THE HISTORY AND DEVELOPMENT OF CARAVELS

A Thesis

by

GEORGE ROBERT SCHWARZ

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

May 2008

Major Subject: Anthropology

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Approved by:

Chair of Committee,	Luis Filipe Vieira de Castro
Committee Members,	Donny L. Hamilton
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ABSTRACT

The History and Development of Caravels. (May 2008)

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An array of ship types was used during the European Age of Expansion (early 15th to early 17th centuries), but one vessel in particular emerges from the historical records as a harbinger of discovery: the caravel. The problem is that little is known about these popular ships of discovery, despite the fair amount of historical evidence that has been uncovered. How big were they? How many men did it take to operate such a vessel? What kind of sailing characteristics did they have? How and by whom were they designed? Where did they originate and how did they develop? These questions cannot be answered by looking at the historical accounts alone.

For this reason, scholars must take another approach for learning about caravels by examining additional sources, namely ancient shipbuilding treatises, archaeological evidence, surviving archaic shipbuilding techniques, and iconographic representations from the past.

Information gained from the available sources reveals many of the caravel's characteristics through time. This ship type outclassed its contemporaries during the age of exploration because of its highly adaptive characteristics. These traits were, principally, its shallow draught, speed, maneuverability, and ability to sail close to the

wind. This combination of attributes made the caravel the ideal ship for reconnaissance along the rocky African coastline, as well as for making the transatlantic voyages to the New World. It was built in a Mediterranean way during its post-medieval phases, a method that still survives in some parts of the world today. During the Age of Discovery (ca. 1430 to 1530), the caravel sat low in the water, had one sterncastle, and was either lateen-rigged or had a combination of square and lateen sails. This vessel reflects the advanced shipbuilding technology that existed in Europe at this time, and played and important role in the voyages which allowed the Europeans to expand their territories around the world.

The results of the studies presented in this thesis provide a history and development of the caravel, which was gradual and often obscure. What has been gained from this work is a body of information that can be applied to other studies about ancient seafaring, and can serve as a starting point for further research.

DEDICATION

For my parents, sisters, and fiancée Bryana.

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Researching a ship from the past without the aid of tangible archaeological evidence has proven to be an undertaking that demanded patience, long hours of research, funding for archival work in Europe, transcription and translation of often seemlingly arcane text, and more patience. More importantly, however, it required guidance from individuals far more knowledgable in the field of nautical archaeology than I initially was. So, it is with pleasure that I take this opportunity to sincerely thank all of the people that have shared their time, energy, experience, and advice to help me in my pursuit of knowledge concerning the history of Iberian seafaring.

I would like to thank my committee chair, Dr. Castro, for his support regarding research opportunities in Portugal, introducing me to other helpful Iberian nautical scholars, sharing his rare sources, and offering valuable advice on the final product of this work. Similarly, I extend my appreciation to my other committee members, Dr. Donny Hamilton and Dr. Jim Rosenheim, for their thoughtful input and words of wisdom.

Thanks to Dr. Francisco Contente Domingues for his sincere interest and contribution to my research. A debt of gratitude goes to Dr. Richard Barker for sharing his information on an early quote regarding a first-hand account about the agility of caravels. Thanks to Captain E.G. Duarte for his advice on sailing dynamics and hydrostatics. I also salute the late Dr. Rob Bonnichsen for his major contribution to the structure and formation of research questions for this thesis.

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I also want to thank my friends and colleagues that have assisted me in one way or another over the course of my studies. Thanks to Tiago Miguel d'Oliveira Xavier Conde Fraga and his wife Sandra for their friendship, support, and assistance navigating the intricacies of Portugal. Thanks to Alexis and Alexa, Dante and Lilia, Randy, Wendy, Mark, Jon, Josh, and the rest of my friends who, because of their enthusiasm, have made this process more rewarding in the end.

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CHAPTER I

INTRODUCTION

From time immemorial waterborne travel has spawned a mélange of interactions between culturally diverse groups. Communication, trade, alliances, conquests, and wars were but a few consequences of contact. Since the era in which ancient Egyptians paddled down the Nile to the times of far-flung Phoenician voyages, and to the later Classical period when Greeks and Romans spread knowledge throughout the Mediterranean, culture has been continuously transmitted. In the Middle Ages, merchant vessels traded throughout the Western world, facilitating a sustained diffusion of ideas, thoughts, and seafaring tradition.

Perhaps one of the most remarkable maritime feats involving the impact of cultural exchange was the European overseas expansion that took place in the 15th century. This late medieval wave of exploration was heralded by Iberian seafaring nations and their agile ships of discovery. Economic, political, and social implications of the Iberian expansion overseas were enormous, unprecedented, and life-altering for many indigenous groups across the globe. During this era, the Portuguese and Spanish kingdoms were engaged in a race to claim possession of the non-Christian world. A combination of ambition, navigational prowess, and advanced naval architecture were among the main attributes responsible for the rise of these nations as naval powers,

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This thesis follows the style of *Historical Archaeology*.

which eventually dominated the oceans and prompted the Pope to divide the world between the two powers.

The ingenuity and aptitude to develop and sail vessels capable of crossing inhospitable and uncharted waters was not gained overnight. Several hundred years of shipbuilding traditions, unique experiments, and varying degrees of success led to gradual improvements in ship design. Moreover, nautical skills in Europe were passed down slowly through generations, built upon by contact with other seafarers, and altered according to circumstance and advances in science and technology. Beginning in the 13th century, rivalries between Venice and Genoa led to great advancements in shipbuilding technology, and the navigational expertise of the Arabs and their subsequent spreading of knowledge throughout the Mediterranean furthered the progress being made in the maritime world. The Scandinavian expansion into the Black Sea and Mediterranean, as well as the seafaring during the Crusades, promoted the dissemination of the knowledge of ship design. Information was distributed as northern vessels sailed throughout Europe and into the Mediterranean, mingling with old traditions and introducing new concepts of ship construction. And although a multitude of maritime cultures participated in the development of shipbuilding and navigational technology, it was the Iberians who ultimately launched the first successful European voyages to discover new routes and lands in a quest for expansion. How did the divided territories of Spain and the small and recently formed country of Portugal accomplish their goals? A multitude of factors played a part in the events that later resulted in the establishment of overseas colonies and trade routes. A foremost attribute supporting the success of

Iberian seafarers was their shipbuilding technology, and the vessels resulting from the use of this technology. The caravel, in particular, emerges from historical documents and iconographic representations as the type employed most frequently for exploration in the 15th and early 16th centuries.

There exists an abundance of information regarding the Age of Discovery, including personal accounts of travelers and explorers of post-medieval Europe. Christopher Columbus's logbook, for example, has been preserved and is available for study. The accounts of Antonio Pigafetta, the Italian chronicler who accompanied Ferdinand Magellan on his quest around the world, survive in numerous editions for readers. Other notes and diaries are in existence as well, providing details of numerous voyages of reconnaissance. But despite the survival of these often first-hand field notes, there is a disappointing paucity of information regarding the actual ships themselves. In fact, there are no known extant archaeological remains of a caravel. Furthermore, during the era in which these vessels were most popular, the Age of Exploration, no construction plans were recorded. Shipbuilding contracts seem to have been lost together with many other documents of this period. As a result, more is known about the construction of 5,000 year-old royal Egyptian barges than caravels from the 15th century. This gap in our knowledge of the history of shipbuilding from this period is a great loss for maritime studies because such data could provide significant understanding of the development of Iberian vessels and seafaring culture from this region of the globe.

Despite the complications associated with the lack of material evidence, it is still possible to study these ships of discovery and fill the voids in our understanding of maritime life and the art of shipbuilding. This work is an effort to compile and analyze the available information concerning the caravel ship type, arguably the most important technological vehicle which successfully propelled the Iberians across the often desolate oceans in their quest to spread Christianity and develop trade routes for the prosperity of their nations. Scholars of Iberian seafaring and naval architecture must search through primary historical references and locate secondary sources to find details of these ships: information which can tell us about shipbuilding techniques, conception and construction, size ranges, rigging arrangements, living spaces, structural soundness, sailing capabilities, crew sizes, cargo space, and many other ship-related details.

The integrated avenue of research employed here is relatively new in nautical archaeology and was developed in Roskilde by the Scandinavian Maritime History Working Group in the 1960s (Crumlin-Pederson 2004:39). It has continued and has been exemplified by Castro and Fonseca (2006) in their analysis of the sailing capabilities and structural integrity of an India *nau*. This is the mind frame in which scholars are developing their work in the SHIPLAB at Texas A&M University's Nautical Archaeology Program, in order to map the gaps in our knowledge. With this approach, other scholars such as architects, computer simulation experts, and engineers are engaged to help nautical archaeologists form better ideas of the past world of seafaring during the age of wooden sailing vessels.

In 1755, a great fire burned Lisbon's archives. This disaster made researching 15th-century ships of exploration more challenging, but, despite this, scholars have overcome this obstacle and located significant intact documents. The 1892 quartercentenary of Columbus's famous voyage to the New World sparked a new and lasting interest in ships of discovery, which have been the subject of many important studies since then. Henrique Lopes de Mendonça, an admiral in the Portuguese navy, was the first to turn the study of naval archaeology in Portugal into its own science, initiated by his seminal work, published in 1890, entitled "Estudos sobre caravelas" (Lopes de Mendonça 1890). Soon after, Lopes de Mendonça published a comprehensive book regarding exploratory vessels in general, called *Estudos Sobre Navios Portugueses dos Séculos XV e XVI* (Lopes de Mendonça 1892). Primarily investigating the manuscript from Biblioteca Nacional de Lisboa entitled *Livro Náutico* (1580-1609), he described the traits and forms of ships based on the rules of naval architecture set forth in the treatise. Some examples are measurements for constructing a *nau* of 600 *tonéis*, a galleon of 500 *tonéis*, and a *caravela redonda* of 150-180 *tonéis* (see Appendix A for a list of measurements; Domingues 2000:15). Furthermore, Lopes de Mendonça characterized other ships used in the initial stages of the European discoveries, including the *barca* and *barinel*.

