was an exciting discovery. The Portuguese found Porto Santo and Madeira in 1420 (although the Genoese had probably discovered them first in 1351 and failed to exploit them), and the Azores, known but lost, were rediscovered in the 1430s and colonized. The Portuguese discovered the Cape Verde islands off Africa in the 1450s and 1460s. These were not the islands of myth, such as Hy-Brasil and Antilia, but real places with infinite possibilities. These island groups provided convenient starting places for many early expeditions into the Atlantic, and the observations of the winds that blew westward from these islands later began to give mariners ideas about heading farther out to sea.

Because the prevailing winds off the coast of the Iberian peninsula blow to the south-southwest, a voyage to the Canaries or the Cape Verdes islands was easy and quick, taking about a week in good weather. The return trip was a different matter. Ships could not easily sail into the wind and against the prevailing currents. A homeward voyage by this route would take months, and could be prohibitive in terms of cost, both in supplies and in lives. Thus, fourteenth- and fifteenth-century sailors turned their ships away from land and swung far out to the northwest in search of a favorable wind, until they picked up prevailing westerlies to take them home. Portuguese mariners called this the *volta do mar* or the "turn of the sea" (possibly named for the popular dance of the day, *la volta*, which was characterized by this type of movement) and used it as "a template with which to plot their courses to Asia, to the Americas, and around the world."[17]

Despite these inviting Atlantic islands, European focus was on the East from whence came spices, silks, and other luxuries, which to many were rapidly becoming necessities. Land routes to the East had been effectively cut off with the reclamation of the Holy Land by the armies of Islam during the thirteenth century, the fall of the Mongol Empire in the fourteenth century, and a general monopoly on Mediterranean trade held by Italian merchants. The only viable route open to those of Western Europe was around Africa, and when Bartholomew Dias rounded the Cape of Good Hope in 1487, even that route was sealed to all but the

---

[17]Alfred W. Crosby, *Ecological Imperialism: The Biological Expansion of Europe, 900-1900* (Cambridge: Cambridge University Press, 1986), 113. European sailors often described their movements in terms of dance steps. In a 1597 voyage to Cape Breton, an English mariner lamented that his ships "were faine to dance the hay foure dayes together" off the coast of France. Richard Hakluyt, *The Principal Navigations, Voyages, Traffiques and Discoveries of the English Nation*, 8 volumes (London: J.M. Dent and Sons, 1926), 6: 112-13.

Portuguese. This left only the unknown route to the West, championed by the Genoese Christopher Columbus.

Bartolomé de Las Casas wrote of Christopher Columbus, "I believe that Christopher Columbus exceeds all others at this time in the art of navigation."[18] While Columbus won this praise from Las Casas solely because he was the first to cross the Ocean Sea, there is merit to Las Casas's observation, for Columbus himself had collected information over the course of many years, which made it possible for him to attempt his enterprise for Spain in 1492. In Book One of *Quaestiones Naturales*, Seneca wrote, "How far is it from the southern shores of Spain to the Indies? It can be completed in the space of a few days if the wind bears the ship."[19] Armed with this information, along with the ancient writings of Aristotle, Ptolemy, Marinus of Tyre, Strabo and Pliny, along with the writings of Marco Polo from the more proximate thirteenth century, and the blessing of the well-respected contemporary cartographer Toscanelli, Columbus was able to present his case for a western route to

---

[18]George E. Nunn, *Geographical Conceptions of Columbus: A Consideration of Four Problems*, American Geographical Research Series, No. 14 (New York: American Geographical Society, 1924), 44. "Ansí creemos que Cristóbal Colón en el arte de navegar excedió sin alguna duda á todos cuantos en su tiempo en el mundo habia."

[19]Nunn, *Geographical Conceptions*, 37. "Quantum enim est quod ad ultimis litoribus Hispaniae usque ad Indos iacet? Paucissimorum dierum spatium, si navem suus ferat ventus, implebit."

the East.

Both Las Casas and Ferdinand Columbus catalogued information about Columbus's knowledge of prevailing winds in the Atlantic and other information about his enterprise before his first voyage. According to Ferdinand Columbus, colonists in the Azores on the islands of Graciosa and Fayal reported that pines of an unknown kind had been cast upon the shore from the west after the wind had blown from that direction for many days. Two human bodies of an unknown race, which Columbus assumed to be Chinese, washed up on the shore of Flores. Martín Vincente, a pilot of the Portuguese king Don Joao, told Columbus that he had fished an ingeniously carved piece of wood out of the sea 450 leagues west of Cape Saint Vincent. Since the wind had been blowing out of the west for many days, Vincente assumed that the carving had been blown eastward from islands in the west. Pedro Correa, Columbus's brother-in-law, found similar carved sticks washed up on the shores of Porto Santo in the Madeiras along with canes that were unlike any found in the known world except in the East Indies. Small covered boats or canoes drifted by off Cape Verga in Africa, presumably having been blown off course in a storm in the Indies.[20] Columbus's own observations of prevailing northwesterly winds off the western coast of Africa added more evidence.

---

[20]*The Life of the Admiral Christopher Columbus by his son Ferdinand*, trans. Benjamin Keen (New Brunswick: Rutgers University Press, 1959), 23-24.

Many sailors with whom Columbus spoke told him of islands that they had seen in their travels west of the Azores and Canaries. Columbus assumed that these "islands" were either reefs, cloud-banks, or the islands of Hy-Brasil or Antilia, though the mention of them gave fuel to his enterprise. Las Casas related the story of an old sailor who presumably gave Columbus directions to lands across the sea which he had accidentally found when blown off course in a gale. But this story was considered apocryphal even then, and the physics of the winds in the Atlantic as they are known today do not allow for this story to be true, even if that sailor possessed all the technology available in the twentieth century. However, it is easy to see how the story could be believed, whether by Columbus or by those who sought to discredit him at the time by claiming that he was merely following someone else's directions.[21] There was no chart of the winds of the Atlantic. No one had definitely sailed across, so anything would appear possible to a man with Columbus's turn of mind and spirit.

Columbus discovered a mere fraction of the winds and currents of the Atlantic during his first voyage in 1492, but the portion that he did discover would prove to be most important. With his return to Spain in 1493, he proved that the Ocean Sea had winds that would provide for a ship's

[21]Samuel Eliot Morison, *Admiral of the Ocean Sea : A Life of Christopher Columbus* (Boston: Little, Brown and Company, 1942), 60-62.

outbound voyage as well as its safe return home.[22] The Spanish now held dominion over the western route to the Indies (albeit the West Indies as they proved to be). Both the French and the English were left with the uninviting prospect of travel to the northwest or the northeast in search of a passage to the East.

The English were late to arrive upon the Atlantic maritime scene despite their location. Before the fifteenth century, they concentrated their interests on the neighboring continent and seldom left European waters. Unless one considers the legendary voyage of Saint Brendan around 500 A.D. and the subsequent wanderings of the Irish Anchorites, the peoples of the British Isles confined themselves to European trade and the occasional quest for the mythical Hy-Brasil, which lay somewhere to the west.[23] The English explorers of the fifteenth and sixteenth centuries had to rely upon the writings and experiences of those who had gone before them until they could gain their own empirical knowledge of the seas. This knowledge came from many quarters. The ancient Greeks and Romans provided

---

[22]See *Appendix One* below for information on Atlantic winds.

[23]Roger Barlowe, *A Brief Summe of Geographie*, ed. E.G.R. Taylor, Hak. Soc. Pub, 2d ser., 69 (London: The Hakluyt Society, 1932), 50. "Weste of yreland is an ylonde called the ilande of brasyll which stondeth in 51 degrees. Hit is almoste rounde, of longitude it hath 12 leges and of latitude 9.ffrom yreland to this yle of brasyll is 70 legis." The island was not removed from British Admiralty charts until 1873.

them with an abstract understanding of the elements of air and water, contact with other countries' shipping introduced new technology to them, and the explorers and fishermen of Portugal and Spain (along with a few from Bristol) supplied a concrete view of the Atlantic.

In the early years of the sixteenth-century, Europeans developed a passion for discovery, fueled by the reports of gold and exotic peoples found in newly discovered lands. The Treaty of Tordesillas between Spain and Portugal in 1494, established a line of demarcation that fell 370 miles west of the Azores, replacing an earlier line of 1493 that was only 100 miles west of that island group. In this new treaty, Pope Alexander VI conferred all new lands "found or to be found" east of that line to Portugal and everything to the west of it to Spain.[24] This effectively gave Portugal control of the spice routes around Africa, and Spain dominion over most of the New World; every other nation was simply ignored. For the English, however, possession truly was nine-tenths of the law, thus they lay claim to trading rights along the west coast of Africa and later claimed North America for their own by right of John Cabot's first voyage in 1497. While the Portuguese were ready to contest any African claims, there were fewer disputes over the northern reaches of North America since that region had

---

[24]J.H. Parry, *The Age of Reconnaissance : Discovery, Exploration and Settlement 1450 to 1650* (New York: Praeger Publishers, 1969), 151-52.

proven to be cold, inhospitable, and devoid of gold, and the route there was at times very treacherous. In fact, only the fishing grounds of the Grand Banks proved attractive to other nations, and an uneasy truce existed between the fishermen who plied those waters.

According to Richard Hakluyt the younger and Walter Ralegh, England's Henry VII could have been the patron of Columbus's initial voyage. Columbus's brother Bartholomew was on his way to London to petition Henry VII for funding when he was captured by pirates. When he eventually arrived in England, according to Hakluyt, Henry accepted his proposal. But the year was then 1493.[25] On his way back to Spain with Henry's offer, Bartholomew discovered that his brother had already sailed across the Ocean Sea and returned, in the service of Ferdinand of Aragon and Isabella of Castile.

The English soon found their own navigator: the Genoese Giovanni Caboto, or John Cabot. On March 5, 1496 Henry VII granted to him and his three sons Lewis, Sebastian, and Sancius letters patent authorizing an expedition to the west for the discovery of new and unknown lands. Henry authorized five ships

> of what burthen or quantity soever they bee, and as many mariners or men as they will have with them in the sayd ships, upon their owne proper costs and charges, to seek out, discover and finde whatsoever isles, countreys, regions or provinces of the heathen and

[25]Hakluyt, *Principal Voyages*, 5: 82.

> infidels whatsoever they be, and in what part of the world soever they be, which before this time have bene unknowen to all Christians.[26]

Henry had nothing to lose, for by this patent Cabot had agreed to pay for everything himself. But Cabot's funds were limited; when he finally left Bristol for the west on May 20, 1497, he had only one vessel, the fifty-tun *Matthew*, only slightly smaller than Columbus's beloved *Niña*.

Cabot's patent makes no mention of the route that he was to take to make these discoveries, and since his life has been so overshadowed (as well as appropriated) by his son Sebastian, his reasoning for taking a northern route is unknown. According to Samuel Eliot Morison, Cabot had likely "pumped sundry master mariners of Bristol in the Iceland trade for information, and learned that in the spring of the year he would have more easterly winds than at any other season." There also seemed to be no difficulty in returning since the expedition would enjoy "a good deal of due north and due south winds too, which *Matthew* could take on her beam."[27]

Cabot sailed to the westernmost point of Ireland, Dursey Head, and took his departure at a latitude of 51° 33' N. Like Columbus, his objective was to sail on a particular line of latitude until he reached his destination. Columbus

---

[26]Hakluyt, *Principal Voyages*, 5: 82.

[27]Samuel Eliot Morison, *The European Discovery of America: The Northern Voyages A.D. 500-1600* (New York: Oxford University Press, 1971), 167-68.

had made his departure from the Canaries at 28° N, hoping to bump into Cipangu (Japan) along the same latitude. Likewise, Cabot departed from Dursey Head hoping to encounter the northern shores of Cathay (China) on a shorter northern route. Finally, Cabot chose this point for departure because mariners said that it lay on the same latitude as Hy-Brasil, which Cabot hoped to discover, thus accomplishing what nearly two decades of Bristol men had failed to do. That this was one of Cabot's motives is confirmed by Pedro de Ayala, the temporary Spanish ambassador to England, in a letter to Ferdinand and Isabella dated July 25, 1498. "For the last seven years the people of Bristol have equipped two, three, and four caravels to go in search of the island of Brasil and the seven cities according to the fancy of this Genoese [Cabot]."[28]

A letter from the English merchant John Day to Columbus written after Cabot's successful return in July of 1497, gave details of Cabot's voyage, including information of the winds encountered:

> . . . and the time that he departed from England was in the end of May and he was en route 35 days before he found land, and the winds were east and northeast and the seas were smooth on the outward as well as the homeward passage, save one day when there blew up a gale, and that was two or three days before he found land; . . . and he went exploring the coast one month more or less and the abovesaid cape of *tierra firma* which is closest to Ireland being [passed] on the return, they arrived off the coast of Europe in 15 days. Carrying a stern wind, he arrived in Brittany

---

[28]Quoted in McCann, *English Discovery of America*, 52.

> because the mariners confused him, saying that he was steering too far north; and from thence he came to Bristol and went to the king to tell him the abovesaid . . .[29]

The rebellion of the Cornishmen, joined by the pretender Perkin Warbeck in late 1497 delayed Cabot's second voyage, but on February 3, 1498, Henry VII issued new letters patent to Cabot allowing him six ships of under two-hundred tuns each and as many Englishmen as were willing to sign on. Henry himself outfitted one ship, leaving the rest to Cabot, who came up with four more, aided by the merchants of Bristol. Cabot departed in May, one of his ships returning to Ireland in distress almost immediately. The other four disappeared, never to be heard from again. Thus ended England's second western venture.

Cabot's first voyage not only gave England a claim to North America, it also proved that the North Atlantic could provide winds for an outward as well as a homeward voyage, if one left at certain times of the year. Cabot's initial crossing of thirty-three days, the same as Columbus's southern crossing (though it covered fewer miles) was a record that stood for almost a century.[30] However, Cabot's second voyage showed that this northern route, fraught with fog, gales, icebergs and "growlers," was a far more dangerous undertaking than Columbus's balmy southern

---

[29]Quoted in Morison, *European Discovery: Northern Voyages*, 207-208.

[30]Morison, *European Discovery: Northern Voyages*, 189.

route.[31] Subsequent voyages to the north, undertaken by England, France, and Portugal would prove this to be unquestionably true.

The English made many voyages into and across the Atlantic in the early years of the sixteenth century, and with each one the sailors gained more knowledge and more practical experience. But it would not be until the middle part of that century, before English ships began to take on a character of their own, leaving behind the Mediterranean-inspired designs of the Spanish and Portuguese and becoming vessels that were custom-made to withstand the rigors of the Atlantic and eventually the Pacific as well.

---

[31]"Growlers" were small chunks of ice broken off from larger icebergs.

Chapter Two

Hull Design and Maintenance

George Best, the chronicler of Martin Frobisher's three voyages to the northwest during the reign of Elizabeth I, identified a "speciall cause" for England's delinquency in maritime activities. Best identified a "lacke of liberalitie in the Nobilitie." Very few members of the upper classes were willing to risk their money in dangerous enterprises that very likely would not turn a profit. Only when merchants and lesser gentry began to pool their resources in joint-stock companies, such as the Muscovy Company, would maritime activities proceed on a greater scale. No amount of money, however, could protect the sailor from the dangers of the sea. Such protection required favorable weather, knowledgeable seamen, and well-built ships. Although Elizabeth had no command over the first, she certainly had the latter two at her disposal.

Before Elizabeth's reign, England's ships were "full of Ragusans, Venetians, Genoese, Normans and Bretons," according to the French ambassador to England in 1540.[1] Indeed, the first recorded English voyage to the west, in

---

[1]E.G.R. Taylor, *The Haven-Finding Art* (London: Hollis and Carter, 1956), 194.

1497, was under the command of the Italian John Cabot. The reliance on foreign experts and literature, such as navigational manuals and rutters, marked the limits of English maritime interest and expertise during the reigns of the first two Tudors. In her book *The Haven-Finding Art*, E.G.R. Taylor wrote that "after Henry VIII died there were said to be three-score French pilots in England, many of them standing high in their profession," but these men were called back to France upon the accession of Henri II. Only the French Huguenot pilot Jean Ribault remained in England, kept under close supervision in the Tower of London. Ribault, Sebastian Cabot (son of John, and formerly the Chief Pilot of Spain), and "the noble Pinteado," an exiled gentleman-pilot of Portugal, were appointed by the Duke of Northumberland to work on charts, rutters, and other necessary equipment in order that England, under Edward VI, might surpass Spain at sea. This combination of men, working at the behest of the English, was "evidence enough of the lack of English maritime skill," according to Professor Taylor.[2]

While homegrown skill may have been lacking in England, there was no want of maritime development during the sixteenth century. In his recent work *The Tudor Navy*, David Loades lays to rest the traditional notion that nothing of importance happened until the reign of Elizabeth, and

---

[2]Taylor, *The Haven-Finding Art*, 195.

recent archaeological and archival work has shown that definite changes were being made in English shipbuilding as early as the reign of Henry VII.[3] But to explain these changes, it is necessary first to go back to the time of Henry V.

Among the fleet of Henry V were several Italian prizes captured in Channel battles with the French in 1416-1417. Unlike the English-built ships in Henry's fleet, these ships of Mediterranean origin were carvel-built, with edge-to-edge planking laid atop a skeleton frame.[4] Thus they had smooth sides, which differed from the overlapped planking of the clinker-built English ships.[5] Although both styles of construction required the use of pitch, rosin and oakum (old rope, tow or flax) to seal the planking, their method of construction was significantly different.[6]

Clinker technology, of northern European origin, is

---

[3]David Loades, *The Tudor Navy: An Administrative, Political and Military History* (Brookfield, Vt.: Scolar Press, 1992); For the most current archaeological work, see J. Richard Steffy, *Wooden Ship Building and the Interpretation of Shipwrecks* (College Station: Texas A&M University Press, 1994).

[4]Olof Hasslöf, "Sources of Maritime History and Methods of Research," *Mariner's Mirror* 52: 2 (May 1966): 136.

[5]Susan Rose, ed., *The Navy of the Lancastrian Kings: Accounts and Inventories of William Soper, Keeper of the King's Ships, 1422-1427* (London: Navy Records Society, 1982), 43-44.

[6]Rose, *The Navy of the Lancastrian Kings*, 116; Henry Manwayring, *The Sea-mans Dictionary: or, an Exposition and Demonstration of all the Parts and Things belonging to a Shippe, etc.* (London: John Booker, 1644), 71.

best illustrated by the remains of Henry V's ships the *Grace Dieu*, found in the River Hamble, in Southampton. Each strake of that ship's planking was made from two 12-inch wide planks and one 8-inch wide plank with a combined thickness of 4 1/2 inches. The wider planks overlapped the strake below, creating a thickness of five layers. The whole assembly was fastened together with clenchnail bolts, iron spikes "driven through from the inside and clenched over circular roves (washers) on the outside."[7] Clinker-built ships were produced with a shell-first construction in which the hull was assembled first and the framework supplied later.[8] Ships of this construction were necessarily slower in the water because of the friction resulting from added surface area.[9]

The addition of the swifter, carvel-built ships from the south was a definite asset to Henry's navy, but the technology needed to repair these ships was so beyond English shipwrights at the time that the Keeper of the King's Ships, William Soper, had to petition the King's Council for permission to hire foreign carpenters because "in this country there are no men who know how to repair

---

[7]Frank Howard, *Sailing Ships of War, 1400-1860* (New York: Mayflower Books, 1979), 18.; Rose, *The Navy of the Lancastrian Kings*, 73.

[8]Hasslöf, "Sources of Maritime History," 134.

[9]Peter Kemp, ed., *The Oxford Companion to Ships and the Sea* (London: Oxford University Press, 1976), 173.

these carracks."[10] This remained the case until the time of Henry VII, when the clinker style in large vessels was finally abandoned. Whereas before, the inventories had listed *spiknayls, clinch-nayls, roffes*, and *rivetts*, in 1495 the inventories began to include *carvell nayles* as well.[11]

Why did the English lag so far behind the shipwrights of the Mediterranean in the fifteenth century? Tradition seems to be the answer. In a field as closely guarded as shipwrightry was at the time, old habits died hard. Frame-first construction was not a continuation of any older system of shipbuilding in the north, as it seemed to be in the Mediterranean. Therefore, the new mode of frame-first construction introduced into England by the capture of southern vessels was in competition with the more familiar shell-first construction that was already in place there.[12]

By the time of Henry VII's death in 1509, English shipwrights were building larger vessels in both clinker-built and carvel-built styles, but the advantages of carvel-built ships over the old style were apparent enough that many older ships were being rebuilt in the new style. Henry's 800-ton warship the *Sovereign*, built originally in

---

[10]Rose, *The Navy of the Lancastrian Kings*, n153, translation mine.

[11]Rose, *The Navy of the Lancastrian Kings*, 73; Hasslöf, "Sources of Maritime History," 137; M. Oppenheim, ed. *Naval Accounts and Inventories of the Reign of Henry VII, 1485-8 and 1495-7* (London: Navy Records Society, 1896), 152.

[12]Steffy, *Wooden Ship Building*, 142.

1488 with a clinker hull, was rebuilt carvel-style around 1509. The remains of this vessel, found at Woolwich in 1912, show adze work on the frames, which suggests that the notches for the clinker-style planking had been smoothed away "to permit alignment of the new planking edges."[13]

Also in 1509, shipwrights began work on a new four-masted, 600-ton carrack called the *Mary Rose*. Evidence from the remains of this vessel, which sank in 1545 during a battle in the Solent, shows that she, too, was begun as a clinker-style vessel. Frames on the starboard quarter of the vessel show marks which indicate that they had originally been cut for lapped strakes but, like the *Sovereign*, had been modified for flush planking. Records indicate that the *Mary Rose* was extensively rebuilt in 1536.[14] Perhaps shipwrights made the conversion then. By the time the *Mary Rose* sank, however, large clinker-built vessels had become passé. A state paper of that same year relates that "clinchers [are] both feeble, olde and out of faschion."[15] In terms of hull construction, England had finally made it out of the Middle Ages.

---

[13]Steffy, *Wooden Ship Building*, 141.

[14]Margaret Rule, *The Mary Rose: The Excavation and Raising of Henry VIII's Flagship* (Annapolis: Naval Institute Press, 1984),

[15]M. Oppenheim, *A History of the Administration of the Royal Navy and of Merchant Shipping in Relation to the Navy from 1509 to 1660* (London, 1896), 54.

Frame-first construction allowed shipwrights to alter the shape of their vessels in ways that had been unavailable to them before. The rounded sterns necessary with clinker construction gave way to the more commodious and more defensible flat "square tuck" sterns. In such a construction, the stern was cut almost vertically down to just above the waterline "and the side planks of the hull were fastened to a U-shaped stern frame that was planked across diagonally."[16] A ship thus built could have guns mounted closer to the water in the stern, which previously had been the most vulnerable part of the ship. The creation of the U-shaped stern frame, or "fashion pieces," also allowed shipwrights to integrate the after castle or "somercastle" into the framework of the ship.[17]

The conversion to carvel-built vessels around the time of Henry VIII's accession was concurrent with the development of lidded gunports sometime between 1500 and 1530.[18] The advantages of armed ships had been recognized as early as the 1330s, but just as quickly the disadvantages became obvious.[19] At first the guns were placed in

---

[16]Howard, *Sailing Ships of War*, 45.

[17]Manwayring, *The Sea-mans Dictionary*, 39.

[18]Carlo M. Cipolla, *Guns, Sails, and Empires: Technological Innovation and the Early Phases of European Expansion 1400-1700* (New York: Pantheon Books, 1965), 81; Loades, *Tudor Navy*, 49; Howard, *Sailing Ships of War*, 46.

[19]Cipolla, *Guns, Sails, and Empires*, 76.

"castles" which were temporary superstructures built fore and aft (complete with crenelations) and primarily designed for the defense of the ship, as well as for the protection of officers and important passengers from the elements. Clinker-style construction dictated that these structures could not be fully integrated into the hull structure, since supports were added after shell construction. Although the structures could be removed from the ship to be stored for later use, their very impermanence meant that they could also be torn off the ship easily in heavy weather. Frame-first construction and the introduction of the flat stern however, allowed the forecastle and summercastle (aft) to be incorporated fully into the hull structure. Period illustrations show guns mounted in these structures with lidded ports as early as the 1490s.[20] Likewise, large, lidded cargo ports (for loading heavy items or even horses) appear on ship's quarters as early as the mid-fifteenth century.[21] Thus, cutting another opening into the side of a ship for a gunport would hardly seem revolutionary. The innovation (perhaps erroneously attributed to the Frenchman Descharges) in the early sixteenth century was that a shipwright was able "to work out how to place the ports without cutting the wales that provided so much of the

---

[20]Illustration from the Warwick Roll [1493] in Howard, *Sailing Ships of War*, 26.

[21]R. Morton Nance, "The Ship of the Renaissance, Part II," *Mariner's Mirror* 41: 4 (November 1955): 284, 288.

longitudinal strength of a carvel-built hull."[22]

Likewise, the new "gundeck" itself had to be adapted to accommodate the realities of shipboard battle. Since Descharges's innovation dictated that the gunports follow the sheer of the wales, which was considerably curved and would make manning artillery on the deck with hazardous, the gundeck had to be built on different levels to compensate for such a slope.

The placing of gunports on the lower decks gave ships the advantage of being able to increase their armament both in number and in size, usually without compromising the stability of the vessel.[23] The problem of stability was overcome by trial and error and improvements in hull design on this account made these ships far better suited to both fighting and sailing.

The death of Henry VIII in 1547 brought his nine-year-old son Edward to the throne. By this time, English ships were on an equal footing with other Western European maritime nations, and because of the concentrated efforts to improve maritime armaments, England's vessels may have even enjoyed an advantage over other nations in gunnery.[24] Decidedly English tactics such as the broadside had been

---

[22]Howard, *Sailing Ships of War*, 46; Robert Gardiner, ed., *Cogs, Caravels and Galleons: The Sailing Ship, 1000-1650* (Annapolis: Naval Institute Press, 1994), 89.

[23]Cipolla, *Guns, Sails, and Empires*, 82.

[24]Loades, *Tudor Navy*, 95.

developed recently during Henry VIII's war with France in the mid 1540s. There was no lack of interest in maritime issues during Edward's short reign, and Edward's government spent £20,000 per year on naval expenses.[25] Yet there were few technical developments in hull design or maintenance during this period.[26]

Mary's reign likewise showed a lack of significant technical development, but England's maritime force was in no way diminished during her short reign, as historians previously believed.[27] The level of peacetime preparedness was as high as it had ever been, and the number of royal ships built between 1553 and 1558 was superior to anything later in the century except for the years 1587-1588.[28] The maritime strength that Elizabeth inherited from her sister was formidable indeed, but an equally important legacy from Mary's reign came to Elizabeth as well. The formation of the Muscovy Company in 1555 ushered in a new era in English seafaring. From that point onward, England's attention would increasingly turn to ventures in the Atlantic.

Elizabeth granted the office of Master Shipwright to

---

[25]Loades, *Tudor Navy*, 155.

[26]Loades, *Tudor Navy*, 94.