As Lopes de Mendonça was releasing his finds and hypotheses to the public, another official of the Portuguese Navy, João Brás de Oliveira, published his book *Os Navios de Vasco da Gama* (Brás de Oliveira 1892). This was an altogether different book, presenting a general perspective of caravels, *naus*, and galleons, as well as other

historically important vessels such as *barcas*, *barinels*, *carracas* and *urcas*. In addition to his descriptions of these craft, Brás de Oliveira put forth his own interpretations of these vessels in the form of reconstructed lines drawings of some of the vessels from Vasco da Gama's 1498 fleet bound for India. These two books, *Estudos Sobre Navios Portugueses dos Séculos XV e XVI* and *Os Navios de Vasco da Gama*, laid the foundation for future studies in Portuguese naval archaeology (Domingues 2000:15).

Two other important early scholars of Iberian seafaring were Artur Baldaque da Silva and Francisco Marques de Sousa Viterbo, who described the ships of discovery and the lives of their shipbuilders in their respective books *Noticia Sobre a Náo S. Gabriel em que Vasco da Gama Foi pela Primeira Vez á India* (1892) and *Trabalhos Náuticos dos Portugueses (Séculos XVI e XVII)* (1892). These works were perhaps not as groundbreaking with regard to archaeological studies as the others because Sousa Viterbo, for example, dealt primarily with the lives and roles of shipwrights, naval architects, ship carpenters, and navigators rather than the morphological traits and structural characteristics of the vessels. Nevertheless, they were important contributions to a wider understanding of the shipbuilding and seafaring environment of this period.

For the quatercentenary of the voyage of Vasco da Gama (1498), Lopes de Mendonça published yet another book entitled *O Padre Fernanado Oliveira e a Sua Obra Náutica* (1898), which translated and annotated the treatise written by Father Fernando Oliveira in 1580. This work, *O Livro da Fábrica das Naus* (1580), is heavily steeped in shipbuilding theory and necessary materials for ship construction and will be explored later in this thesis.

Henrique Quirino da Fonseca, still another admiral from the Portuguese Navy, published the first great monograph concerning the caravel specifically. His book, published in 1934, is entitled *A Caravela Portuguesa e a Prioridade Técnica das Navegações Portugueses*, and deals with many particulars of the vessel, including various aspects of sailing and aerodynamics of the lateen sail, etymology of the word "caravel," ship crews, artillery, and much more. It stands even today as the seminal work on caravels and contains the most important historical sources for the study of this type of vessel.

Approximately 50 years later, between 1980 and 1990, another significant study on the caravel was published by António Tengarrinha Pires. *Caravelas dos Descobrimentos* (980-90), a series of five small books, is mostly concerned with navigation, and only the fifth booklet describes the caravels used during the Age of Discovery. The first part of *Tres Séculos no Mar (1640-1910)* (1974), a 30-volume opus by António Marques Esparteiro concerning three centuries of Portuguese navigation, deals with both caravels and galleons, but the majority addresses ships built well after the Iberian discoveries. Important monographs dedicated to João Brás de Oliveira, which involve historical naval vessels are "Capitães, naus, e caravelas da armada de Cabral" (1979) by Moacyr Soares Pereira and "A armada de Fernão de Magalhães" (1975) by João da Gama Pimentel Barata. An additional work published in 1992, entitled *Novos Elementos para o Estudo da Arquitectura Naval Portuguesa Antiga* (1992) by Hernâni Amaral Xavier, presents a lucid study of Manuel Fernandes's 17th-century shipbuilding

treatise, which includes rules for constructing caravels of 11 and 12 *rumos*, or 17 and 18.5 m (see Appendix A; Domingues 2000:23-29).

In 1989, *Estudos de Arqueologia Naval*, the compiled works of João da Gama Pimentel Barata, was published in three parts. The second part of this book, despite being incomplete, is dedicated to caravels, although many pages relate to *naus* and galleons (Domingues 2000:32).

There are several other works that will be drawn upon in this thesis which concern Iberian ships and naval architecture, but the above studies are mentioned because they set the initial pace for serious research on caravels by analyzing archival documents and treatises from medieval and post-medieval Europe. Although these early studies provide valuable information, they do not usually incorporate other lines of evidence in their analyses. The documentary sources alone do not give, for example, detailed evidence of appearance, structural integrity, or sailing characteristics. For this reason there is a need for a fresh and comprehensive look at the sources from which caravels emerge.

The goal of this research is to provide a better understanding of the structural components, chronological development, and historical significance of the Iberian caravel through multiple lines of evidence. These topics embody a variety of themes. For example, this study also addresses the question of how the Portuguese became the innovators of exploration during the 15th century. They expanded their empire south, reaching the north coast of Africa, set up trading ports all along Africa's west coast, and eventually reached the Indian Ocean and the Indian subcontinent, establishing a complex

trade network in Asia. The caravel, with its shallow draft, lateen-rigged sails, relative lightness, and quick maneuverability made it an exceptionally adaptive vessel for the task of exploration. But this is not to assume that the advent of this type of ship allowed easy passage to uncharted waters. Fifteenth-and sixteenth-century mariners had to face many dangers at sea to begin with, and the unknown regions to which the Portuguese navigators headed were laden with additional hazards. The distance required them to secure a source of water along the way, or to carry more water than was needed on shorter journeys. They also had to face the inevitability of death along the way, which meant recruiting larger crews. Additionally, they were confronted with unfavorable weather conditions, harsh rocky coasts, unfamiliar currents and adverse winds, as well as limited geographical knowledge. Due to the recorded success of the ship, there is little doubt that the caravel was a pivotal factor that enabled the further investigation of these regions. The questions remain, however, as to how, exactly, the Portuguese, in particular, utilized this craft to achieve their maritime accomplishments. The more we know about this vessel type, the more we will know about exploration as a whole during the era of post-medieval reconnaissance and discovery.

The methodological approach used in this project for gathering facts about caravels involves drawing on many lines of evidence, including historical accounts and archival documents, contemporary iconographic representations of the caravel, ethnographic analogies to shipbuilding techniques still used in some parts of the world today, archaeological parallels of similarly built Iberian watercraft, and ancient shipbuilding and nautical treatises. Ultimately, this work is intended to provide scholars

with an updated basis from which to expand our knowledge of caravels in the future, when the remains of this type of ship are someday located.

CHAPTER II

IBERIAN SEAFARING TRADITION

Origins of Expansion

Although Portugal's famous captains, navigators, and explorers are credited for much of the pioneering during the Age of Discovery (ca. 1430-1530), the nation was not a mighty seafaring entity with centuries of experience in oceanic exploration. In fact, the first inhabitants that shifted into that part of the Iberian Peninsula were mostly gatherers, concentrating on vegetables and grubs for subsistence. Due to a coastline stretching 848 kilometers with few islands, scant openings along the coastline, a small number of good inland harbors, lack of gulfs, and frequently stormy western winds, the geography of this part of the Peninsula suggests minimal alimentary reliance on the sea throughout pre-history (Figure 2-1; Marques 1976:3). Often thought by Mediterranean peoples in ancient times to be the edge of the earth, this was certainly not the place of origin for Europe's maritime growth.

Overseas expansion actually began far earlier than the 15th century in Europe and can first be traced archaeologically to the efforts of the Minoans, the first known great sea power of the Mediterranean. These mariners developed trading routes as they pushed out into the western Mediterranean, establishing trading stations in Sicily, Greece, Rhodes, Cyprus, and the Levant between 1800 and 1500 B.C. The Minoan seafaring culture was followed by the Phoenicians, and after them the Greeks who succeeded the Cretans and became the foremost maritime power in the Mediterranean.

FIGURE 2-1. The coastline of the Iberian Peninsula (After Google 2007)

Pottery fragments help reconstruct the routes of the Greek merchant ships, which traveled eastward to the west coast of Asia Minor, or southward to Crete from where they then turned east through Rhodes and Cyprus to the cities along the Syrian coast (Casson 1991:23-24). Between 1200 and 1000 B.C., before the Greeks, the Phoenicians plowed even further west through the Mediterranean, reaching from Tyre (in modern Lebanon) to Utica and Cadiz (Casson 1991:72).

Stories of seafaring go back more than 3,000 years in the Mediterranean, referring to journeys of exploration, such as the tale of Jason and the Argonauts, who navigated to the far eastern corner of the Black Sea in search of treasure. Although not abundant in navigational details, geographical notations, or ship descriptions, this account exemplifies the fascination with exploration and adventure from a very early time.

During the reign of Egyptian Pharaoh Necho (609-595 B.C.), Phoenician mariners are reported by the Greek historian Herodotus to have made the first circumnavigation of Africa from east to west in sea-going galleys. These vessels left Egypt through the Erythraean Sea, rounded the Cape of Good Hope, voyaged along the African coast and entered the Mediterranean to report to the pharaoh at the mouth of the Nile after three years. Although discounted by Herodotus, some recent historians have come to accept the possibility of this early discovery (Morison 1971:5).

The Greeks stretched west and east during the middle of the first millennium, from 800 to 500 B.C., sailing to the ends of the Mediterranean and along the coasts of the Black Sea (Diffie and Winius 1977:3). While making these voyages, these mariners seem to have been exploring the world while simultaneously satisfying their scientific curiosity, eventually paving the way for later European expansion.

Before the discovery of Atlantic islands, such as the Canaries and Azores in the 14th century by Genoese, Castilian, Malloracan, and Portuguese sailors, Arab seafarers had sojourned into the hostile high seas of the Atlantic and allegedly located certain islands prior to the 12th century. These early explorers reportedly sailed out of Lisbon, discovered—or rediscovered—some populated islands, and returned to Portugal. These islands, probably the Canaries, which had been earlier colonized by the Carthaginians, were too far to be commercially lucrative and ultimately were not included in the grand scheme of Muslim economic activity. It is, in fact, the record of these early expeditions that fostered the notion of islands lying in the western reaches of the Atlantic Ocean (Morison 1971:5; Marques 1976:136).