[27]Elaine W. Fowler, *English Sea Power in the Early Tudor Period, 1485-1558* (Ithaca: Cornell University Press, 1965), 36: "The navy unquestionably had fallen on evil days."

[28]Loades, *Tudor Navy*, 159, 169.

Matthew Baker in 1572. Baker was the son of James Baker, who had served in a similar capacity under Henry VIII. The elder Baker received a lifetime annuity from the crown beginning in 1538, and Matthew inherited this annuity in 1572.[29] Under the guidance of Matthew Baker and John Hawkins, who was appointed Treasurer of the Queen's Majesty's Marine Cause in 1578, domestic shipwrightry developed a distinctively English form. Elizabeth placed Hawkins in charge of royal ships where his often radical ideas of ship design and maintenance endured harsh criticism. Ten years and £250,000 later, however, Elizabeth's prudent choice would be vindicated when sleek English ships beat back the great, lumbering Armada of Spain.

The changes wrought by Baker and Hawkins were largely of hull design. The top-heavy, fortified ships of Henry VIII's day gave way to more streamlined vessels by sixteenth-century standards. Under Hawkins's guidance, English shipwrights began lowering the high castles that had been characteristic of earlier ships such as the *Jesus of Lübeck,* which had served as his own flagship in the ill-fated expedition to San Juan de Ulua in 1568. Here, Hawkins discovered first hand that a top-heavy, deep-waisted ship was not the optimal vessel for fighting or manoeuvering.

---

[29]*The Autobiography of Phineas Pett*, W.G. Perrin, ed., Publications of the Navy Records Society vol 51 (London: Navy Records Society, 1918), xvii.

While that information did him no good in 1568, he used it to the advantage of the English fleet twenty years later.

Lowering the high fortifications permitted a more effective use of deck armaments. By decking over the deep waist of the ship, Hawkins allowed for the placement of more deck guns to make an English broadside much more effective and all but eliminate the need for boarding and hand-to-hand combat. Still more important, the streamlining of the ship permitted greater stability and maneuverability, while still allowing for effective weaponry. The elimination of the high sterncastle and forecastle reduced roll, which if extreme enough could capsize a ship. Furthermore, the reduction in height in the profile of a ship made the vessel more aerodynamic and able to sail closer to the wind (The older carracks could only sail eight points from the wind. The new-style galleons could sail six points from the wind, or 22 1/2 degrees better).[30] What was left of the high stern acted as an additional sail, providing needed help in pushing the stern around in the course of a tack. Initiated by Hawkins, these changes appeared radical to a highly conservative maritime community.[31] The resulting ships were true English galleons, and although it would be incorrect to say that Hawkins *invented* the galleon, his encouragement to

---

[30]Loades, *Tudor Navy*, 196; John Harland, *Seamanship in the Age of Sail* (London: Conway Maritime Press, 1984), 11.

[31]Alan Moore, "The Snow," *Mariner's Mirror*, 2: 2 (February 1912): 41.

English shipwrights to build the sleeker, faster ships was instrumental in making the change.[32]

Matthew Baker, who pioneered some innovations of his own, put Hawkins's changes into practice. Under Baker, shipbuilding began to be more standardized. Tonnage, which had previously been determined by comparative estimates was standardized by a formula of Baker's making. Using the 252-gallon Bordeaux wine cask as his standard of measurement, Baker devised the following formula:

$$\frac{\text{Keel Length} \times \text{Greatest Breadth} \times \text{Depth}}{100} \times (1 + 1/3) = \text{Tonnage}$$[33]

Thus a ship with a keel length of 50 feet, a breadth of 20 feet and a depth of hold of 10 feet would be of 100 tons burden, and with a tonnage of 134.

While this measurement of burden bears little resemblance to modern freight capacity, it did serve as a convenient method of comparison at the time and allowed for a more exact calculation of harbor fees and building costs.[34] It also allowed a shipwright to figure the tonnage of a prospective ship **before** it was built, rather than having to wait until the ship was complete to get an accurate measurement (which previously entailed loading the

---

[32]Loades, *Tudor Navy*, 195.

[33]Peter Kirsch, *The Galleon: The Great Ships of the Armada Era* (Annapolis: Naval Institute Press, 1990), 25.

[34]Kirsch, *The Galleon*, 24.

ship with cargo and then counting the actual number of barrels).[35]

Baker was also the first English shipwright to commit ship designs to paper. Baker was probably the primary author of the anonymous manuscript *Fragments of Ancient English Shipwrightry*, c.1586, which depicted sail plans, decorations and techniques of calculating proper dimensions within its pages. The manuscript, found in the Pepys Library at Magdalene College, Cambridge, also shows the proper hull design for a new-style vessel. Having studied the shapes of fishes, Baker had determined that the hull below the waterline should have the shape of a codfish head with a mackerel tail, so that it might properly slice through the water.[36]

Among other things, Baker's manuscript describes the construction method known as "whole-moulding." In this type of ship construction, the largest rib of the ship, the midship frame, serves as a template for the remaining frames. Through meticulous geometrical calculation following the drawing of three or four arcs, the exact dimensions of an entire ship could be laid out on paper, before the shipwright ever set foot in the shipyard. Baker

---

[35]William Salisbury, "Early Tonnage Measurement in England," *Mariner's Mirror* 52: 1 (February 1966): 43-44.

[36]David Beers Quinn, *North America From Earliest Discovery to First Settlements* (New York: Harper and Row, 1977), 93.

based his example on a Venetian method which he had encountered a few years previously on a visit to the Mediterranean.[37]

The manuscript also shows the shipwright at work in his studio, utilizing sweeps, or mathematical compasses to draw the lines of the ship. As Master Shipwright, Baker could not be in all royal dockyards at once. By working out the dimensions and framework of a vessel on paper, his desires could be made known to his various shipwrights without Baker having to be physically present. This was a far more precise method than building ships "by eye," as shipwrights had done previously. Although English shipwrights were becoming more scientific in the late sixteenth century, it was obvious that there was much room for improvement. Baker's drawings represented the ideal in shipbuilding: all shipwrights were to be educated and mathematically competent. Of course the reality fell somewhat short of the mark.

In the meantime, ships continued to be built that were less than perfect when launched. Thomas Hariot, an associate of Walter Ralegh as well as a naturalist and explorer, commented on this problem. Through his own observations, he had concluded that while English ships were

---

[37]Richard Barker, "Design in the Dockyards, about 1600," in *Carvel Construction Technique: Fifth International Symposium on Boat and Ship Archaeology, Amsterdam, 1988*, eds. Reinder Reinders and Kees Paul (Oxford: Oxbow Books, 1991), 64.

the best in the European maritime world, there was still room for improvement.[38] A contemporary of Baker's, Hariot was "in no way overawed by [him], nor fearful of challenging the reasoning of the Master Shipwright."[39] For Hariot, Baker's calculations for tonnage were too crude, and Hariot recommended measuring displacement instead.

Hariot made observations of many of the ships used by Walter Ralegh in his various enterprises and was able to make several suggestions that would aid in the building of a better boat. He found that "the chief propertyes of a ship in the sea [were] To go well; to steer well, & beare a good sayle."[40] Unfortunately, many ships used by both Crown and merchant were compromised by "the Burthen that belongeth to the owners profit, which some to much affecting hath made vs to haue so many furred ships."[41] "Furring" a ship, according to Henry Manwayring, who clearly disapproved of the practice, involved placing "planck upon planck" at the waterline in order "to make a ship beare a better saile, for when a ship is too narrow and the bearing either not laid out enough, or too low, then they must make her broader, and lay her bearing higher" Manwayring went on to complain that

---

[38]John W. Shirley, *Thomas Harriot: A Biography* (Oxford: Clarendon Press, 1983), 100.

[39]Shirley, *Thomas Harriot*, 101.

[40]Shirley, *Thomas Harriot*, 100.

[41]Shirley, *Thomas Harriot*, 100.

"in all the world, there are not so many ships Furd, as are in England: and it is pitty that there is no order taken, either for the punishing of those who build such ships; or the preventing of it; for it is as infinite losse to the owners, and an utter spoiling and disgrace to all ships that are so handled."[42]

Hariot worked with Baker until his death, each man striving to improve the state of English shipwrightry. Although each made significant contributions to English ship design, theirs was an uphill battle.

In the closing years of the sixteenth century, George Weymouth wrote that "The Shipwrights of England and of Christendom build ships only by uncertain traditional precepts and observations and chiefly by the deceiving aim of their eye, where for want of skill to work by such proportions as in Art is required and is ever certain, I have found these defects."[43] What Weymouth found was that despite the increasing use of mathematics in shipbuilding, shipwrights still clung to the older methods and thus could produce "no. . . two ships alike."[44]

Standards of workmanship were also variable during this period. Entering the English Channel in 1593, Richard Hawkins's vice-admiral suddenly signalled distress, causing

---

[42]Manwayring, *The Sea-mans Dictionary*, 43-44.

[43]Quoted in Pett, *Autobiography*, lxxii.

[44]Pett, *Autobiography*, lxxiii.

Hawkins to edge alongside her to find the cause. The ship "had sprung a great leake," and needed to return to safer waters to repair it. Hawkins went aboard and "presently found, that betwixt wind and water, the calkers had left a seame uncalked, which being filled up with pitch only, the sea laboring that out, had been sufficient to have sunk her in short space, if it had not beene discovered in time." After caulking the seam with oakum and reapplying pitch, Hawkins found that the ship was again seaworthy.

This incident caused Hawkins to lament in his *Observations* that the standards of workmanship in 1593 were not as high as they had been in the past. He proposed two solutions that would preclude another near-disaster such as his vice-admiral had faced. First, he felt that if caulkers were held accountable for their work and fined for mistakes, such an incident would not occur. He also proposed more rigorous testing of the hull before the ship was launched. The caulkers should at "the next tide to fill her with water, which will undoubtedly discover the defect, for no pitcht place without calking, can suffer the force and peaze [weight] of the water."[45] Unfortunately, such preventive measures as Hawkins prescribed were rarely done, and it was usually up to the crew and sometimes the passengers to

---

[45]Clements R. Markham, ed., *The Hawkins' Voyages during the reigns of Henry VIII, Queen Elizabeth, and James I*, Hak. Soc. Pubs., 1st ser., 57 (1878; reprint, New York: Burt Franklin, 1970), 204.

remedy the leaks as they were found.[46] The introduction of chain-pumps in the 1580s for pumping the bilges did not make the ships any less leaky, but they did aid considerably in keeping the ships drier within.

While hull design had reached a new sophistication during Elizabeth's reign, there still remained the problem of properly maintaining the wooden hull of the ship from the ravages of the sea. Throughout the fifteenth century, countless vessels rotted at their moorings for lack of proper maintenance, and the general policy of the Crown was to get rid of vessels in times of peace. This saved on maintenance costs and transferred the burden of maintenance to the private sector. It was not until the end of Henry VII's reign that large numbers of royal ships were routinely maintained during peacetime.[47] Such maintenance included scraping, oiling, *brooming* (burning off the slime that collected on the hull) and re-caulking the outer hull as well as "rummaging," or cleaning the bilge and cargo area within.[48] Little changed in this type of maintenance over

---

[46]Silvester Jourdain, *A Discovery of the Barmudas, Otherwise called the Ile of Divels 1610*, ed. Joseph Quincy Adams (New York: Scholars Facsimiles and Reprints, 1940), 4-5; Samuel Purchas, *Hakluytus Posthumus or Purchas His Pilgrimes*, 20 vols. (New York: The Macmillan Company, 1906), 19: 6-13.

[47]Loades, *Tudor Navy*, 52.

[48]Rose, *The Navy of the Lancastrian Kings*, 61 - 131; Oppenheim, *Naval Accounts*, 7 - 337; John Smith, *The Complete Works of John Smith*, Philip Barbour, ed. (Chapel Hill: University of North Carolina Press, 1988), 66 - 67.

the next three hundred years.

Preventive maintenance, however, did improve during the sixteenth century, and as Englishmen ventured across the Atlantic they found new menaces that threatened the wooden walls of their vessels. The teredo worm (*teredo navalis*), abundant in the tropics, sought out the unprotected planking of a ship's hull for its home and in short order could turn a heavy oaken beam into lacy ruin. Mariners experimented with different forms of sheathing as well as constant maintenance in efforts to stave off the effects of this tiny menace. During his voyage to the South Sea in 1593, John Hawkins's son, Richard, recorded his observations of worms as he encountered them. Unlike the typical ship's log of the day, his account included histories of problems and their solutions.

Off the shore of Brazil, near the equinoctial line, where Hawkins had brought his ship for cleaning and maintenance, he "found her all under water covered with these wormes, as bigge as the little finger of a man, on the outside of the planke, not fully covered, but halfe the thicknesse of their bodie, like to a gelly, wrought into the planke as with a gowdge."[49] The sight of these creatures launched Hawkins into a world history of preventive sheathing. In Spain and Portugal "some sheathe their shippes with lead, "but the cost and added weight were

[49]C. R. Markham, *Hawkins*, 201.

unattractive to Hawkins and "it is nothing durable, but subject to many casualties." Double planking, used by mariners of all nations was "little better then that with lead ; for besides his waight, it dureth little, because the worme in small time passeth through the one and the other." Other methods involved placing substances such as canvas or glass-laced pitch in between the two layers of planking, but Hawkins dismissed them as "of small continuance, and so not to be regarded." The Chinese, according to hearsay used varnish which was said "to be durable and of that vertue, as neither worme nor water peirceth it; neither hath the sunne power against it."[50] But Hawkins, as well as other European mariners, evidently lacked the recipe for this remarkable varnish, and even forty years later it still remained a maritime myth which, "if true," wrote Nathaniel Butler in 1634, "were worth a voyage to bring home the experiment."[51]

Burning the "utter planke till it come to be in every place like a cole, and after to pitch it" was "not bad," but naturally, Hawkins had the best solution, "invented by my father. . . and experience hath taught it to be the best and of least cost." By smearing a mixture of tar and hair between the hull and sheathing boards, "the hayre and the

---

[50]C. R. Markham, *Hawkins*, 202-203.