Despite these early investigations of the world's oceans, there was little or no encroachment into the Atlantic Ocean until northern European explorers ventured further into the icy Norwegian Sea to discover–or rediscover—and colonize Iceland and the Faeroe Islands in the ninth century. This period of discovery came only after the adoption of the mast and sail in northern Europe, which probably did not occur until the seventh century in Scandinavia. Why these implements were not used earlier is unclear, since this technology had been in use in the Mediterranean for four millennia, but reliance on oars and lightly constructed vessels by northern European mariners is evident in the archaeological record (Christensen 2001:79). In any event, Viking expansion reached a pinnacle at about A.D. 1000 when the Nordic mariners encountered the east coast of North America. Although they did not leave permanent settlements on their new-found territory, Icelandic chroniclers did spread the knowledge of these new discoveries to Europe. It has even been suggested that Columbus knew of this new world during his journey west to find India in the 15th century, though this notion is contended by historian Samuel Elliot Morison since there appears to be no historical proof of Columbus's knowledge of these early voyages (Òlafsson 2000:143; Morison 1971:62). Considering the previous voyages of exploration and discovery, the question remains as to why it took an additional four hundred years to venture further out into the Atlantic and begin colonization of outside territories. And why was it that Iberian seafarers, particularly the Portuguese, a small nation with barely one million inhabitants during the Age of Discovery, eventually launched the first effective exploratory campaigns that

began European expansion around the world. A short history of the formation of Portugal helps to explain their role during this era of maritime exploration.

Emergence of Portugal as a Seafaring Nation

Starting in the fifth century, northern tribes—including the Vandals, Suevi, Visigoths, and Alans—infiltrated Iberia, overwhelming the already fragmented Roman Lusitanian forces and establishing a number of small states that lasted almost 300 years. Subsequently, the invasion of the Iberian Peninsula by Arab forces in A.D. 711 initiated another era of subjugation for the Lusitani, who were by now mixed with Roman soldiers from all over the Roman Empire (Curchin 1991:101). Reconquest began in 718 with the battle of Covadonga led by the Christian kings in Spain. It would not gain momentum, however, until the 11th century, when population growth throughout western Europe triggered a French expansion into the west which pushed the Muslim rulers continuously to the south. Although other parts of the Peninsula attained their autonomy early on, the struggle for Christian land would last until 1492 in Castile. It is through this appropriation of former Christian soil that Portuguese kings were born, and Portugal eventually emerged as an independent state.

Initially battles with both Spanish and Arabic neighbors were few and territory reclamation was gradual, but as the population grew, the Christian forces took Muslim towns as they slowly made their way south through Extremadura, Alentejo, and Andalucia. By the ninth century, a Christian region, which came to be known as "territorium Portucalense", was established between what is now Minho province and Douro River (Wheeler 2002:xxxviii). For the first nearly 200 years of the Reconquest,

northern Portugal was part of the Leonese kingdom, united under a single family. Portugal's growing strength, however, was eventually recognized by the Leonese king Fernando I (1035-1056) and his centralizing policy. Autonomy arrived in the following century with the birth of Afonso Henriques, son of the feudal Count Henri of Burgundy and a Spanish princess. Afonso's mother, Tarasia, had inherited Portugal at her husband Henri's death. Meanwhile, the Spanish northern province of Galicia was under the rule of Afonso's cousin, Alfonso Raimundez (Alfonso VII), and from 1128 to 1137, historical records indicate that Afonso Henriques was in a near perpetual state of dissent against his cousin. As history would demonstrate, Afonso's intent was clearly to separate from Leon, gain territorial expansion of his feudal fief, and be named by the pope as king of his domain (Marques 1976:39).

It took many years for Afonso to accomplish his goal, and only in 1143 was a treaty made with the assistance of Rome, granting Afonso the title of king. Certain feudal obligations, however, were still required of Afonso to remain in good standing with the then "emperor" Alfonso VII. Meanwhile, both Portugal and Spain were fighting against the Muslim infidels that had strongholds all over the southern portion of the Peninsula. A courageous and enthusiastic leader, Afonso Henriques built a castle in Leiria in 1135 and successfully launched an invasion into the core of Islamic territory in what is now central Portugal. In 1147, Afonso rallied the support of the Crusaders, who were on their way to the Holy Land for the Second Crusade. With approximately 200 ships from northern European countries, the combined forces seized Lisbon from its Muslim rulers (Diffie and Winius 1977:14). Through numerous *fossados*, or chartered

offensive raids, other strongholds fell to Afonso shortly after the conquest of Lisbon. These include Alenquer, Òbidos, Almada, Sintra, Sesimbra, and Palmela, which allowed Afonso to broaden his boundaries to the Tagus River (Powers 1987:58; Saraiva 1997:15). As the battles raged, Afonso constantly strived to assert his authority as the leader of Portugal, continually seeking formal papal recognition of both his title and his kingdom. Finally, with much persuasion and monetary incentive, Pope Alexander III recognized Afonso as king and his state as a kingdom in 1179 (Marques 1976:42).

Meanwhile, agriculture dominated the economy, with wine, grain, hides, flax, and beeswax leading in production. In addition, cattle ranching and sheep herding thrived due to a 13th-century population boom throughout Europe that increased demand for Iberian wool (McAlister 1984:21). In the 12th century, especially along the coast, small villages manufactured fishing boats and depended mostly on fish for their subsistence. Early historical records indicate that this was a local activity, however, with rare cases of external trade of surplus. Nevertheless, it is known that Normans and Crusaders were familiar with the coasts of Portugal, and had been calling on them regularly from the ninth century to the middle of the 12th. For instance, archival documents reveal that a late 12th-century Flemish trading vessel wrecked in Portuguese waters, indicating a possible early stage for long-distance trade with northern European countries (Marques 1976:56-58). Although coastal fishing did not initially impact Portugal's external commerce to a large degree, the nautical skills that were acquired, mastered, and passed on through generations became necessary attributes for the 15th-century mariners who developed the expertise for Atlantic exploration.

There is documentary evidence from the 13th century showing that Portuguese already had commercial links to entrepôts in the Mediterranean and northern Europe, but only at the end of the century were Portuguese merchants becoming significant enough to compete with foreigners. At this time, the most important exports from Portugal were wine, salt, and oil; wood was also important, although secondary to the others. Ancillary products included cork, wax, hides, and skins. After the conquest of the Algarve, figs, almonds, and dried fruits were also commercially viable for exportation. Meanwhile, principle imports included weapons, iron and other metals, cloth, sumptuary articles, and provisions (Albuquerque 2001:13-16).

Throughout the Middle Ages a slowly developing commercial revolution changed the way trade was conducted, especially with regard to overseas commerce. A system of loans designed for long-distance or otherwise risky ventures was developed to help investors take advantage of growing trade in the Mediterranean and northern Europe. This system was motivated by the trade routes employed during the increasingly frequent Crusades. The sea loan, for example, gave a borrower a chance to return the loan on condition that the vessel transporting the borrowed money or goods safely completed its voyage. Although sales, loans, and exchange were the key factors of trade during this era, the expansion of trade was largely propelled by the *commenda* and *compagnia* contracts, the fundamental legal tools used to combine capital and bring together partnerships for commercial gain (Lopez and Raymond 1955:168-174). *Commenda*, an Italian term with roots from the 10th century, evolved to become a widely-used set of binding contracts which permitted trade between a traveling

associate—*tractator*—and his sedentary investor—*commendator* (Pryor 1987:6). The *commenda* developed in the Mediterranean throughout the Middle Ages and was adopted by other western European nations, and merchants on the Iberian Peninsula were employing the system early on. The *commenda* and related system of contracts permitted a huge increase in foreign trade due to availability of funds to poor but ambitious entrepreneurs, as well as cargo insurance, which eased the minds of the participants providing the capital.

In the 12th century, Portuguese were established in the British Isles, and by the late 13th century, Portuguese merchants could be found in many parts of western Europe, strengthening the nation's commercial ties. In turn, this led to compacts and insurance systems with England, and, by the middle of the 14th century, a Portuguese factory house was established in Bruges. At this point the Portuguese were exporting additional products to Europe, including raisins, honey, tallow, leather, and esparto grass (Marques 1976:92). Always encouraging foreign professionals, King Dinis (1279-1325) bid Manuel Pessanha from Genoa to come to Portugal and be his admiral in 1317. As a result, Pessanha's knowledge of seafaring and shipbuilding spread throughout the country and left a lasting impression which would be significant in the future voyages of the Portuguese navigators (Diffie and Winius 1977:26). Further strengthening commercial ties, in 1338, King Afonso IV (1325-1357) passed a letter of commercial privilege for Florentine merchants and the Bardi Company from Florence. Then, in 1357, King Pedro (1357-1367) gave letters confirming privileges to merchants from Genoa and Milan, and similar letters were soon prepared for Catalan merchants in 1362.

After the 1383-1385 war of succession ending with the marriage of the new king João I and Phillipa of Lancaster, these privileges were extended in 1398 to English merchants. Furthermore, trade between Iberian and Muslim merchants never slowed during this period, even while Portuguese and Spanish kings continued to drive the Arab and Maghrebi rulers back from their *taifas*, or emirates, throughout the Peninsula (Albuquerque 2001:26-27).

Western European trade in the East prospered from an early time and was strengthened in the West as Venice developed its traditional trade with the Byzantine Empire. In the eighth century, Venice and other port towns became liaisons between the sophisticated Islamic and Byzantine economies and the benighted western European financial system. The involvement of these towns was due to the Lombardi domination of part of Italy. This domination transformed these places into Byzantine realms in the Western world. They eventually gained relative autonomy, however, while keeping prosperous commercial relations with Islamic nations (Lopez and Raymond 1955:33).

Due to the rise of a middle class and the development of the medieval town in the 10th century, a population of craftsmen and merchants was born. As a result, markets continually developed in and around towns—initially in southern Italy, but eventually across all of western Europe in general (Lopez and Raymond 1955:51). Over time, merchants become increasingly more powerful throughout Europe. King Afonso III (1248-1279) consulted merchants before creating and promulgating the Portuguese law of 1253, in which the court was to be presided over by a price-fixer instead of being regulated as a free-market operation. King Dinis chose Pedro Martins, a bourgeois of

Lisbon, to accompany the clergyman João Sueiro to the English court in 1293 to study the terms of an agreement between the two countries. Moreover, the middle class was instrumental in the establishment of Dom João, Master of Avis, as the king of Portugal in 1385 (Peres 1943:29). This strong rise of a middle class, increase in trade and mobility of people, and expansion of foreign commercial ties were some of the factors that, less than 40 years later, impelled the Portuguese navigators, sailors, adventurers, and merchantmen to participate in the exploration of West Africa and the Atlantic islands.