[51]Nathaniel Butler, *Six Dialogues about Sea Services*, ed. W.G. Perrin (1634; reprint, London: The Navy Records Society, 1929), 105.

tarre so involve [the worm] that he is choked therewith."[52]

The elder Hawkins' worm solution proved to be a sensible one for it was the only method given for sheathing by John Smith in his 1627 work *A Sea Grammar* and by Henry Manwayring in *The Sea-mans Dictionary* of 1644 (written much earlier, possibly even predating Smith).[53] Nathaniel Butler also lists it as "the surest known way with us," but added a few more solutions.[54] Mixing red pepper with the pitch or tar "will preserve her from being eaten with the worm, at least so long as the stuff will hang upon her sides, which may be about two months space." And, as if anticipating the future, Butler wrote of ships in the East Indian trade that had their rudders covered with thin plates of copper, a sheathing common to English ships of the next century.[55]

Sheathing alone was not enough to maintain the integrity of the hull below the waterline, however. Constant maintenance was required to keep the ship sound. Richard Madox, minister on the *Galleon Leicester* in 1582, told of a place near Labrador where "Sir Francis Drake graved and bremd his ship," and John Davis likewise spoke of

---

[52]C.R. Markham, *Hawkins*, 203-4; Loades, *Tudor Navy*, 196.

[53]John Smith, *A Sea Grammar*, ed. Kermit Goell (1627; reprint, London: Michael Joseph, 1970), 16.; Manwayring, *A Sea-mans Dictionary*, 92-93.

[54]Butler, *Six Dialogues*, 104-105.

[55]Butler, *Six Dialogues*, 104-105.

graving the *Moonelight* during his second Northwest voyage in 1586.[56] Breaming a ship is "but washing or burning of all the filth with reeds or broome," according to Smith, "either in a dry dock or upon her *Careene*; which is to make her so light, as you may bring her to lye on the one side so much as may be, in the calmest water you can. . ." To grave a ship, however, the vessel must be out of the water, on her side. Following the breaming, a mixture of "trayne-oyle, Rosen and Brimstone boyled together" was applied to that portion of the ship's hull which lay below the waterline, in a procedure known as "paying" (not to be confused with "paying a seam," a different process altogether).[57]

Washing the ship was another way of maintaining her when careening, graving, or dry docking were not feasible. During the final voyage of Sir Francis Drake and Sir John Hawkins in 1595, the captains of the various ships washed their vessels often as they travelled through the West Indies. Washing a ship involved "bringing all her guns to the one side of the ship, and causing the ship's company to hang upon the yards on that side also, that she may be made to heel over that way." Only about five or six inches of

---

[56]Elizabeth Story Donno, ed., *An Elizabethan in 1582: The Diary of Richard Madox, Fellow of All Souls*, Hak. Soc. Pub., 2nd ser. 147 (London, 1976), 208; John Davis, *The Voyages and Works of John Davis the Navigator*, ed., A.H. Markham, Hak. Soc. Pub., 1st ser. 59 (London, 1880), 26.

[57]Smith, *Sea Grammar*, 16; Butler, *Six Dialogues*, 132; Manwayring, *A Sea-mans Dictionary*, 74.

the hull according to Butler, or five or six strakes according to Manwayring, would be out of the water on the opposite side, but every little bit helped. The exposed hull was then scraped of its "filth and foulness" and the procedure was repeated for the other side.[58] All of these methods for maintaining the hull were necessary if the ship were to stay afloat.[59]

Regardless of the methods used, there was "no ship so tight, but that with her labouring in the Sea, (nay though she ride in Harbour) [she] will make some water."[60] How much and how fast depended on a number of things. Bilge-pumps, hollow wooden tubes outfitted with pistons and leather valves, stood by the main mast, ready to pump out excess water that had found its way into the hold. Routine pumping occurred as needed, depending on the age and condition of the ship. But sometimes a ship required pumping merely to stay afloat.

According to Manwayring, "we say a ship is Leake, when she makes more water then is ordinary, which is some hundred strokes in 24. or 48. howres."[61] The *Sunneshine*, a bark used as the vice-admiral in John Davis's third voyage to the

---

[58]Butler, *Six Dialogues*, 132; Manwayring, *A Sea-mans Dictionary*, 113.

[59]Butler, *Six Dialogues*, 104-105.

[60]Manwayring, *A Sea-mans Dictionary*, 60.

[61]Manwayring, *A Sea-mans Dictionary*, 60.

Northwest in 1587, sprang a leak which required "500 strokes at the pump in a watch [four hours]," and the *Elizabeth*, the admiral of the fleet, required 300 strokes after a mere month of sailing.[62]

The number of strokes required to keep the *Sea Venture* afloat in 1609 following a violent hurricane was not recorded, but the travails of the passengers and crew as they labored for three days and nights to keep their ship from sinking were documented by William Strachey and Silvester Jourdain in two separate accounts of that wreck. Passengers and crew alike manned the pumps continuously and bailed the ship with "buckets, baricos and kettles."[63] Others ventured below decks in an effort to find the leak and plug it up from within. They used everything available to stop the flow, even pieces of beef, but the source of the largest leak evaded them. Within sight of the Bermudas, however, the ship lodged between two rocks, and the 150 passengers and crew were forced to cease their labors and to go ashore.[64]

Had they been able to locate the leak, the men and women of the *Sea Venture* might have had a less harrowing trip, but they seem to have had neither the means nor the

---

[62]Hakluyt, *Principal Navigations*, 5: 310-12.

[63]Jourdain, *Discovery of the Barmudas*, 4.

[64]Purchas, *Pilgrimes*, 6-13; Jourdain, *Discovery of the Barmudas*, 4-5.

knowledge of later years. Butler's solution, which does not appear in Smith or Manwayring may be a later development. To find the source of a leak, wrote Butler, "is by the use of an empty earthen pot, the mouth whereof is to be placed upon some piece of a board within the hold of the ship whereunto any man laying his ear as close as possibly he can, if there be any inlet of water in any part of the hold, or near unto it, it will be audibly heard." The louder the sound was, the closer the leak. A trumpet could also be used in place of an earthen pot.

Once the crew found the leak, they could work to repair it. If the leak was high enough, it could be fixed by nailing a sheet of lead over it from within, or by heeling the ship over, the lead could be nailed directly onto the hull. If the leak was beneath the waterline, "the course is to stitch or sew up a course sail, or (which is better) some remnant of a small netting into the form of a bag with some long and well opened rope yarns put within it, and then, sinking this bag under the keel, to bring it up as near as may be directly against the place of the leak and there let it lie, that by the indraught of the water the oakum or rope yarn that is within the bag may be sucked into the hole or crack of the leak and so be stopped...."[65]
Hawkins's method would remain the standard until it was combined with copper sheathing in the early eighteenth

[65]Butler, *Six Dialogues*, 23.

century.[66]

Needs of defense and exploration caused English hull design and maintenance to move forward throughout the sixteenth century. The maneuverability and increased speed of Hawkins's "race-built" galleons would ensure that England dominated the Atlantic in the seventeenth century. The empirical method of shipbuilding of the Elizabethan period continued; John Smith complained in 1627 that if ships were "all built after one mould - as also their Masts, Yards, Cables, Cordage and Sailes - were all the stuffe of like goodnesse, a methodicall rule, as you see, might bee projected; but their lengths, bredths, depthe, rakes and burthens are so variable and different, that nothing but experiences can possibly teach it."[67] But the seeds for a more standardized method had been sown by Hawkins, Hariot, Baker, and Weymouth.

---

[66]Kemp, *Oxford Companion*, 777.

[67]Smith, *Sea Grammar*, 20.

Chapter Three

Sails, Masts and Rigging

Travel in the Atlantic before the late fifteenth century was limited. Sailors preferred coastal work in known waters to the uncertainty of the oceanic unknown. Even the early-fifteenth-century voyages of the Portuguese hugged the coastline of Africa. Advances in navigational equipment allowed mariners to break away from the coastline as the century progressed, but knowledge of the wind and how to harness it were necessary before ships could leave familiar waters with confidence.

Until the mid-fifteenth century, English ships were powered primarily by one large square sail attached to a single mast stepped amidships. Made of hemp, flax, or occasionally wool, these huge sails provided adequate motive power when the wind came from dead aft to abeam of the ship. However, they proved inadequate in any kind of headwind, thus limiting mobility in certain conditions. The use of the Norse bowline (introduced to the rest of Europe in the eleventh and twelfth centuries) allowed such ships to sail slightly closer to the wind by keeping the windward edges of the sails taut so that they would not collapse or shiver when brought close to the wind.[1]

As trade increased throughout the late medieval world, larger ships were more in demand and a larger ship required a larger sail. But such huge sails proved to be unwieldy, expensive, and a liability since mariners were forced to rely on the dubious strength of a single sail. Although the addition of detachable "bonnets" around 1350 allowed sailors to increase or decrease sail area to some extent at the foot of the sail, this did very little toward lowering costs or dependence on a fragile piece of fabric that delivered the ship's sole source of forward motion.[2] In addition to the bonnets, some English ships carried a topsail above the mainsail as early as the 1390s, much as ancient Greek and Roman ships had carried centuries before.[3] This effectively added sail area in a more manageable way. The first medieval topsails were likely rigged to the upper portion of the mainmast, below the masthead, or on a flagstaff set atop the mainmast. Separate topmasts with attendant shrouds and

---

[1]Roger C. Smith, *Vanguard of Empire: Ships of Exploration in the Age of Columbus* (New York: Oxford University Press, 1993), 114. See also Smith, *Sea Grammar*, 28.

[2]Bertil Sandahl, *Middle English Sea Terms, II. Masts, Spars, and Sails* (Upsala, Sweden: A.B. Lunequistka Bokhandeln, 1958), 20-24.

[3]Lionel Casson, *Ships and Seamanship in the Ancient World* (Baltimore: Johns Hopkins University Press, 1995), 241-42.

stays appeared no later than the 1450s however.[4]

English capture of several southern European vessels in the first half of the fifteenth century (mainly during the reign of Henry V) introduced the notion of multiple masts to English shipwrights. Mediterranean galleys often carried two lateen rigged masts. Southern European carracks (adapted from the northern European cog - a flat-hulled, wide cargo carrier with a single square sail) often carried a small mast stepped aft of the main. This mizzen mast, as it was called, supported a small lateen sail which allowed these vessels greater maneuverability in a wider variety of wind conditions and broke the monopoly of the single sail.[5] If one sail ripped or was in some other way disabled, there was another sail and another mast to rely on.[6] The lateen sail, so-called because of the belief that it was introduced into the Mediterranean or "Latin" area by the Arabs in the eighth or ninth century, is a triangular sail on a yard which points fore-and-aft.[7] With such a sail, a sailor can

---

[4]Sandahl, *Sea Terms, II*, 112, 114-15.

[5]Sandahl, *Sea Terms, II*, 76. Sandahl believes that the term "mizzen" comes from the Italian *mezzana* or "middle." However, Sandahl does not believe this denotes the placement of the mast, but rather the arrangement of the sail "medially," or in a fore-and-aft position.

[6]Ian Friel, *The Good Ship: Ships, Shipbuilding and Technology in England, 1200-1520* (Baltimore: The Johns Hopkins University Press, 1995), 158-62.

[7]Fore-and-aft rigs were not unknown in the Mediterranean prior to the Muslim advance. Sprit rigs were used as early as the second century B.C., and historian

point into the wind and make headway. With the lateen sail brought out of the Mediterranean and into the Atlantic, "the seaman was freed from the tyranny of the following wind."[8]

English shipwrights apparently took the notion of multiple masts a step further. According to an inventory of 1420, Henry V's royal vessel the *Grace Dieu* carried not only a mainmast and a mizzen but a third mast. While it is possible that this third mast was merely a spare and was carried unstepped somewhere on the ship -- there is no mention of a yard for this mast - it may have been stepped forward of the main to aid in steering the head of the vessel. But an actual foremast was not long in coming, for in 1432 the balinger *Petit Jesus* carried a mainmast, a mizzen mast, and a "ffokesail".[9] A fourth mast carrying a lateen sail was added by 1484. This small "bonaventure" mast, stepped aft of the mizzen, carried a smaller lateen sail and required an "outligger," or spar, projecting from the stern of the vessel to provide additional space for that sail's rigging. The origins of the name are somewhat

---

Lionel Casson has found pictorial evidence of the lateen in the Mediterranean as early as the second century A.D. The Mediterranean lateen might well have been an independent development. Casson, *Ships and Seamanship*, 243-45.

[8]David W. Waters, *The Art of Navigation in England in Elizabethan and Early Stuart Times* (New Haven: Yale University Press, 1958), 20-21.

[9]Friel, *The Good Ship*, 162; Sandahl, *Sea Terms II*, 38. "Et in vij. Remis longis pro predicta Balingera Regis ordinata vnacum vno velo vocato Mesansayll' et vno velo vocato ffokesayll' emptis de dicto Petro..."

obscure, but etymologist Bertil Sandahl believes that an English sailor or shipwright might have seen such a mast on an Italian vessel of that name (Buona Ventura, Bonaventura, etc.) and thus given the mast the name as well.[10]

Throughout the fifteenth century, English ships continued to grow vertically. By the end of the century, these ships also sported spritsails (also called watersails because of their habit of dipping into the water) at the bow to aid in steering, and by the first decade of the sixteenth century, there were topsails on all masts to counterbalance the spritsail. These topsails added more canvas without sacrificing manageability while also taking advantages of breezes aloft. Removable topmasts gave the rig more versatility as well. English ships of the 1490s were every bit as capable of crossing the Atlantic as the Iberian *naos* and *carabelas* used by Columbus in 1492[11].