Early Efforts at Exploration in the High Seas

At some point in the late 13th century, Italian and Catalan pilots began using the boxed compass and drafting portolan charts, enhancing navigational accuracy. Sailing duration was consequently extended, which in turn allowed cartographers to more easily delineate Mediterranean—and later Atlantic—coastlines, showing relative distances between way stations (Lewis and Runyan 1985:74). In May of 1291, the Genoese Vivaldi brothers are said to have made an adventurous attempt to reach India by circumnavigating Africa, but little is known of the progress of this voyage. Although this was probably an expedition organized to reach fellow nationals already sailing in eastern waters, Genoa was, at this time, heavily concentrated on trade possibilities in the Black Sea. Thus no further exploratory attempts of this magnitude seem to have been made to this region (Scammell 1981:164). Nevertheless, Italian mariners, who had traded in the Atlantic as early as the 12th century, were likely the first to launch expeditions of exploration in the fashion of the western European discoverers.

Throughout the early 14th century, additional expeditions were made by Genoese traders and adventurers into the Atlantic, likely resulting in the initial discovery of the Madeira Islands, some of the islands of the Canary archipelago, and possibly the Azores as well. A letter from 1341 by an Italian humanist scholar, Giovanni Boccaccio, details a further voyage involving Genoese, Florentine, Portuguese, and Castilian mariners, which mentions three vessels outfitted by King Afonso IV leaving Lisbon on an expedition to conquer cities and castles in the Canary Islands (Peres 1943:16; Diffie and Winius 1977:27). Soon after, in 1344, the old rivalry between Castile and Portugal reemerged, bringing more conflict. Despite a papal bull issued by Pope Clement VI to give Luis de España temporal jurisdiction over the said islands, both countries vied for possession of the Canaries and vigorously defended their claims. This issue, however, would not be resolved for more than a century (Diffie and Winius 1977:30). The Madeira Islands, another cause for contention between Portugal and Castile, were also under dispute at the end of the 14th century, but ultimately fell under the wing of the Portuguese empire in the early part of the 15th century.

Considering the amount of international interest in overseas exploration, it seems appropriate to examine why it was the Portuguese, instead of more powerful and influential countries, who were among the most prevalent explorers during the Age of Discovery. Despite the numerous voyages undertaken by the Genoese, Catalans, Castilians, and Mallorcans during the remainder of the 14th century—largely to dispute claim of the Canaries, no new lands were discovered. And although fishing and seal hunting continued, interest in overseas expansion waned as the kingdoms succumbed to

internal strife, war with rival nations and infidels, and the Black Death. The Portuguese, on the other hand, had ousted the Muslims from their country and were not as plagued by corruption and intrigue between king and nobility. This left them freer to experiment with overseas expansion, which was coupled with crusading fervor. Furthermore, the knowledge of Guinea gold, the quest for the legendary priest-king Prester John, and the acquisition of Oriental spices further prompted the desire to explore the increasingly less-terrifying Atlantic waters. After c. 1442, successful slaving voyages and the development of the slave trade mounted further incentive for southerly voyages along the west coast of Africa, an enterprise which helped to finance these expensive exploratory expeditions (Boxer 1969:18-24). These cumulating factors continuously added to the decision-making process of kings, princes, nobles, and merchants as the events of the Age of Discovery unfolded.

Developments Leading to Portuguese Exploration and Expansion

The military conquest of the North African city of Ceuta, initiated by King João I (1385-1433) in 1415, is often proclaimed to be the inception of Portuguese overseas expansion. This expedition, much debated by the Portuguese king and his advisors, was actually an attempt to assert dominance over the Muslims after most of the infidels had been expelled from Portugal earlier in the century. In truth, the capture of the Muslim city probably had more to do with a prolongation of the Reconquest than with overseas expansion (Serrão 1998:255). While battles were being fought throughout Spain to drive Muslims out of Castilian and Aragónese territories, Portugal was relatively free from the influence of Islamic rulers. Although peace was established in the country, the

Portuguese soldiers who had fought to defend their realm were now becoming restless. Rather than risk having his armies fight for Castile, the Portuguese king may have sought an alternative situation to keep his forces occupied. Coffers drained, fueled by crusading zeal, and wishing to provide his sons with an opportunity to heroically prove themselves in battle, King João I launched the invasion of Ceuta in July 1415, defeating the defenders after a single day of combat. The king thus bestowed to his sons Pedro and Henry the titles Duke of Coimbra and Duke of Viseu, respectively, which were the first duchies to be created in Portugal (Livermore 1976:109).

Soon after the conquest of Ceuta, there surfaced an interest in colonizing the Madeira Islands, which had not previously been inhabited. This was the next logical step for Portuguese expansion, and was achieved by 1420, when two expeditions were sent from the Algarve to seize Madeira and Porto Santo for good. Simultaneously, the Portuguese were engrossed in the conquest of the Canaries and launched an attack against Spanish-held Grand Canary in 1424 or 1425, which failed due to overwhelming odds. Portuguese seamen were also exploring the northern Atlantic and probably discovered some of the Azorean Islands around 1427. A definite colonization of the islands, however, can be attributed in 1432 to Friar Gonçalo Velho, one of the commendators of the military Order of Christ (Peres 1959:37; Marques 1976:148; Diffie and Winius 1977:58).

By the time the Portuguese gained and sustained control of the Moroccan city of Ceuta, they dreamed of controlling the sources of gold in the Upper Niger and Senegal rivers. Perhaps at this point they sought to access those sites via coastal routes in order to

redirect the gold trade from the caravans of the western Sudan and the Muslim intermediaries of Barbary. There was good incentive for this, since gold was scarce in western Europe during this era (Boxer 1969:19). Another reason to press on along the coast of Africa was to search for the mythical Prester John, a rumored potentate who ruled beyond Muslim territory in Ethiopia and held a great Christian empire. This was a strategic approach in the mind of the western Christian king: with the discovery of this elaborate kingdom deep in the realm of the infidels and the subsequent combination of forces from the West, the Muslims, continuously advancing west and threatening Constantinople and eastern Europe, could be attacked from the east and thoroughly annihilated (Diffie and Winius 1977:36).

Motivation of the Infante

Often cited as the trailblazer of European discoveries, the Infante Dom Henrique—known popularly as Prince Henry the Navigator—was responsible for initiating and then supporting many of the voyages of discovery along the northwestern coast of Africa during his lifetime. The fifth son of King João I and his queen, Princess Phillippa of Lancaster, Henry took his royal duties to heart and was highly lauded by the chronicler Azurara in his accounts. According to the chronicler, after Ceuta was taken by the Portuguese, Henry continually kept armed ships at the African port city. The objective was twofold: constant preparation for war against marauding infidels; and to obtain knowledge of the lands that lay beyond the Canary Islands, particularly the mysterious Cape Bojador, a jutting promontory not previously reached by sea (Figure 2-2; Azurara 1966:27). Henry appears to have been genuinely concerned with the

discovery of these lands, "and seeing no other prince took any pains in this matter, he sent out his own ships against those parts, to have manifest certainty of them all" (Azurara 1966:28).

Whether the Prince's primary motives were the advancement of geographical and scientific knowledge, conversion of heathen subjects to Christianity, thirst for Guinea gold, Portuguese expansion, slave trade, utter destruction of his enemies, or combination of these goals, is debated even today. There is considerable doubt among scholars that Henry was scientifically erudite, or even "surrounded by scientists," as is often claimed. It is possible, however, that he had a navigational chart maker named Jacome de Mallorca, the son of the author of the Catalan map of ca. 1375, Abraham Cresques, in his company. There is also contention over the existence of Henry's famous school of navigation at Sagres, which is not mentioned in the annals of the chroniclers, and has been related by the scholar Duarte Leite as a myth coming to England from France, completely devoid of fact (Leite 1958:16; Diffie and Winius 1977:115).

Despite the contending views of Henry's scholastic life, the prince had an encouraging and influential hand in the voyages of discovery, as described by Azurara in his chronicles. Although Henry ostensibly had many reasons to continue sending knights and squires south along the African coast in lateen-rigged caravels and square-rigged lapstrake *barchas*, the prime focus in his life seems to have been on military campaigns in Granada and Morocco, where he dedicated the majority of his time and resources. The voyages of discovery, no doubt interesting to the prince, were likely regarded primarily as a path to augment his revenues, perpetually exhausted by his military and political