Sixteenth and early seventeenth-century additions to English rigging were largely refinements rather than innovations. Mathematical formulae dictated the proper lengths of masts and spars so that a ship would be neither "Taunt-masted" (top heavy with mast and sails) nor "low

---

[10]Sandahl, *Sea Terms, II*, 18-19.

[11]Friel, *The Good Ship*, 160; Samuel Eliot Morison, ed., *Journals and Other Documents on the Life and Voyages of Christopher Columbus* (New York: The Heritage Press, 1963), 80.

masted."[12] These calculations in turn allowed the sailmaker to know what size sails a particular vessel might need. All of these measurements were ultimately derived from the keel length.[13]

The most important sixteenth-century innovation from the British Isles was that of the studdingsail, which was first mentioned in an anonymous Scottish work of 1549. *The Complaynt of Scotlande* gave an eyewitness account of a Scottish galleas (a vessel equipped with oars and sails) doing battle with another vessel. The observer recounted the cries of the sailors as they worked with the rigging, and observed that "for more speed the galleas put forth her studding sails."[14] John Smith explained that such sails were "bolts of Canvasse or any cloth that will hold wind, [which] wee extend alongst the side of the maine sail, and boomes it out with a boome or long pole."[15] Like the

---

[12]Smith, *Sea Grammar*, 18.

[13]Smith, *Sea Grammar*, 18-19; "But the Rule most used is to take the 4/5 parts of the bredth of the Ship and multiply that by three, [which] will give you so many foot as your maine Mast should bee in length...The fore Mast is to be in length 4/5 of the maine Mast...[etc] Now as you take the proportion of the Masts from the Beame or bredth of the Ship, so doe you the length of the yards from the Keele."

[14]James A. H. Murray, ed., *The Complaynt of Scotlande wyth ane Exortatione to the Thre Estaits to be vigilante in the Deffens of their Public Veil 1549* (London: The Early English Text Society, 1872), 42. "For mair speid the galliasse pat furtht hir stoytene salis."

[15]Smith, *Sea Grammar*, 39.

earlier bonnets, studdingsails allowed the mariner to add canvas without enlarging the main body of the sail.

With gradual increases in the amount of canvas that a ship could carry and decreased dependence on large, single sails, English vessels became more efficient, if not faster. The introduction of greater numbers of pulleys and winches allowed a smaller number of men to do the work. Although the English never decreased their crews to the extent that the Dutch did in the early seventeenth century, fewer men meant better living conditions on the small cramped vessels that made up the majority of the English fleet.[16]

---

[16]Richard W. Unger, *Dutch Shipbuilding Before 1800* (Amsterdam: Van Gorcum & Company, 1978), 37. The average size of English ships around 1600 was 100 tuns.

Chapter Four

Advances in Navigation

Like shipbuilding, the art of navigation and oceanic pilotage was relatively static in medieval England, only advancing as the rest of Europe advanced. But by the 1550s, interest in the study of mathematical navigation grew in England, largely fostered by the mathematician John Dee. Dee, one of the founding fellows of Trinity College at Oxford, cultivated a number of learned friends throughout the continent. He collected geographical information from Gemma Frisius, the German globe maker whose creations featured a northwesterly passage from the Atlantic to the Orient, and also drew map projections based on the works of his friend Gerard Mercator. Dee's knowledge greatly excited men such as Hugh Willoughby and Richard Chancellor who sailed for the newly founded Muscovy Company in 1553.[1] Originally called "The Merchants Adventurers of England for the Discovery of Lands, Territories, Isles, Dominions and Seignories Unknown," this joint-stock company called on Dee for advice -- should they go to the northwest or northeast? Dee recommended the northeast, partly because the northeastern passage seemed feasible, partly for economic

[1]E.G.R. Taylor, *The Haven-Finding Art* (London: Hollis and Carter, 1956), 199.

reasons. Muscovy was a cold place and could greatly benefit from English wool.[2] These northeastern voyages to Muscovy as well as southern voyages to Morocco and West Africa by Thomas Wyndham made clear the need for advanced navigational skills.

David Waters defines the two forms of navigation practiced by English sailors during the reign of Elizabeth as the empirical method of pilotage, which made use of "the observation of terrestrial objects," and the mathematical method of celestial navigation.[3] In simpler terms, the pilot looked down while the navigator looked up. It was during the reign of Elizabeth that the English sailor began turning his gaze upward in earnest.

In 1563, Stephen Borough laid before Queen Elizabeth a plea for his appointment as Chief Pilot of England, a new position, based on the comparable one in Spain that was previously held by Sebastian Cabot, lured back to England in the 1540s. In the two papers that he submitted to the crown, he pointed to the need for well-trained mariners, in particular pilots and navigators, on board English ships.[4] While Elizabeth made no such appointment in 1563, interest

---

[2]Samuel Eliot Morison, *The European Discovery of America: The Northern Voyages A.D. 500 - 1600* (New York: Oxford University Press, 1971), 482-84.

[3]David W. Waters, *The Art of Navigation in England in Elizabethan and Early Stuart Times* (New Haven: Yale University Press, 1958), 5.

[4]Taylor, *Haven-Finding Art*, 199.

in advanced navigational practices grew, as shown by the printing of various works of cosmography and navigation.

William Bourne, an inn-keeper and port-reeve of Gravesend, published *An Almanack and Prognostication for iii Yeres with Serten Rules of Navigation* in 1567 and expanded it in 1574 under the title, *A Regiment for the Sea*. These manuals rendered into plain English the essentials of navigation found in Richard Eden's less readable translation of Martin Cortés's *Arte de Navegar*. However, Bourne admitted that the first qualification of a successful ship's master was that he must first be a good coaster, that is, a pilot. Only if he went into open waters would he have need of the knowledge of the navigational instruments that Bourne explained in his book.

Pilotage, therefore, was the most important of an Elizabethan mariner's skills. At the mariners disposal were several tools that would help him feel his way along a coastline or across an ocean. Like the sounding line, many dated back to ancient times. Its use is referred to in the works of Homer as well as the Bible. A good pilot would carry several sounding lines with him in the event of a mishap, such as happened on Martin Frobisher's first voyage to the northwest in 1576. "In halling up the lead the line brake, and so we lost our lead," wrote the master of the *Gabriel*, but it is obvious that he had spares, for he "sownded again" the next day.[5] The compass had likewise been used for hundreds of years and by 1218 was considered "most necessary for such as sail the sea."[6] But other items, such as the log-and-line and the traverse board, did not gain widespread use until the last half of the sixteenth century.

William Bourne's *Regiment* was the first work to mention the log-and-line, or chip log. This device consisted of a board attached to a "line of a great length, which they make fast at one ende, and at the other ende, and middle, they have a piece of lyne which they make fast with a small thred to stande lyke unto a crowfoote." Tossing this off the taffrail of the vessel, the sailors measured time with "either a minute of an hour glass, or else a knowne parte of an houre by some number of woordes, or such other lyke." When the sand in the glass ran out, "or the number of wordes [was] spoken," the sailors hauled in the log "and looke[d] how many fathomes the shippe hath gone in that time."[7] The introduction of such a device, which occasionally had knots tied along the line to better count the fathoms, made calculating the ship's speed, or "way," an easier and more precise task.

---

[5]David Beers Quinn, ed., *New American World: A Documentary History of North America to 1612*, 5 vols. (New York: Hector Bye and Arno Press, 1979), 4: 203.

[6]Waters, *Art of Navigation*, 23.

[7]Quoted in Taylor, *Haven-Finding Art*, 201.

In order to keep track of the speed as well as the compass course, the traverse board gained use during the latter part of the century. Bourne is also the first to mention "the board," although it had probably been in use before that time. Primarily designed to allow illiterate sailors to communicate complex information to the ship's pilot, the traverse board consisted of a depiction of a compass rose, with eight lines of holes drilled along each of the thirty-two compass points to indicate course, and eight horizontal lines of holes drilled at the foot of the board for indicating speed (probably not routinely found on traverse boards until around 1600).[8] Every half hour during a helmsman's four-hour watch, the helmsman checked his compass course and indicated this course by plugging a peg into the corresponding compass point on the board. In this way he and the pilot could keep track of the traverses, or tacks upon which the ship had sailed. Wrote Morison, "All ships of this era wanted the wind to be on the quarter, or dead aft, to make best speed and least leeway. If the wind came 'scant' i.e. dead ahead or less than four or five compass points from their course, they were forced, if the sea were very rough to lay to: or, in a moderate sea, to beat to windward, which they called 'traversing.' This meant zig-zagging with the wind first on one side and then

---

[8]Waters, *Art of Navigation*, 37.

on the other."[9] Since sailors were unable at that time to calculate longitude, it therefore became necessary to keep an accurate accounting of every movement of the ship. Information of the ship's traverses, together with an accounting of the speed (indicated also with pegs in the rows of holes at the foot of the board) allowed the pilot to chart the ship's course without benefit of knowing latitude or longitude. Unfortunately, the mathematics involved were often beyond the average pilot, and it was not until the latter part of the seventeenth century that pilots were able to use the information on the traverse board with a consistent degree of accuracy.[10]

Taken collectively, the calculations made by the Elizabethan ship's pilot formed the basis of a system of navigation known as dead reckoning. According to David Quinn, "The art of dead reckoning was developed by plotting direction run and distance traveled on a blank chart with dividers, later aided by parallel rulers, and so making up a picture of the course made good."[11] Added to this were the more ancient skills of the pilot. These included careful observation of landmarks and weather patterns, an accounting of the composition of the ocean floor (obtained whenever the

---

[9]Morison, *European Discovery: Northern Voyages*, 136.

[10]Waters *Art of Navigation*, 138.

[11]David Beers Quinn, *North America from Earliest Discovery to First Settlements: The Norse Voyages to 1612* (New York: Harper and Row, 1977), 77.

pilot cast the sounding line), the identification and observation of pelagic and non-pelagic birds, deep and shallow-water fish, seaweed, and debris. It is no wonder that sailors, ever the practical sort, referred to this mode of sailing as "By guess and by God."[12]

While the pilot busied himself with empirical observations and earth-based phenomena, the navigator turned his sights to the celestial realm with the aid of recently developed navigational tools. Instruments such as the quadrant and the astrolabe had been available to English mariners since the beginning of the sixteenth century. By means of these instruments, the well-trained navigator could determine his latitude to within a half of a degree, given the right conditions, by observing the altitudes of the sun or the north star.[13] Unfortunately, the right conditions rarely presented themselves. The quadrant's dangling plumb-bob limited shipboard sightings to the calmest of days, and even the heavy astrolabe required calmer seas than were generally found in the Atlantic for an accurate reading. In fact, Waters concluded that "astrolabes . . . were too inexact for stellar sights at sea," as were quadrants.[14] Nonetheless, they found their way onto many English ships in

---

[12]Peter Kemp, *The Oxford Companion to Ships and the Sea* (London: Oxford University Press, 1976), 123-24.

[13]Quinn, *North America*, 79.

[14]Waters, *Art of Navigation*, 228.

the sixteenth century. Martin Frobisher took with him on his first northwest voyage not only a mariner's astrolabe but a planispheric one for use on land.[15]

The wooden crosstaff, or *balestila* introduced to England by John Dee in the 1550s, developed from the Arabic *kamal* and provided the mariner with a more stable instrument. This instrument consisted of a long staff marked by degrees from zero to ninety on which a sliding transom was placed. By placing the staff on his cheekbone beneath his eye, the navigator could then line up the horizon with the bottom of the transom and the celestial object with the top to determine the altitude of that object by reading the degree marking from the staff. But the crosstaff could not be used in high latitudes for north star sightings, nor in low latitudes for sun sightings because of the limited viewing range of the human eye. Even in acceptable latitudes, the human eye would still have difficulty focusing upon two widely-spaced objects, in this case the star and the horizon, not to mention problems with parallax created by the necessity of placing the crosstaff upon the cheekbone beneath one eye while sighting the objects with the other eye. Furthermore, since the crosstaff required the use of the horizon in conjunction with the star's position, "the opportunities for taking star sights were limited, as they are today, to the twilight

---

[15] Quinn, *New American World*, 197.

hours of dawn and dusk. Only then are the stars and the horizon both clearly discernible."[16] The crosstaff was also painful to use, for unlike the quadrant and astrolabe, which could be used in sun sightings without looking directly at the sun by the use of shadows, the crosstaff required its user to line the top part of its transom-piece with the center of the sun. This could only be done by looking directly at the sun. By Bourne's time, however, the clever navigator either added a piece of smoked glass to his transom pieces, or covered "the sun with the end of the transversary and deducting 15' - the sun's semi-diameter - from the observed altitude," according to Bourne.[17] Despite its drawbacks, the crosstaff was the most accurate of the three instruments.

In 1581 on the Continent the crosstaff acquired three transom pieces of varying sizes and four different scales instead of a single transom and scale. This allowed the scales to be made much larger and made the observations more accurate. However, the problems inherent in the older, single-transom crosstaff were still present. It was not until 1595 that an instrument was invented that overcame these difficulties. In that year John Davis's *The Seamans Secrets* introduced his own adaptation of the crosstaff, which "eliminated the possibility of parallax and the

---

[16]Waters, *Art of Navigation*, 228.