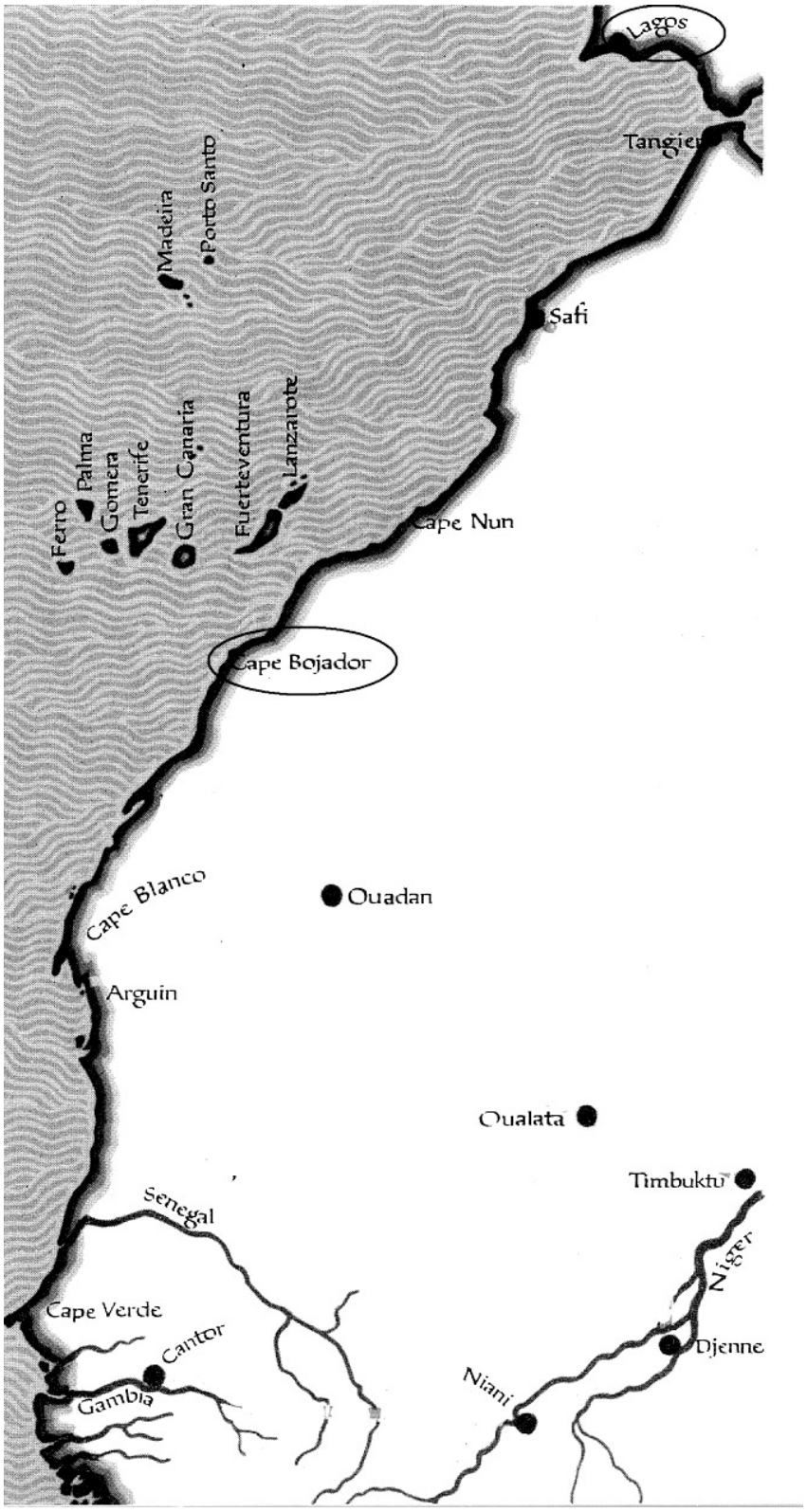

FIGURE 2-2. The African coastline and Cape Bojador (After Landström 1964:167)

ventures (Marques 1976:143; Oliveira 1991:76; Barker 1992b:435; Castro 2008:73).

Initial Voyages of Discovery and Slave Raiding

Chroniclers disclosed that the "Navigator"—an appellation designated to him by a 19th-century English writer and admirer of Henry—sent vessels south along the African coast from as early as 1419 in search of new lands and their inhabitants (Scammell 1981:228). His first alleged goal was to reach Cape Bojador, a nightmare for Henry's navigators who had all heard the horror stories involving the shallow and tempestuous Sea of Terror and the desolate lands that were devoid of trees, herbs, water, and human habitation (Figure 2-2). These were widespread rumors disseminated by Spanish mariners, according to Azurara. In the first 12 years of Henry's campaign a series of voyages along the coast were undertaken. Henry sent his *barchas* and *barinéis* on their southerly journeys year after year, spending vast amounts of his revenue for the cause. Although all of these ships returned without ever reaching Cape Bojador, Henry was patient with these early attempts and rewarded the captains well, often sending them back out or finding other, braver souls for the daunting quest. Finally, after a dozen years of failed endeavors, the prince armed a *barcha* for his squire Gil Eanes and once again organized an expedition to the insurmountable Cape Bojador. Eanes only made it to the Canary Islands on his first voyage, seized by the same fear as previous explorers, and returned to Portugal in 1433. Prince Henry, upon the squire's return, injected his fervor into the mind of Eanes and sent him out yet again in his *barcha* to the jutting cape in 1434. This time Eanes doubled the cape and found the lands beyond it very different from what he had imagined (Azurara 1966:31-33).

Breaking the psychological barrier that had prevented so many early explorers from traveling further down the western coast of Africa, Eanes's famous voyage initiated a breakthrough in future expeditions, which advanced much faster than the previous ones (Diffie and Winius 1977:68). On a third voyage, Eanes was accompanied by another captain, Affonso Gonçalves Baldaia, in a *barinel*. This time they passed an alleged 50 leagues (241 km) beyond Cape Bojador, finding not inhabitants but footprints of men and camels, before they returned to Portugal. In 1436, Baldaia was sent by Henry to return to the lands beyond the cape and bring back some of the natives. He sailed even further, a reported 70 leagues (338 km) past the previous voyage, and finally had an encounter with the natives. There was a short scuffle, but Baldaia was not able to return with any captives. Instead he found a herd of sea lions and brought back their skins as a sort of compensation for his failed attempt (Azurara 1966:34-38).

Even though progress was being made in terms of distance covered down the coast of Africa, certain other events within Portugal caused a hiatus in the voyages of discovery. In 1437, charged with commanding the armed fleet, Henry went to Tangier on a military expedition against the Muslims. A disastrous event, the Portuguese were cut off from their vessels upon arrival, and much of the army was captured, including Henry's brother Fernando. The following year, King Duarte died from an outbreak of plague. His heir, Dom Pedro, was only six years old. Queen Leonor was appointed regent, but Pedro's half-brother Afonso, count of Barcelos, also wanted a hand in influencing the young king. Henry found himself engulfed in the drama within the courts and, "toiling for peace and good settlement of affairs" (Azurara 1966:39), did not send

any further ships beyond the cape for some time. Between 1436-1441, two voyages were made down towards Cape Bojador, but there is no account of these journeys (Azurara 1966:38-39; Livermore 1976:112-113; Serrão 1998:259).

Exploration resumed in 1441 with Antão Gonçalves's trip to Guinea, which was at that time a generic term for west African coasts, islands, and lands reaching beyond Cape Bojador. Gonçalves returned from this travels with two slaves, a male and female Moor. From this point on, the only type of ship mentioned in the *Chronicles of Guinea* as being used for exploration is the *caravela*. The *barcha* and the *barinel*, discussed in more detail in the next chapter, lost favor to the lighter, longer, and higher lateen-rigged caravel, which was able to handle the shallow coasts and high winds of the increasingly longer journeys southward (Figure 2-3). Following Gonçalves's return, Nuno Tristão and Gonçalves were sent back in their caravels to explore beyond the Pedra da Galé, the furthest point yet traveled. Tristão was told by Prince Henry to go as far as he possibly could, and "bestir himself to capture some people" (Azurara 1966:44). Tristão, Gonçalves, and other knights joined together, ambushing the natives and taking 10 captives including men, women, and children.

So began the slaving voyages of the 1440s, during which hundreds of Moors were captured by the Portuguese explorers and transported to Lagos. Granted a league of territory in the Algarve by his brother Pedro, Henry began the construction of his Villa do Infante, which became a town thriving with slaves. Once the skeptics of the discoveries witnessed their neighbors' houses full of slaves, many changed their stances

and began to praise Henry and join the ventures for profit. Since most of the Moors were initially taken to Lagos, this is where interested opportunists first sought licenses

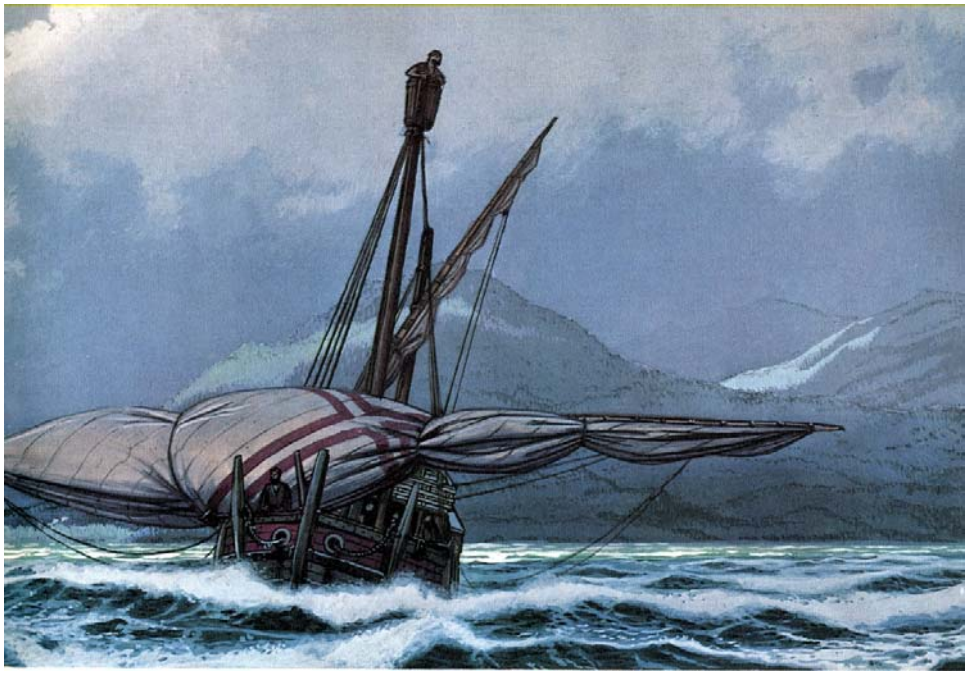

FIGURE 2-3. Caravel in a squall off the coast of Sierra Leone (After Landtröm 1964:197)

from Henry to make voyages to the western coasts of Africa in search of prisoners. Lançarote da Ilha, collector of royal taxes in the Port of Lagos, was the first of these adventurers to obtain a license, and was ordered by Henry to hoist the banner with the Cross of the Order of Jesus Christ on each of his six caravels. In 1444, he sailed to the islands just beyond Cape Blanco and, after a few engagements with the largely unarmed and defenseless natives, returned to Lagos with 235 prisoners, a customary fifth of which went to Henry according to the stipulations set forth in the monopoly he received from the king in 1443 (Azurara 1966; Diffie and Winius 1977:80). These slave raids—

conducted in a very similar manner—continued throughout the 1440s, and were paramount in helping to finance the early voyages of discovery. After some years of contact with the peoples of Senegambia and Upper Guinea, the Portuguese found that it was much easier to procure slaves by simply bartering with local chiefs, since they were nearly always ready to sell their own captives or condemned criminals for profit (Boxer 1969:25).

By the mid-1440s Portuguese merchants and slave-hunters began to establish *feitorias*, or trading posts, on African shores. This obviated the need to do all their business from their anchored vessels. The first one was built at Arguim for the purpose of exploiting the trans-Sahara trade of the western Sudan. Ten years later a castle was built there, and the Portuguese exchanged commodities with the Moors at Arguim. This system was fairly efficient and eventually became a prototype of the many *feitorias* that the Portuguese later built along the African and Asian coasts, reaching as far as the Moluccas in South East Asia (Boxer 1969:25).