[17]Waters, *Art of Navigation*, 135.

handicap of glare in sun sights and the supreme difficulty of sighting simultaneously two widely separated objects, such as the sun and the horizon, by devising a back-staff of great simplicity."[18] The observer stood with his back to the sun rather than facing it, and used shadows cast by a fixed vane lined up with a slitted horizon vane to determine the sun's altitude. In this manner, the navigator had only to look at the horizon through the slitted vane, rather than at both the horizon and the sun.[19]

Innovations in the length of scale, made by Davis shortly after the introduction of his back-staff, allowed the navigator to take sun sightings even in equatorial waters, whereas he had previously been limited to the use of the unstable astrolabe or quadrant for sun sightings in those regions. Thus with the introduction of Davis's back-staff, English navigation, heretofore an inexact and mysterious art, became a science easily within reach of the average ship's officer.

William Bourne wrote in 1571, "Of all sciences that is used with us in England, Navigation is one of the principall and most necessary for the benefite of our Realme and native country and also most defencible against our enemies, because we lie environed rounde aboute with the

---

[18]Waters, *Art of Navigation*, 205.

[19]Waters, *Art of Navigation*, 205-206.

sea."[20] In the last quarter of the sixteenth century, the mariners of England had seemingly awakened from a long sleep and began to take their place alongside the other maritime powers in Europe, not as apprentices but as equals. Advances in and the interplay between pilotage and celestial observation, those two branches of navigation called *la navigation cōmune* and *la navigation grande* by the Flemish teacher Michiel Coignet in 1581, thus allowed the English mariner during the reign of Elizabeth I confidently to break away from his coastline and sail into open water.

[20]Quoted in Waters, *Art of Navigation*, 127.

Chapter Five

Shipboard Conditions

The crossing from England to North or South America or to the many Atlantic islands was a common bond between those who arrived in the New World. Whether sailor or passenger, male or female, adult or child, every person who came to the New World shared a common experience -- the experience of life within the wooden walls of a sailing vessel.

There were also common problems which affected not only the integrity of the vessel but the lives of those on board. As the English began to venture across the Atlantic regularly during the reign of Queen Elizabeth, they began to identify these problems and in most cases attempted to solve them. But many problems were not easily solved without a great deal of trial and error and empirical observation.

Narratives, ship's logs, and diaries provide a wealth of information about shipboard life during the sixteenth and early seventeenth centuries. But to see the change (or continuity) in a particular area, one must look beyond these accounts to the popular works of men such as John Smith, Henry Manwayring, and Nathaniel Butler, whose dictionaries and dialogues concerning seafaring life were published throughout the seventeenth century. Manwayring's *The*

Seaman's Dictionary: or, an Exposition and Demonstration of all the Parts and Things belonging to a Shippe, etc. was available in manuscript form sometime between 1620 and 1623 but was not published until 1644. John Smith's *A Sea Grammar* appeared in the bookstalls of London in 1627, following the publication of a similar, less detailed work by Smith the previous year. Nathaniel Butler's *Six Dialogues about Sea Services* existed as a well-circulated manuscript as early as 1634, but was not published until 1685. That Smith borrowed heavily from Manwayring, and Butler from both, is evident from the nearly word-for-word duplication of many entries. Yet there is enough new material in both Smith and Butler to be useful for this study.[1]

When each man, woman, or child climbed aboard the small, square-rigged sailing vessels that would bear them into and across the Atlantic, they entered into a community where each person's life might depend upon another's actions. This "ocean adventure left an indelible mark that irrevocably offset their experience from that of landsmen

---

[1]John Smith, *A Sea Grammar*, ed. Kermit Goell (London: Michael Joseph, 1970), 16; Henry Manwayring, *A Sea-mans Dictionary: or, an Exposition and Demonstration of all the Parts and Things Belonging to a Shippe* (London: John Booker, 1644), 92-93; Nathaniel Butler, *Six Dialogues About Sea Services*, ed. W.G. Perrin, The Navy Records Society, vol. 65 (London, 1929), 105.

who stayed at home."[2] Within the confines of wooden walls, each problem and each action taken to counter it took on a greater significance to all on board, since inaction or inappropriate action could mean a watery death for the citizens of this floating community.

Not all of these inhabitants were human. Animals were often brought as breeding stock for colonial ventures. The *Blessing*, bound for Jamestown in 1609 carried "sixe Mares and two Horses" for use in the Virginia colony. Larger animals such as horses and cattle were kept closely confined in the cargo decks so that they might not harm themselves or create hazards for others. Smaller livestock lived in cages and sometimes even had free run of the ship. But more commonly, there were animals whose destiny it was to grace the sailor's table. The difficulties in preserving food for long crossings made temporary transportation of live animals for fresh meat an inviting prospect. On a voyage to Brazil in 1580, ship's purser Thomas Grigs wrote that "we tooke into our ship a beefe alive, which served for the victualling of the ship, and the refreshing of our men, and to make us the merrier at Shrovetide."[3] Large tortoises, which did not need much upkeep or space, could easily keep a

---

[2]David Cressy, *Coming Over: Migration and Communication between England and New England in the Seventeenth Century* (New York: Cambridge University Press, 1989), 145.

[3]Hakluyt, *Principal Navigations*, 8: 22.

ship in fresh meat.[4] Likewise, the *Edward Bonaventure* in its aborted voyage to China in 1582 was home to "40. hens, ducks, turkies, and parrats" for a time.[5]

Pets were not uncommon on English vessels of this period. Parrots and monkeys proved to be popular souvenirs among sailors and passengers who travelled in the tropics[6]. For those whose voyages took them into colder regions, however, wild foxes and dogs became the pets of choice.[7] Hunting dogs such as spaniels and greyhounds as well as the fierce battle mastiffs could also be found aboard many vessels.[8] Richard Madox enjoyed the antics of a trick dog which his compatriots took from a Spanish prize in 1582. The dog danced, sang from a score, and even mimicked plowing for the delighted crew.[9]

While many of these creatures came aboard as pets, not every parrot ended up gracing an English sailor's shoulder, nor did every monkey make it back to England to delight

---

[4]Hakluyt, *Principal Navigations*, 7: 163.

[5]Hakluyt, *Principal Navigations*, 8: 130.

[6]Hakluyt, *Principal Navigations*, 8: 130; See also Hakluyt, *Principal Navigations*, 6: 345 and Hakluyt, *Principal Navigations*, 7: 61.

[7]Donald S. Johnson, *Charting the Sea of Darkness: The Four Voyages of Henry Hudson* (Camden: International Marine, 1993), 62.

[8]Johnson, *Charting the Sea of Darkness*, 57.

[9]Elizabeth Story Donno, ed., *An Elizabethan in 1582: The Diary of Richard Madox, Fellow of All Souls*, Hak. Soc. Pub., 2d ser. 147 (London, 1976), 112.

young ladies with its antics. Any animal found on a ship could become a meal if times were desperate enough. "Rats, cats, mice and dogs" fed John Hawkins's beleaguered crew of the *Jesus of Lübeck* following the attack by the Spanish at San Juan de Ulua in 1568. In fact, "parrats and monkeyes that were had in great price, were thought there very profitable if they served the turn of one dinner," wrote one crew member.[10]

Although rats might have proved a welcome repast in times of want, they were usually not wanted at all. But the damp and close environment of the hold provided a ready home for the black rat (*Rattus rattus rattus*) which creeped aboard ships in port by crossing the mooring lines or hitched a ride in the cargo as it was loaded. With their own private stock of food appropriated from the huge casks stored below decks, a pair of rats could easily multiply to a dozen in just one month's time if no preventive measures were taken.[11] Dogs seem to have served this purpose, based on skeletal remains found on the *Mary Rose*, but the best prevention available was the cat, and ships often carried several.[12] Henry Hudson had a cat with him and Richard Hawkins carried several. Unfortunately, as was the case

---

[10]Hakluyt, *Principal Navigations*, 7: 61.

[11]Robert Hendrickson, *More Cunning Than Man: A Social History of Rats and Men* (New York: Stein and Day, 1983), 72-78.

[12]Rule, *The Mary Rose*, 186.

with Hawkins, the cats were often unable to control the rat population. "Though we had diverse catts and used other preventions," related Hawkins, "in a small time [the rats] multiplied in such a manner as is incredible." The rats were known to "consume of the best victuals, they eate the sayles; and neither packe nor chest is free from their surprises." Hawkins also tried poisoning the rats, but they proved to be too fruitful for his efforts to make a difference.[13]

While rats could easily destroy a ship's food supply on their own, there were other forces working at the same task. Worms, mold, poor preparation, heat, and time all took their toll on the precious supplies of food and drink packed aboard these ships. Ferdinand Columbus did not exaggerate when he wrote of his father's fourth voyage in 1504 that "what with the heat and the dampness even the biscuit was so full of worms that, God help me, I saw many wait until nightfall to eat the porridge made of it so as not to see the worms; others were so used to eating them that they did not bother to pick them out, for they might lose their

---

[13]Johnson, *Charting the Sea of Darkness*, 111.; C.R. Markham, *Hawkins*, 217-18.; Rats swimming from wrecked vessels off the coast of Bermuda (as well as riding ashore in cargo from 1609 onward) were to blame for the rat invasion of that island soon after -- where there had been none before. Unfortunately, the *Sea Venture's* cat had gone down with the ship. Eventually cats had to be imported from England to help combat the problem.

supper by being so fastidious."[14] Conditions had not changed significantly by the time of Hawkins, Drake, or Davis, for biscuits were still alive with maggots.

In fact, the victualling of a ship was one area in which there were few improvements made during the sixteenth and seventeenth centuries, and in some cases the standards even slipped backward. When Richard Madox sailed across the Atlantic to Brazil in 1582, there were grumblings on board about the quality of goods provided by the merchant Richard Grafton, who "had profited much in the obtaining of provisions" at the expense of crew and passengers, who, "destitute of the necessary food and drink . . . would have almost perished to a man" had there not been ample time spent ashore, both in Africa and Brazil. The beef proved inedible "for no other reason...except that it was at first badly salted," and the crew feared "lest he had doen much hurt in our provision for he had bowght green billet, which sweating and working in the close hold did heat al the hold wonderfullye," thus speeding the decay of other supplies.[15]

Things were no better by 1634. The captain in Butler's dialogue complained "that there had been found very ill dealing; and that not only in the provisions of flesh...but in the rottenness of the cheese, in the frowsiness and foul

---

[14]*The Life of the Admiral Christopher Columbus by His Son Ferdinand*, trans. Benjamin Keen (New Brunswick: Rutgers University Press, 1959), 247.

[15]Donno, *An Elizabethan in 1582*, 137-38, 188, 242.

condition of the butter, and in the badness of the salted fish..."[16]

Water and other liquids likewise proved problematic. Even in the best of conditions, water could remain potable only for a few weeks, and conditions were rarely ideal. Water, as well as other victuals, needed to be stored in well-seasoned casks in order to remain fresh for as long as possible.[17] Most important, however, water needed to be readily available for resupply, and if a ship was blown off course or at the mercy of contrary winds, even the best of barrels could afford passengers and crew little help if the casks were empty.

Returning from their voyage to the Azores in 1589, George, Earl of Cumberland, and his men were unable to raise the coasts of either Ireland or England because of contrary winds. Reduced from quarter-rations of water to "three or four spoones full of vinegar to drinke at a meale" the crew despaired. "When there fell any haile or raine," wrote the chronicler, Edward Wright, "the haile-stones wee gathered up, and did eate them more pleasantly then if they had bene the sweetest Comfits in the worlde...." When it rained, the men hung out sheets to catch the water and sucked the water from wet clothes. But the situation soon so grew desperate

---

[16]Butler, *Six Dialogues*, 57.

[17]Garrett Mattingly, *The Armada* (Boston: Houghton Mifflin Company, 1959), 121.

that the men began drinking the dirty run-off from the deck, which they mixed with sugar, and licking "the boards under feete, the sides, railes, and Masts of the shippe" as it rained. Some even put "bullets of lead into their mouthes to slake their thirst."[18] The crew of the *Galleon Leicester*, in less dire straits, also caught water from a "sodayn gust of rayn," but after four days the water stank. John Hawkins didn't help matters by commenting to the crew that he had "kept some sweet 3 moneths," to which Richard Madox wryly commented in his diary, "there was little to believe."[19]

By 1593, the English (or at least Richard Hawkins) had the capability of distilling salt water for drinking, but it was not widely practiced. Even by 1634 distillation was still in the experimental stages at sea, but Butler's captain hoped that it would "prove perfect and accomplished; and so enlarged as may serve of very great use, in cases of extremity" and wished "that all ships that are designed abroad to long voyages over large seas should be furnished with utensils proper to this purpose."[20]

Just as fresh water was important to crew and passengers, so was fresh food. Judging from narratives and ship's logs, it was obtained frequently. Fish and porpoises

---

[18]Hakluyt, *Principal Navigations*, 4: 373-74.

[19]Donno, *An Elizabethan in 1582*, 149.

[20]Butler, *Six Dialogues*, 59-60.

were the most abundant source of fresh food while at sea, although birds, seaweed, and even barnacles provided a break from the monotonous rounds of loblolly (seasoned oatmeal), salted meat, and biscuit. Richard Madox dined on dolphin, mullet, flying fish, porpoise, an albatross, and barnacles scraped from the ship's hull, which he said tasted like crayfish.[21] John Davis likewise dined on porpoise during his first Northwest voyage in 1586, but his repast was much more interesting when he accompanied Thomas Cavendish to the straits of Magellan in 1591.[22]

Unable to sail through the straits, Davis's ship the *Dainty* was forced to turn back twice. After the first attempt, his men lived off "muskles, water and weeds of the sea, with a small reliefe of the ships store in meale sometimes" until they could resupply for a second attempt. Sailing up the coast of South America, they found an island of penguins, and left there for Brazil with 14,000 birds, which they salted and dried before making a second attempt at the straits. That attempt proved no better, and the *Dainty* turned northward towards home. Unfortunately they did not have access to information gathered by John Chidley and Paul Wheele who had attempted the straits the year before. They, too, had gathered penguins and found that

---

[21]Donno, *An Elizabethan in 1582*, 147, 152, 157, 158, 165.