Due to the accelerated activity along the African coast, Henry was granted an additional monopoly on the lands beyond Cape Bojador in 1446. The Infante's exclusive control forced anyone who went to those regions to pay Henry the customary fifth of whatever profits were gained on their ventures. Very much active in his own right, the following year he sent yet another foreign adventurer, "Vallarte the Dane", beyond Cape Bojador on a mission involving a treaty with the Christian king in the Negro lands. This expedition shows that the belief in Prester John was still very much alive and of prime importance to these later voyages. The undertaking was a failure, however, and

Vallarte's caravels returned to Portugal without him. By the time Azurara ended the *Chronicles of Guinea* in 1448, 51 vessels had gone beyond Cape Bojador in recorded voyages, and approximately 927 slaves had been taken from those regions (Diffie and Winius 1977:90).

Further Advancements along the Guinea Coast and the Voyages of Cadamosto

Another hiatus in the progress of exploration may have ensued during the following decade or so, for the next surviving written evidence regarding a new Portuguese discovery does not appear until 1462, when Pedro de Sintra sailed beyond Sierra Leone. Real progress along the African coast did not resume until the royal contract made with Fernão Gomes in 1469. From 1451-1454, Portugal was at war with Castile over the Canary Islands. Another reason for this pause is the time and resources spent for an expedition to Alcácer Ceguer in 1458. Prince Henry's financial resources were gradually dwindling, making it difficult to fund new voyages down the coast of Africa (Crone 1937:xxi). Despite the lack of dedication to new discoveries along the African coast during this period, there were some noteworthy journeys made in the 1450s, particularly by the Venetian nobleman Alouise da Cadamosto and the Portuguese Diogo Gomes.

Cadamosto was a Venetian adventurer who participated in the Portuguese discoveries, and is historically important on account of his published journal, *The Voyages of Cadamosto*, which relates his expeditions to Africa and some of the Atlantic islands. Agreeing to the terms of Henry's monopoly on the lands beyond Bojador, the young Cadamosto prepared for adventure on the high seas, writing "…after many days

he [Henry] had a new caravel fitted for me, of some 90 *botti* burden [about 40 *tonéis* burden], the patron of which was one Vinzente Dies…"(Crone 1937:6). During his first voyage in 1455, Cadamosto traveled to Porto Santo, Madeira, and the Canary Islands, describing the Canaries and its inhabitants, the Guanches, in clear geographical detail and with great interest. Subsequently, he and the accompanying caravels sailed to Cape Blanco and further south to the mouth of the Senegal River and Cape Verde. The following year Cadamosto again set out to Guinea in caravels, traveling to the Gambia and possibly discovering the Cape Verde Islands (Figure 2-4).

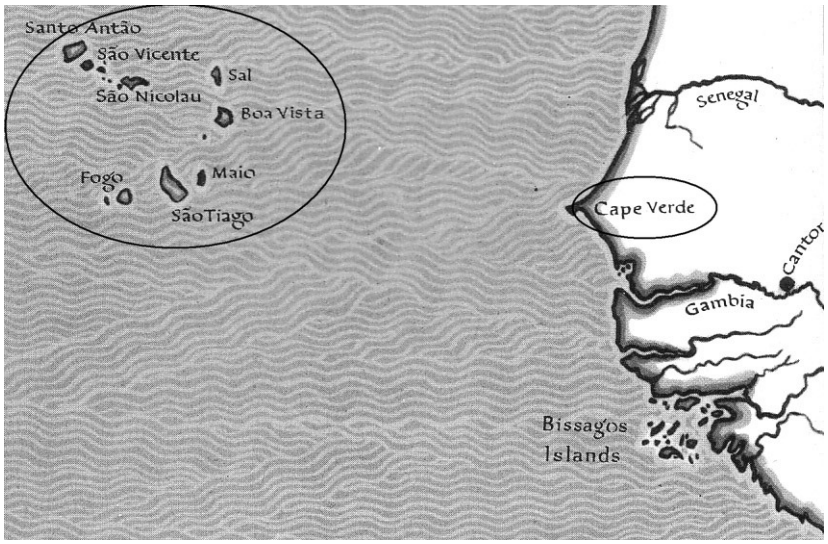

FIGURE 2-4. Cape Verde Islands off the western coast of Africa (After Landström 1964:179)

Diogo Gomes, sailing under the Portuguese banner during the same years as Cadamosto, journeyed to the Rio Grande north of the Gambia Territory, and relates in his journal the success he had acquiring a small quantity of spices in that region. He also describes some geographical features of the area, and at Cantor he inquired about the

trade routes to Timbuktu and Kukia. Sometime between 1458 and 1460, he made a second voyage, during which he too claims to have discovered the Cape Verde Islands (Crone 1937:xxv-xxvi).

Additional Voyages of Discovery

By the time of the Infante's death in 1460, the Portuguese had reached as far as Sierra Leone and the Gulf of Guinea, believing it was the southernmost tip of Africa, and thus that India was quite close. As Prester John was sought from the west and south, the Portuguese may have been convinced that he and his kingdom, which would undoubtedly join the Portuguese forces to crush the Muslims from within, were just around the corner. The Portuguese participation in the crusade helps explain their incentive to continue the voyages of discovery in search of Christian forces. In spite of this impetus for exploration, King Afonso V (1448-1484) was also engaged in new conquest in Morocco. Therefore, during the 1460s and 1470s, more attention was paid to this goal than prospects of reconnaissance (Marques 1976:163). In November 1469, a contract was made between the Portuguese crown and Fernão Gomes, providing him exclusive commercial rights to the discovery of lands beyond Sierra Leone, where Pedro de Sintra and Soeiro da Costa had left off. There were some limitations, but this five year contract obligated him to discover 100 leagues along the coast per year. By the end of his contract, the captains and explorers in the service of Gomes had discovered African coastline as far south as Cape Catarina, as well as some Atlantic islands—including São Tomé and Príncipe (Barros 1932:chap. 2; Peres 1943:144-149).

In 1474, King Afonso V appointed the prince Dom João as the superintendent of African exploration, charging him with the investigation of Guinea and the seas, lands, people, and things relating to it (Peres 1943:173). This was the beginning of a new explosion of Portuguese exploration and discovery, as the future king of Portugal initiated his career in expansion. Dom João II (1481-1495) was crowned in 1481, and he immediately set out to achieve his expansionist goals. After the grand fortress at São Jorge da Mina on the coast of Guinea was built, King João II assumed an additional title beyond that of King of Portugal and of the Algarves—he now claimed also the title of Lord of Guinea. Additionally, King João II hoped to enlist the assistance of the elusive Prester John, who would help him secure the Indies trade from Venice and Islam. Some historians claim that to discourage foreign competition, the king circulated the rumor that only lateen-rigged caravels could hope to return from the Guinea coast. It is likely that at this time, only shipbuilders from the Iberian Peninsula were constructing caravels, and most of these were built in Portuguese ports (Sanceau 1967:32-35; Humble 1978:36).

In 1482, King João II ordered Diogo Cão to sail along the coast of Africa as far as he could and to take along with him the first of the granite pillars, or *padrões*, which were to mark the nautical landfalls of the Portuguese explorers. Cão planted the first *padrão* at the estuary of a river the Portuguese named Rio do Padrão. This pillar, standing at the height of two men, had a shield with the arms of Portugal engraved on it, and was capped with a cross. Around the pillar were inscribed the names of the king and his captain, along with the date of the expedition. A second *padrão* was erected further

down the coast as far as Cape Santa Maria. Cão then returned to Portugal, bringing with him natives of the lands he had visited. He reported that he had seen the coast of Africa running east, and therefore he must have reached the end of Africa. Returning on a second voyage in his caravels, Cão found that the coast continued to unfurl, and he eventually turned back (Sanceau 1967:35-39).

Monumental Discoveries

Following the voyages of Diogo Cão, King João II decided to send more expeditions to find the end of Africa and reach India and Prester John. Two of these were land expeditions, meant to add to the geographical knowledge of Africa and find links to Prester John. Pedro da Covilhã and Afonso de Paiva were ordered to travel to East Africa and collect information about sea routes and supply ports on the coasts of the Indian Ocean, while the navigator Bartolomeu Dias was sent to circumnavigate the continent. Although neither Covilhã nor de Paiva returned to Portugal, Covilhã did send word of his journey, claiming that ships could definitely reach the extremities of Africa if they sailed far enough along the Guinea coast—an affirmation that Dias would confirm with his voyages of exploration (Brendon 1929:61).

Since the voyages were becoming increasingly long, and depletion of provisions was becoming a grave issue, Bartolomeu Dias prepared arduously for many months at sea, choosing two 50 *tonéis* caravels and a *naveta*—a small ship loaded with supplies—for his mission. Departing from Portugal in 1486, Dias led his vessels far south along the coast, diligently recording and naming new points as they passed them. At 29 degrees of latitude, Dias and his caravels were prevented from continuing due to adverse winds

blowing south south-east. After five days, they decided to take a course which rounded the headwinds and converged with the trade winds. Sailing for 15 days, 300 leagues away from land, then south to 40 degrees of latitude, the fleet turned east and south toward the coast of Africa once again. Finally, turning north at some point, they sighted a coast, which they followed north-east. Pushing on, despite severe disapproval from his crew, Dias finally found a cape that was initially named the Cape of Storms, ultimately marking the end of Africa. Later, at the insistence of the king, this cape was renamed the Cape of Good Hope, signifying the potential of further expeditions to reach India along this route (Sanceau 1967:41-44). Because of his ailing health and the political crisis that preceded his death, King João II was not able to send another fleet to reach India during his lifetime—although this was on his agenda (Greenlee 1967:xv).

Meanwhile, another navigator was preparing for an unprecedented voyage. Christopher Columbus's plan, which was formed in his mind at an early age probably while working as a cartographer in Lisbon, was to reach Japan by sailing west and to discover other islands on the way. This idea was first presented to King João II in 1484, who, after conferring with his advisors, which included two Jewish physicians of reputed skill in celestial navigation, turned the plan down. There were several possible reasons for this, but the physicians may have had a more accurate vision regarding the distance to be covered than did Columbus. Moreover, at this time King João II was more interested in completing the circumnavigation of Africa, which seemed to almost be in plain sight. Deciding to try his luck with the Queen of Spain, Columbus sought council with Isabella, who received him in 1486. Although she turned him down more than once,

after nearly six years of reviewing the possibilities of the project, she eventually followed her instincts and agreed to back him (Wright and Rapport 1957:84).

The town of Palos, Spain, provided Columbus with the necessary ships, which were initially supposed to be three caravels. *Santa Clara*, more commonly known as *Niña*, was a locally built caravel and would become Columbus's favorite ship, which he repeatedly praised in his logs (Figure 2-5). *Pinta*, another caravel a bit larger than *Niña* and square-rigged from the beginning, was also locally built. Because the third caravel was delayed in its arrival, Columbus decided to charter a ship from Galicia that was in port. The owner and captain of this vessel was Juan de la Cosa, who became an important member of the expedition. *Santa María*, actually a *nau*, became Columbus's flagship (Wright and Rapport 1957:87).

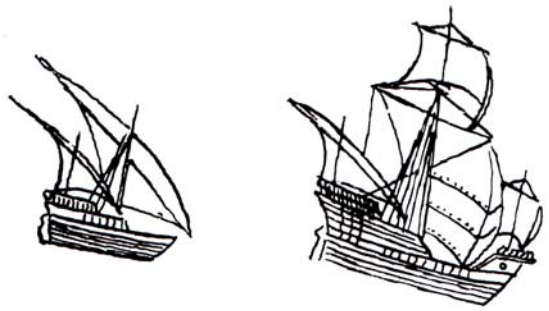

FIGURE 2-5. Drawings of a caravel and *nau* by Christopher Columbus (After Fonseca 1934[2]:6-7)

The three vessels departed from Palos on 3 August 1492 and headed toward the Canary Islands, where a brief stopover was warranted for repairing *Pinta's* rudder and restocking provisions (Morison 1942:163). Other than this short respite at the Canaries, the admiral and his crews sailed non stop for two months across the Atlantic Ocean

without detecting coastline. On 11 October 1492, Columbus's fleet sighted land and disembarked at San Salvador, one of the islands in the Bahamas group. In the following months Columbus traveled to Hispaniola, where he was unable to locate any of the cities described by Marco Polo. Since there was no reason to think otherwise, he determined he had reached a remote expanse of Japan. In any event, the existence of a new continent between Europe and Asia was an oddity and, despite having led four expeditions to the West, Columbus never truly understood the extent of his discoveries, and died unaware of the existence of either North or South America. And although Columbus is often credited for discovering America, it is possible that sailors from Bristol first touched the coast of North America while searching for the island of Brazil, far to the west of Ireland. If the Grand Banks off Newfoundland were not first stumbled upon by these mariners in the early 1490s, they were found by the Italian navigator Giovanni Caboto—John Cabot—in the service of Henry VII of England, when he coasted the southern shoals there in 1497 (Brendon 1929:54-56; Penrose 1952:144; Wright and Rapport 1957:80). Nevertheless, Columbus's expedition was important, gutsy, and lofty, proving the capability of these far-flung voyages. Moreover, the discovery of the Americas jumpstarted other Portuguese advancements to India and expedited the famous voyage of Vasco da Gama only a few years later.

The ten year interval between Dias's and da Gama's voyages has never been fully explained, but was certainly due to a multitude of events, including the death of King João II and the succession of King Manuel (1495-1521). It has also been suggested that information on favorable winds to the Cape of Good Hope may have been collected

during that period, for da Gama did not use Dias's route on his expedition (Parry 1963:139). Furthermore, da Gama's undertaking was ambitiously planned as an armed mercantile envoy and not a voyage of discovery. His fleet consisted of two *naus* of approximately 100 to 120 *tonéis* burden, a caravel of 50 *tonéis*, and a small store-ship. The recommendation to use these roomier, square-rigged *naus* with high castles fore and aft was put forth by Dias, who willingly lent the bulk of his experience to the planning of the expedition. In fact, Dias accompanied da Gama for part of the voyage in his own caravel, providing knowledge and insight to the campaign. Departing Lisbon 7 July 1497, the fleet sailed first to the Cape Verde Islands, where it stopped for a short time on 27 July. From there, the ships traveled along the African coast, avoiding treacherous winds and currents when possible, bearing south-westward until reaching within 600 miles of the South American mainland, then turning to the south-east and gradually beating back against the trade winds until they anchored at an inlet they named St. Helena Bay on 7 November. Da Gama had sailed 4,500 miles from the Cape Verde Islands at this point with no sight of land. This was the longest of such voyages, outdistancing Columbus's voyage from the Canaries to Watling by 1,900 miles (Brendon 1929:65; Parry 1963:140).

After a brief stay to clean the vessels and repair rigging, the fleet took off for the Cape of Good Hope, which they doubled on 22 November. Battling scurvy, weathering harsh storms, and making multiple stops along the way, da Gama finally reached the island of Mozambique on 2 March 1498. Their reception was initially cordial because the Arabs in Mozambique thought the European voyagers were actually Turks. The tide

changed, however, when a seasoned Moorish merchant reported that these were actually Portuguese Christians, the very same conquerors of Arzilla and Tangier. It was also in this port that da Gama started looking for a reliable Arab pilot to take him to Calicut, which he was told was some 900 (5,000 km) leagues away. After bombarding the Sultan's village at Mozambique, to prove they were unafraid of the threats hurled by their mortal enemies, the Portuguese commander set out for Mombasa to find a better pilot for Calicut. Thus, the Portuguese began their hostile presence in the Moorish territories of southern Africa and the Indian subcontinent (Sanceau 1967:81-90; Jones 1978:58).

On 15 April 1498, the Portuguese fleet reached Malindi, where da Gama finally found an able Arab pilot, Ahmad Ibn Majid, who could take him to his destination. On 20 May, they put in at Calicut, the lavish city of the Malabar Coast, ultimately ending the quest that arguably began with the conquest of Ceuta in 1415 (Lopes de Mendonça 1924:10).

Although numerous additional voyages took place and new lands and opportunities were discovered by the Portuguese and Spanish, the expedition led by Vasco da Gama effectively ended the voyages of discovery and the initial quests for India and the spice lands. Vasco da Gama, who carried with him a letter from the king of Portugal for Prester John, was unable to find the legendary potentate and confirm his existence beyond the Moorish lands. He did, however, begin the belligerent relations with the Arabs that would characterize the Portuguese presence on the Indian Ocean during the following centuries.

It is in the historical context briefly outlined in this chapter that the ships of discovery are studied by maritime historians and nautical archaeologists. This perspective is vital in comprehending how and why the Portuguese became such successful seafarers, and ultimately how they developed and utilized the caravel for their ambitious expansionist objectives. In the end, it seems to have been the rise of the Portuguese middle class and the gradually developing seafaring nation, both derived from fishing and trade, which prompted the need for expansion. This, in turn, led to a technological advancement in shipbuilding. The uncharted waters of the Atlantic and the rocky coasts of Africa forced shipbuilders to develop vessels that were capable of sailing in the high seas in foreign territory. The gradual transformation of the caravel from a small ship tender to an oceanic voyager was one significant occurrence that led the Iberian nations to the forefront of European overseas expansion.

CHAPTER III

SHIPS OF DISCOVERY

Maritime expansion depended, at least partly, on the technology required to produce ships capable of making extended voyages. The combination of preferred features was delicate because ships of exploration had to navigate in the open sea as well as on rivers and coastal waters. The vessels were to be seaworthy yet compact enough for a small crew to handle, since water and provisions were limited on lengthy trips (Smith 1993:30). For generations prior to the first European voyages of discovery, Portuguese mariners and fishermen made increasingly longer excursions in search of fish, seals, whales, and other commodities. At times, they entered African waters and beached on foreign ground if they thought the risk warranted the profit. Steadily their navigational skills increased, and ships became more adaptable for this kind of coastal voyaging. Gradual technological advancements in ship design led to the production of vessels able to sail in harsher oceanic conditions, to reach further into unexplored waters and coastlines, and to return home intact. As a response to an increasing commercial interest in maritime trade and exploration, additional developments in shipbuilding eventually resulted in advanced sea-going vessels which were, in effect, the ships of discovery (Marques 1976:137-138).

Fishing vessels were mostly used in initial excursions to the northwestern coast of Africa. These craft had been sojourning to this area on fishing trips before oceanic exploration was even considered by Portuguese noblemen (Unger 1997:237, chap. 12).

Such ships, principally *barchas* and *barinéis*, must have been sturdily built and with considerable freeboard, designed to handle the mechanical torsions forced on their hulls by deep sea navigation and along the Atlantic seaboard (Bellec et al. 1993:110).

Barcha

A common term found in archival documents, *barca* has caused much confusion for scholars because it may have been a general descriptive term, used for several different ship types over a wide range of time. First mentioned in Portuguese documents in A.D. 911, it was used as a generic word for vessel, and had already been known by Saint Isidoro, in his *Etymologiae*, at the beginning of the seventh century (Pico 1963:34). *Barca* was designated, at least initially, to craft of relatively small tonnage which may have served as ship tenders. According to Admiral Brás de Oliveira, the *barcha* likely originated in northern European nations, and stemmed from the *drakars* and *snekkars* of the Scandinavians and Normans. The Viking ships were double-ended and had one mast which hoisted an enormous sail. They were steered with an oar on either side, and later adopted a rudder with a tiller operated by a rope. The Normans were known to have visited the coasts of the Peninsula, and the ships of the Crusaders often came to Portugal to assist the Portuguese monarchs in the wars against the Moors. This kind of ship, capable of sailing the Atlantic if necessary, may be an example of a *barcha* prototype used along the coast of Africa for exploration (Brás de Oliveira 1940:18; Christensen 2001:81).