[22]Hakluyt, *Principal Navigations*, 8: 282.

they "must be eaten with speed: for wee found them to be of no long continuance...."[23] Davis's crew was to find this out first hand, for "after we came neere unto the sun," wrote the chronicler, John Jane, "our dried Penguins began to corrupt, and there bred in the[m] a most lothsome and ugly worm of an inch long. This worme did so mightily increase and devoure our victuals, that there was in reason no hope how we should avoide famine, but be devoured of these wicked creatures...." These maggots were voracious, and "there was nothing that they did not devoure, only yron excepted: our clothes, boots, shooes, hats, shirts, stockings and, for the ship, they did so eat the timbers as that we greatly feared they would undoe us by gnawing through the ships side."[24]

Davis's men were also plagued by strange swellings which began in their ankles and spread rapidly to their chests, making it hard to breathe. Then the disease "fell into their cods: and their cods and yardes did swell most grievously and most dreadfully to behold, so that they could neither stand, lie nor goe." All but sixteen men died, and of those only five were able to stand and work what was left of the sails and so bring the *Dainty* home.[25]

Davis's experience in 1591 was extreme, but extremities

---

[23]Hakluyt, *Principal Navigations*, 8: 283.

[24]Davis, *Voyages and Works*, 122, 126-27.

[25]Davis, *Voyages and Works*, 126-27.

were part of seafaring life. Either all went well or all went to hell. Francis Drake's West Indian expedition of 1585 was struck with the plague and hundreds died, trapped together in their floating coffins. Drake himself died of a shipboard "fluxe" in 1595, following fellow captains John Hawkins and Master Yorke, who had both succumbed to illness in the preceding weeks.[26] Diseases listed as fever, fluxes, plagues, and calentures all took their toll on many of those who crossed the Atlantic in the late sixteenth century.

But conditions were not always so dire. Robert Fotherby bragged in October 1614 that when William Baffin's ship arrived in Wapping after a Northwest voyage of six months, on board was "the whole number of men she carried forth (my selfe excepted, that was come before), being sixe and twentie, all in perfect health."[27] Likewise, all passengers and crew bound for Jamestown in 1607 arrived alive, with the exception of one man whose "fat melted within him" while hunting wild boar in the Caribbean islands.[28] There were, in fact, many voyages in which "nothing happened unto us."[29]

---

[26]Hakluyt, *Principal Navigations*, 7: 186, 190, 194.

[27]Clements R. Markham, ed., *The Voyages of William Baffin 1612-1622*, Hak. Soc. Pub., 1st ser. 63 (London, 1881), 102.

[28]Lyon Gardiner Tyler, ed., *Narratives of Early Virginia 1606-1625*, Original Narratives of Early American History (New York: Charles Scribner's Sons, 1907), 8.

[29]Hakluyt, *Principal Navigations*, 7: 174.

The outcome of each voyage depended greatly on the cleanliness of the ship. As early as 1553, it was recognized that poor ship hygiene might be responsible for the poor health of passengers and crew. In his "Ordinances, instructions and advertisements of and for the direction of the intended voyage for Cathay" of 1553, Sebastian Cabot ordered that there should be no liquor "spilt on the balast, nor filthines to be left within boord" and that the cook room, and all other places should be kept clean "for the better health of the companie."[30] Of course, it was difficult to keep ships clean when they held over a hundred people and often live animals as well. Nearly eighty years later, the captain of the *Arbella* in 1630 complained to John Winthrop that "our landmen were very nasty and slovenly, and that the gun deck where they lodged was so beastly and noisome with their victuals and beastliness as would much endanger the health of the ship."[31]

Preventive measures such as rummaging, which involved removing soiled ballast and replacing it with fresh, and designating a ship's liar every Monday, whose punishment it was to clean the beakhead and the chainplates -- those parts of the ship used for a toilet, may have alleviated some

---

[30]Hakluyt, *Principal Navigations*, 1: 235.

[31]Quoted in Cressy, *Coming Over*, 163.

problems.[32] Butler's suggestion of washing the ship every day with vinegar and fumigating the tween-deck area with burning tar echoed Hawkins, but his notion of allowing the passengers on deck into the fresh air at all times during fair weather was radical.[33] Unfortunately, the small size of many ships plying the Atlantic did not allow for the passenger free access to the weather deck. Since the nature of disease was improperly understood throughout the sixteenth and seventeenth centuries, very little else could be done.

One disease common to the seafarer (as well as to the landsman, though it is less celebrated in literature) was understood properly enough, and although its coming could not always be prevented, it could easily be cured. The disease was scurvy, and its symptoms were well known to the seasoned sailor. "The signes to know this disease in the beginning are divers," wrote Richard Hawkins. "It bringeth with it a great desire to drinke, and causeth a generall swelling of all parts of the body, especially the legs and gums, and many times the teeth fall out of the jawes without paine." It could also be identified "by denting of the flesh of the leggs with a mans finger, the pit remayning

---

[32]Smith, *Sea Grammar*, 44-45; Donno, *An Elizabethan in 1582*, 136; Manwayring, *A Sea-mans Dictioanary*, 87; Butler, *Six Dialogues*, 229-30.

[33]Butler, *Six Dialogues*, 62; C.R. Markham, *Hawkins*, 142.

without filling up in a good space. Others show it in their lasinesse: others complaine of the cricke of the backe, etc., all which are, for the most part, certaine tokens of infection."[34] Hawkins claimed that scurvy could be caused by an unclean ship and recommended a vinegar wash to remedy the situation. But he also recognized that scurvy came from an improper diet and that the addition of "sower orranges and lemons" to the diet along with other fresh foods "gave health to those that used it."[35] By the first quarter of the seventeenth century, John Smith suggested that every ship's commander should carry with him "the juyce of Limons for the scurvy."[36] Butler echoed this advice later and included oranges and limes as well in his list of necessities.[37] While Captain Cook may have gotten credit for curing scurvy at sea in the eighteenth century, Elizabethan and Jacobean sailors were on the right track.

While scurvy was a common shipboard ailment, seasickness was the universal leveller. The pitching and tossing of the round-bottomed vessels sent many captains, sailors, and passengers running for the lee side of the ship. Then, as now, there was no completely effective cure. Richard Madox, who suffered much from seasickness in 1582,

---

[34]C.R. Markham, *Hawkins*, 138.

[35]C.R. Markham, *Hawkins*, 140-41.

[36]Smith, *Sea Grammar*, 96.

[37]Donno, *An Elizabethan in 1582*, 66.

had the experience of the sailors around him to draw from as he searched for relief. "I was tawght many medcynes to avoyd the sycknes of the sea as namely a safron paper on the stomak or to drink the juse of wormwod," he wrote. He also experimented with a broth, cooked in an earthen pipkin, consisting of "violet flowrs, borage flowrs, rosemary flowrs...caphers...and rosemary and tyme." But the only thing that seemed to work was "to keep very warme, to be sure of hote supping often, to use moderate motion and to bear yt with a good corage til by acqueyntance you become familiar with the heaving and setting of the ship and be able to brooke the seas...."[38] No better advice exists even today.

Change in shipboard life was slow in the sixteenth and seventeenth centuries. Problems common to the early years still plagued ships, sailors and passengers in later years. But there **was** progress. Conditions on board gradually improved and new methods of shipboard survival, often invented under extreme circumstances, were used along with the old. Pursers took greater care in lading victuals, captains turned a conscientious eye toward the quality of air in their holds, and the traditions of the sea guaranteed that at least the chainplates and beakhead would remain clean throughout the week.

---

[38]Donno, *An Elizabethan in 1582*, 110, 143.

Conclusion

Between 1560 and 1686, England's merchant shipping increased from 50,000 tons to 340,000 tons.[1] Ships increased in both number and size, thanks to a growing sophistication in shipwrightry techniques. England's greatest maritime competitors during this period, the Iberians and the Dutch, fell behind the English in terms of safety and multi-purpose use. The English race-built ships with their lower centers of gravity proved swifter and safer than the Spanish ships that challenged the English in 1588, and English ships continued to surpass Spanish ships in the seventeenth century. The Dutch, whose ships were marvels of specialization, were unable to prevail at sea against multi-purpose English ships during three wars with England between 1652 and 1674, leaving England unmatched at sea.[2] Why was England, a nation that had been so inferior in maritime affairs up to the beginning of the sixteenth century, suddenly the most sophisticated and successful maritime power in the Western world?

---

[1]Christopher Lloyd, *The British Seaman, 1200-1860: A Social Survey* (Rutherford, N.J.: Fairleigh Dickinson University Press, 1970), 34.

[2]Lloyd, *The British Seaman*, 69; Richard W. Unger, *Dutch Shipbuilding Before 1800* (Amsterdam: Van Gorcum & Company, 1978), 112-13.

The religious and political upheavals of the sixteenth century led to an increase in maritime activity in England. Henry VIII's break with the Catholic Church placed England in the unenviable position of championing the Protestant cause against the impressive continental powers of both France and Spain. Rumblings about a Spanish invasion fleet were heard far in advance of the year 1588, and French piratical raids on the southern English coast had occurred since earliest memory. It became increasingly obvious that England's best defense was a strong maritime presence.

Although England's naval fleet was on occasion quite impressive, her greatest advantage lay in her merchant fleet. Unlike the Dutch, who built highly specialized vessels that could not easily switch from one task to another, English shipwrights tended toward the generic, building vessels that could bear armaments as easily as they could carry cargo.[3] The crown was very much the driving force behind this development, paying bounties to shipbuilders who agreed to construct merchant ships that could be called into military duty as needed.[4] Government subsidies thus increased the number of vessels placed into production in the late sixteenth and early seventeenth

---

[3]Unger, *Dutch Shipbuilding*, 25.

[4]Brian Dietz, "The Royal Bounty and English Shipping in the Sixteenth and Seventeenth Centuries," *Mariner's Mirror* 77 (February 1991): 5. The *Susan Constant*, which brought over several colonists to Virginia in 1607, was one of these bounty ships.

centuries.

The crown was also very much the moving force behind the privateering that arose as hostilities with Spain ensued in the last quarter of the sixteenth century. Letters of marque issued by the crown for privateering expeditions against the Spanish paid £47 on every £1 invested.[5] It was a lucrative business in times of war and far more attractive to sailors who earned an average of 10 shillings a month in the merchant service.[6] The rewards of privateering during the Spanish wars, and later the Dutch wars brought many more ships into service.

Above all, English sailors' and shipwrights' empirical observations did the most to realize England's maritime potential during the sixteenth and seventeenth centuries. By the late sixteenth century, English mariners were "assured to have commodity of the current[s]" which they had encountered in their travels, based on years of observation.[7] Knowledge of the winds, waters, and currents of the Atlantic, and later all the seas of the world, allowed the English not only to travel appropriate routes for the different seasons, but also to design their vessels

---

[5]Lloyd, *The British Seaman*, 36. See also Kenneth R. Andrews, *Elizabethan Privateering: English Privateering During the Spanish War, 1585-1603* (Cambridge: Cambridge University Press, 1985).

[6]Lloyd, *The British Seaman*, 48.

[7]Hakluyt, *Principal Navigations*, 6: 7.

to withstand the rigors of the seas.[8] Improvements in pilotage and navigational technique insured that those routes could be sailed repeatedly without fear of becoming lost. English innovations such as the backstaff allowed mariners to more accurately pinpoint their latitudes, and the introduction of the traverse board gave pilots a rudimentary way to figure longitude (in an era without accurate chronometers) without any extensive knowledge of astronomy. Experimentation with building and maintenance techniques increased the lifespan as well as the effectiveness of English vessels as experimentation with shipboard diet and hygiene increased the lifespan and effectiveness of the crews and passengers within. The capture and occasional purchase of foreign vessels also brought new construction techniques and ideas to English shipwrights who borrowed, modified and created technologies that increased the efficiency of England's fleets. By the late seventeenth century, English ships, borne on the wings of the wind, had rendered the globe accessible to the people of England.[9]

---

[8]For example, Walter Ralegh pointed out that it was best to leave England for Guyana in July in order to avoid mid-summer hurricanes (which generally occur further south at that time of year). Further, one should leave Guyana for England in April. By following this advice, one could avoid "so many calmes, so much heat, such outragious gustes, foule weather, and contrarie windes." Hakluyt, *Principal Navigations*, 7: 346.

[9]Bacon, *Works*, 19.

Appendix One

The winds of the Atlantic vary from season to season, but there is a discernible pattern at all times. With the benefit of modern technology as well as five hundred years of sailing experience in the Atlantic, it is possible to make a few general statements about the wind and current patterns of the Atlantic. This knowledge is essential for understanding why the explorers from Columbus onward chose the routes they did and built the types of vessels they did.

The rotation of winds and the flow of currents in the Atlantic occurs because of the rotation of the earth and the land masses that break up the oceans. If the ocean completely covered the globe, with no land masses to hinder the air flow, the winds would be symmetrical over both hemispheres. But because the Earth rotates, the winds, which would otherwise blow from the pole to the equator and back, are deflected to the right, or west in the northern hemisphere and to the left, or east in the southern. This pattern, called the Coriolis Effect in the nineteenth century, applies to any moving object connected to a rotating body. Inertia deflects the object from its path. In the North Atlantic, hot air rising from the equator travels northward to the pole, but is deflected by the earth's rotation and cools at about thirty degrees latitude.

At this point, the wind is travelling nearly perpendicular to its original northerly course and it begins its descent southward. Mariners refer to these winds as the westerlies because they seem to spring from that direction. Meanwhile, cooler air rushes to fill the gap at the equator, but it, too, is deflected from its course and heads to the west. These winds become the "Trade Winds," so-called because of their use by European ships in trade with the Caribbean. Hence the circular pattern in the North Atlantic. The pattern drifts however, following the sun in its seasonal cycle, and the "equator of the winds" drifts north and south of the earth's equator as well, bringing with it a band of calm known today as the doldrums, where the trades of the northern hemisphere meet with those of the southern, thus cancelling one another.[1] Likewise, a band of calm exists between the trades and the westerlies known as the "Horse Latitudes."

The rotation of the Earth also shapes the pattern of the currents in the North Atlantic. While there are many differences in temperature and salinity in the Atlantic, which cause the waters to move at varying rates, the wind is the primary means of surface movement.[2] Land masses, which stand in the way of these currents, deflect them so that

---

[1]Lyall Watson, *Heaven's Breath : A Natural History of the Wind* (New York: William Morrow and Company, 1984), 29.

[2]E.G.R. Taylor, *The Haven-Finding Art* (London: Hollis and Carter, 1956), 24.

they often flow perpendicular to the wind, causing leeway in a ship. These currents average around two knots, except for the Gulf Stream in the North Atlantic. The Gulf Stream originates from the meeting of a southern hemisphere current that is deflected northward by the huge headland of Brazil. It joins the outflow from the Amazon, which in turn joins the current associated with the northern trades. It circles the Caribbean basin and shoots out of the narrow channel between Florida and the Bermuda bank. Heated from its stay in the tropics, the current heads northward at a speed of roughly four to five knots, separated from the coast of North America by a cooler, fresher current from the north. At about forty to forty-five degrees latitude, it veers off to the east and meets the cold Labrador current heading south. The meeting of such wildly divergent water temperatures creates a massive fog bank off Newfoundland and the Grand Banks region, which early explorers remarked upon. Reaching Northern Europe, the Gulf Stream slows to a drift, but retains enough warmth to keep northern European ports free from ice.[3] Lesser currents abound in the polar regions, passing as the seasons allow around Greenland and Iceland and southward past Scandinavia.

---

[3]Taylor, *Haven-Finding Art*, 24-26.

Works Cited

I. Primary Sources

Anonymous. *The Complaynt of Scotlande wyth ane Exortatione to the Thre Estaits to be vigilante in the Deffens of their Public Veil 1549*. Edited by James A. H. Murray. London: The Early English Text Society, 1872.

Aristotle. *Meteorologica*. Translated by H.D.P. Lee. Loeb Classical Library. Cambridge: Harvard University Press, 1952.

Bacon, Francis. *The Works of Francis Bacon*. 14 vols. Edited by James Spedding, Robert Ellis, and Douglas Heath. New York: Garrett Press, 1968.

Baffin, William. *The Voyages of William Baffin 1612-1622*. Edited by Clements R. Markham. Hakluyt Society Publications, 1st ser., vol. 63. London, 1881.

Barlowe, Roger, trans. *A Briefe Summe of Geographie*. Edited by E.G.R. Taylor. Hakluyt Society Publications, 2d ser., vol. 69. London, 1932.

Butler, Nathaniel. *Six Dialogues About Sea Services*. Edited by W.G. Perrin. The Navy Records Society, vol. 65. London, 1929.

Chaucer, Geoffrey. *The Student's Chaucer*. Edited by Walter W. Skeat. Oxford: Clarendon Press, 1929.

Colón, Fernando. *The Life of the Admiral Christopher Columbus by His Son Ferdinand*. Translated by Benjamin Keen. New Brunswick: Rutgers University Press, 1959.

Cortés, Martin. *The Art of Navigation*. Translated by Richard Eden. London: R. Jugge, 1561.

Davis, John. *The Voyages and Works of John Davis the Navigator*. Edited by Albert Hastings Markham. Hakluyt Society Publications, 1st ser., vol. 59. London, 1880.

Hakluyt, Richard. *The Principal Navigations, Voyages, Traffiques and Discoveries of the English Nation*, 8 vols. London: J.M. Dent and Sons, 1926.

Higden, Ranulf. *Polychronicon Ranulphi Higden Monachi Cestrensis Together with the English Translations of John Trevisa and of an Unknown Writer of the Fifteenth Century*. 9 vols., *Rerum Britannicarum Medii Aevi Scriptores* (Rolls Series), Vol. 41. Edited by Churchill Babington. London: Longman Green, 1865.

Jourdain, Silvester. *A Discovery of the Barmudas, Otherwise called the Ile of Divels 1610*. Edited by Joseph Quincy Adams. New York: Scholar's Facsimiles and Reprints, 1940.

Madox, Richard. *An Elizabethan in 1582: The Diary of Richard Madox, Fellow of All Souls*. Edited by Elizabeth Story Donno. Hakluyt Society Publications, 2d ser., vol. 147. London, 1976.

Manwayring, Henry. *The Sea-mans Dictionary: or, an Exposition and Demonstration of all the Parts and Things belonging to a Shippe, etc*. London: John Booker, 1644.

Markham, Clements R. Markham, ed. *The Hawkins' Voyages during the reigns of Henry VIII, Queen Elizabeth, and James I*. Hakluyt Society Publications, 1st ser., vol. 57. London, 1878.

De Medina, Pedro. *A Navigator's Universe: The Libro de Cosmographia of 1538*. Translated by Ursula Lamb. Chicago: University of Chicago Press, 1972.

Morison, Samuel Eliot, ed. *Journals and Other Documents of the Life and Voyages of Christopher Columbus*. New York: The Heritage Press, 1963.

Oppenheim, Michael. *Naval Accounts and Inventories of the Reign of Henry VII, 1485-8 and 1495-7*. The Navy Records Society, vol. 8. London, 1896.

Pett, Phineas. *The Autobiography of Phineas Pett*. Edited by W.G. Perrin. The Navy Records Society, vol. 51. London, 1918.

Pliny. *Natural History*. 10 vols. Translated by W.H. Rackham. Loeb Classical Library. Cambridge: Harvard University Press, 1938.

Purchas, Samuel. *Hakluytus Posthumus or Purchas His Pilgrimes*. 20 Vols. New York: The Macmillan Company, 1906.

Quinn, David Beers, ed. *New American World: A Documentary History of North America to 1612*. 5 vols. New York: Arno Press, 1979.

Rose, Susan, ed. *The Navy of the Lancastrian Kings: Accounts and Inventoried of William Soper, Keeper of the King's Ships, 1422-1427*. The Navy Records Society, vol. 123. London, 1982.

Smith, John. *A Sea Grammar*. Edited by Kermit Goell. London: Michael Joseph, 1970.

___________. *The Complete Works of John Smith*. 3 vols. Edited by Philip Barbour. Chapel Hill: University of North Carolina Press, 1988.

Steele, Robert. *Mediæval Lore From Bartholomew Anglicus*. New York: Cooper Square Publications, 1966.

Tyler, Lyon Gardiner, ed. *Narratives of Early Virginia, 1606-1625*. Original Narratives of Early American History. New York: Charles Scribner's Sons, 1907.

II. Secondary Sources

Andrews, Kenneth R. *Elizabethan Privateering: English Privateering During the Spanish War, 1585-1603*. Cambridge: Cambridge University Press, 1985.

Barker, Richard. "Design in the Dockyards, about 1600." In *Carvel Construction Technique: Fifth International Symposium on Boat and Ship Archaeology, Amsterdam 1988*. Edited by Reinder Reinders and Kees Paul. Oxford: Oxbow Books, 1991.

Burstyn, Harold L. "Theories of Winds and Ocean Currents From the Discoveries to the End of the Seventeenth Century." *Terrae Incognitae* 3 (1971): 7-31.

Casson, Lionel. *Ships and Seamanship in the Ancient World*. Baltimore: Johns Hopkins University Press, 1995.

Cipolla, Carlo M. *Guns, Sails and Empires: Technological Innovation and the Early Phases of European Expansion, 1400-1700*. New York: Pantheon Books, 1965.

Cressy, David. *Coming Over: Migration and Communication between England and New England in the Seventeenth Century*. New York: Cambridge University Press, 1989.

Crosby, Alfred W. *Ecological Imperialism: The Biological Expansion of Europe, 900-1900*. Cambridge: Cambridge University Press, 1986.

Dietz, Brian. "The Royal Bounty and English Shipping in the Sixteenth and Seventeenth Centuries." *Mariner's Mirror* 77 (February 1991): 5-20.

Fowler, Elaine W. *English Sea Power in the Early Tudor Period, 1485-1558*. Ithaca: Cornell University Press, 1965.

Friel, Ian. *The Good Ship: Ships, Shipbuilding and Technology in England, 1200-1520*. Baltimore: Johns Hopkins University Press, 1995.

Gardiner, Robert, ed. *Cogs, Caravels and Galleons: The Sailing Ship, 1000-1650*. Annapolis: Naval Institute Press, 1994.

Harland, John. *Seamanship in the Age of Sail*. London: Conway Maritime Press, 1984.

Hasslöf, Olof. "Sources of Maritime History and Methods of Research." *Mariner's Mirror* 52 (May 1966): 127-44.

Hendrickson, Robert. *More Cunning Than Man: A Social History of Rats and Men*. New York: Stein and Day, 1983.

Howard, Frank. *Sailing Ships of War, 1400-1860*. New York: Mayflower Books, 1979.

Johnson, Donald S. *Charting the Sea of Darkness: The Four Voyages of Henry Hudson*. Camden: International Marine, 1993.

Kearney, Hugh. *Science and Change, 1500-1700*. New York: World University Library, 1971.

Kemp, Peter, ed. *The Oxford Companion to Ships and the Sea*. London: Oxford University Press, 1976.

Kirsch, Peter. *The Galleon: The Great Ships of the Armada Era*. Annapolis: Naval Institute Press, 1990.

Lloyd, Christopher. *The British Seaman, 1200-1860: A Social Survey*. Rutherford, N.J.: Fairleigh-Dickinson University Press, 1970.

Loades, David. *The Tudor Navy: An Administrative, Political and Military History*. Brookfield, Vt.: Scolar Press, 1992.

Mattingly, Garrett. *The Armada*. Boston: Houghton Mifflin Company, 1959.

McAlister, Lyle N. *Spain and Portugal in the New World, 1492-1700*. Minneapolis: University of Minnesota Press, 1984.

McCann, Franklin T. *English Discovery of America to 1585*. New York: King's Crown Press, 1952.

Moore, Alan. "The Snow." *Mariner's Mirror* 2 (February 1912): 38-43.

Morison, Samuel Eliot. *Admiral of the Ocean Sea: A Life of Christopher Columbus*. Boston: Little, Brown and Company, 1942.

______________________. *The European Discovery of America: The Northern Voyages, A.D. 500-1600*. New York: Oxford University Press, 1971.

______________________. *The European Discovery of America: The Southern Voyages, 1492-1616*. New York: Oxford University Press, 1974.

Nance, R. Morton. "The Ship of the Renaissance, Part II." *Mariner's Mirror* 41 (November 1955): 281-98.

Nunn, George E. *Geographical Conceptions of Columbus: A Consideration of Four Problems*. American Geographical Research Series, No. 14. New York: American Geographical Society, 1924.

Oppenheim, Michael. *A History of the Administration of the Royal Navy and of Merchant Shipping in Relation to the Navy from 1509 to 1660*. London: John Lane, 1896.

Parry, J.H. *The Age of Reconnaissance: Discovery, Exploration, and Settlement, 1450 to 1650*. New York: Praeger Publishers, 1969.

Quinn, David Beers. *England and the Discovery of America, 1481-1620*. New York: Alfred A. Knopf, 1974.

____________________. *North America From Earliest Discovery to First Settlements*. New York: Harper and Row, 1977.

Quinn, David Beers and A. N. Ryan. *England's Sea Empire, 1550-1642*. Early Modern Europe Today Series. London: George Allen and Unwin, 1983.

Rule, Margaret. *The Mary Rose: The Excavation and Raising of Henry VIII's Flagship*. Annapolis: Naval Institute Press, 1984.

Salisbury, William. "Early Tonnage Measurement in England." *Mariner's Mirror* 52 (February 1966): 41-52.

Sandahl, Bertil. *Middle English Sea Terms, I. The Ship's Hull*. Upsala, Sweden: A.-B Lundequistka Bokhandeln, 1951.

________________. *Middle English Sea Terms, II. Masts, Spars, and Sails*. Upsala, Sweden: A.-B. Lundequistka Bokhandeln, 1958.

Shirley, John W. *Thomas Harriot: A Biography*. Oxford: Clarendon Press, 1983.

Smith, Roger C. *Vanguard of Empire: Ships of Exploration in the Age of Columbus*. New York: Oxford University Press, 1993.

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

Taylor, E.G.R. *The Haven-Finding Art*. London: Hollis and Carter, 1956.

Unger, Richard W. *Dutch Shipbuilding Before 1800*. Amsterdam: Van Gorcum & Company, 1978.

Waters, David W. *The Art of Navigation in England in Elizabethan and Early Stuart Times*. New Haven: Yale University Press, 1958.

Watson, Lyall. *Heaven's Breath: A Natural History of the Wind*. New York: William Morrow and Company, 1984.

VITA

Anna Gibson Holloway

Born in Winston-Salem, North Carolina, July 1, 1963. Graduated from R.J. Reynolds Senior High School in that city, June 1981. Attended The University of North Carolina at Greensboro where the author received a B.A. in English Literature in 1986 and a B.A. in Classical Civilization in 1990. In August 1992, the author entered the College of William and Mary as a graduate assistant in the Department of History. The author has completed the required coursework and examinations for both the M.A. and Ph.D. degrees in history at the College of William and Mary, and is currently completing the dissertation requirement for the Ph.D. She is employed by the Colonial Williamsburg Foundation.