Although Lopes de Mendonça agrees the *barcha* originally came from shipbuilders of northern Europe, he does not think the terms *barca* and *barcha*

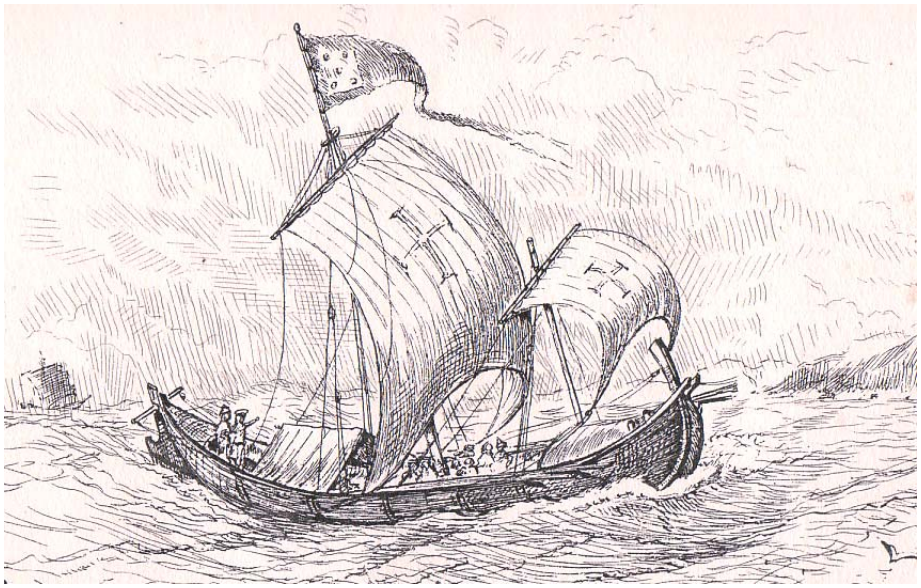

FIGURE 3-1. Conjectural rendition of a *barcha* under sail (After Brás de Oliveira 1940:6)

refer to the same vessel type in archival documents. He points to accounts by the chronicler Azurara, in which a *barcha* was fitted out for the explorer Gil Eanes. In the *Chronicas do Conde Dom Pedro e do Conde Dom Duarte*, however, the word *barca* has a different meaning: a cargo vessel used by Castilians, Moors, and Portuguese in the Strait of Gibraltar. One passage in these chronicles refers to a *barca* of 30 *tonéis* which carried 60 Moors and 62 horses, indicating a more capacious vessel built for transport rather than exploration (Lopes de Mendonça 1892:12).

This school of thought, however, has more recently been dissolved by scholars of Iberian seafaring. The appearances of the terms '*barca'* and '*barcha*' in archival documents through the ages indicates that these are likely orthographic variations of the same word, though '*barcha*' does not seem to emerge until the 15th century. As mentioned above, '*barca*' was used in documents as a generic designation for a boat of smaller capacity, while '*navio*' was commonly used for vessels of larger capacity,

though this was not always the case. In archival records from the 12th to the 19th centuries, *barcas* appear in all dimensions and with diverse functions. In the 13th century, *barcas* are seen as cargo transporters, and later in the 14th century they were being named for their specific services: *barcas de carga* (cargo), *de carreto* (freight), *do condato* (tax collection), *de congregar* (sea eel fishing), *de mercadorias* (merchandise), *de mercee* (fish monger), *da passagem* (passenger transport), *de pesca* (fishing), *de sardinha* (sardine fishing), *de sal* (salt transport), *seeira* (fishing vessel), and *taberneira* (vintner). The fact that these boats were generally of small size is evident in period documentation. A 15th-century document from the chronicler Fernão Lopes refers to *barcas* as vessels of small capacity: "as barcas erã navios pequenos". Similarly, the chronicler Azurara considered a *barca* of 30 *tonéis* from a document dated to 1293 as large (Pico 1963:41-50; Domingues 2005; Castro 2007, pers. comm.).

In the chronicles from the Age of Discovery, the *barcha* that was used for exploration was perhaps between 15 and 30 *tonéis* and was primarily a sailing vessel with one or possibly two masts fitted with quadrangular sails. It also, however, facilitated the ancillary use of oars. A sketch of a *barcha* was designed by Bràs de Oliveira in the late 19th century, but it is a largely inaccurate rendition due to the lack of knowledge concerning this ship type (Figure 3-1). The *barcha* was partially decked, if at all, and the extremities were probably fine like many contemporary fishing boats. Steering was enabled through a tiller, and the ship may have been manned by 14 or 15 sailors (Bellec 1993:112; Smith 1993:37). It is important to note that these characteristics are largely conjectural, deduced by scholars from scant descriptions found

in archival records. Despite the abundant occurrence of the term '*barca*' in such documents, little is actually known of the appearance or operation of these ships. Few, if any, real inferences can be drawn regarding specific traits of the *barcas* of discovery, including the type of rig they employed (Domingues 2005). In the 1580s, over a century after they were used for exploration, Fernando Oliveira mentions *barchas* being similar to the *trincados de Galiza*, or lapstrake vessels from Galicia, which may have been influenced from northern European shipbuilding practices (Oliveira 1991:76; Barker 1992:435; Castro 2008:73).

The small scale of the *barca* is evident from a passage in which the 16th-century historian João de Barros recounts the voyage of Gonçalves Zarco, "…before they arrived at the African coast, it flew about, short-lived in the contrary winds on its voyage, that they feared for loss of life, because the ship was too small, and the sea too vast…"(Lopes de Mendonça 1892:15). The most famous voyage involving this early ship of exploration is the doubling of Cape Bojador in 1434 by Prince Henry's squire, Gil Eanes, a feat which effectively dispelled for navigators many myths surrounding the dreaded Sea of Terror (Bellec 1993:112).

Barinel

Interpreting the historical texts without any sound iconographic or archaeological evidence, some historians have sustained that the *barinel* (plural *barinéis*), being larger and sturdier at 60 to 90 *tonéis*, gradually replaced the *barcha* as voyages along the African coast were extended. Few details are known about the *barinel*, but it may have been shearer at the fore than the *barcha*, forming a loftier bow which made it a more

suitable opponent against the forces of the open sea (Bellec 1993:113). It drew more water than the *barcha*, had a launch boat, and probably was fitted with more than one sail, an uncommon rig at the beginning of the 15th century. It has been suggested that the vessel had a quadrangular sail and possibly a lateen sail, although this is contended by some scholars, who reserve the inception of the lateen sail during the Age of Discovery for the caravel (Lopes de Mendonça 1892:17). After 1450, it may also have had a square transom to facilitate a large rudder, and the stern may have had an awning to serve as shelter (Brás de Oliveira 1940:20).

It is possible that this type of vessel also had oars with which to navigate in calm weather, although this idea is challenged by Lopes de Mendonça who refers to a passage from Azurara in which a *barinel* was towed into port by a *galeota* until it could anchor close to the sand bar. Lopes de Mendonça reasons that if the *barinel* had oars, it would not need to be drawn inland by another vessel (Lopes de Mendonça 1892:17). It is likely that *barinéis* were originally propelled by both oars and sail, but as they grew in size the oars were abandoned (Unger 1997:223, chap. 12).

The origin of the *barinel* may lie in the countries of northern Europe due to its parallel to the English "balener" and the belief that the ship had a truncated side, common in the Bay of Biscay, where it was likely used as a whaler. Conversely, it may have had Mediterranean roots, considering the similar Greek word *baris* and the fact that *barinéis* of 90 to 130 *tonéis* were used in the Mediterranean by 1440-1459 (Lopes de Mendonça 1892:17; Bellec 1993:113; Elbl 2000:92).

Bartolomeu and António de Noli, when in the service of Prince Henry, brought a *barinel* that was purchased in Genoa for the purpose of exploring the coast of Africa. When Henry sent Gil Eanes back to Cape Bojador in his *barcha*, he also sent Afonso Gonçalves Baldaia to follow along in a *barinel* (Brás de Oliveira 1940:20). Although these ships were used for exploration for over a century, they were rarely mentioned even by chroniclers and never were favored for voyages to Africa (Unger 1997:232, chap. 12).

As the Portuguese produced northern-influenced fishing craft and cargo vessels during the High Middle Ages, they also absorbed Mediterranean shipbuilding traditions. As mentioned above, we know that as early as the 14th century the Portuguese crown imported Genoese sailors to improve naval forces for their battles against the Muslims. At the same time these Mediterranean shipbuilders may have showed the Portuguese how to build and use galleys using a frame-first method of construction, opposite from the shell-first method mastered by the northern Europeans. Mediterranean lateen-rigged galleys were an essential part of Portuguese naval forces in the 14th and 15th centuries, and the same shipbuilding techniques were used to build other types of vessels as well (Unger 1997:235, chap. 12; Roberts 2000:12).

Caravela

Like the *barcha* and *barinel,* the *caravela* was also a work vessel, and was primarily used for fishing before it was used for reconnaissance. Throughout its 500 years of recorded history, the ship developed into a multitude of sizes and forms. If the earliest version was set side by side with the latest version, there would probably be little

resemblance. There are several distinct types that will be discussed in the next chapter, based largely on historical documents and iconography, but the *caravela latina* seems to have been the principal ship of exploration and discovery.

The origin of the caravel is nebulous and subject to debate, but the name *caravellum* shows up in Genoese documents as a ship tender in the middle of the 12th century (Ciciliot 1998:72). Portuguese records written in 1255 from the *foral* of Vila Nova de Gaia refer to caravels of light tonnage used for fishing (Elbl 1985:546; Smith 1993:35). By the time they were used to explore the west coast of Africa, they had been in use as fishing vessels on the Iberian Peninsula for at least 200 years. This suggests that by the middle of the 15th century, these ships were fully decked and had two, three, or four masts, which were fitted with lateen sails (Figure 3-2). Although some authors suggest that this type of vessel may have had earlier ties to the Portuguese *barinel*, it is not known if this was ever a fact. It is apparent that the caravel gradually replaced some of the functions of the *barinel* through time, however, eventually replacing it entirely as a ship of discovery (Elbl 1985:549).

As fishing vessels, caravels were probably at least partially decked, had a single sterncastle, and were fitted with one or two masts carrying lateen sails. Due to its small size and shallow draught, this craft was presumably efficient in coastal and riverine fishing expeditions but perhaps not designed to sail in the high seas. Caravels seem to have had a number of oars for maneuvering when harnessing available wind was not an option (Smith 1993:38).

The vessel's attractive characteristics—shallow draught, windward sailing ability, speed and maneuverability—inspired its adaptation for longer voyages; and in time the ship replaced the more conservative *barchas* and *barinéis* of earlier expeditions. Despite such adverse traits as small capacity, slight scantlings, and possibly also the need for a relatively large crew to operate the lateen sails, the caravel was better suited for the open seas and longer voyages. It seems to have been approximately 50 *tonéis*, from 20 to 30 m in length, and 6 to 8 m in breadth. Its combination of lateen sails, fine lines, shallow draught, and axial rudder eventually produced a very efficient sailing ship (Smith 1993:38,41; Martínez-Hidalgo 1957).

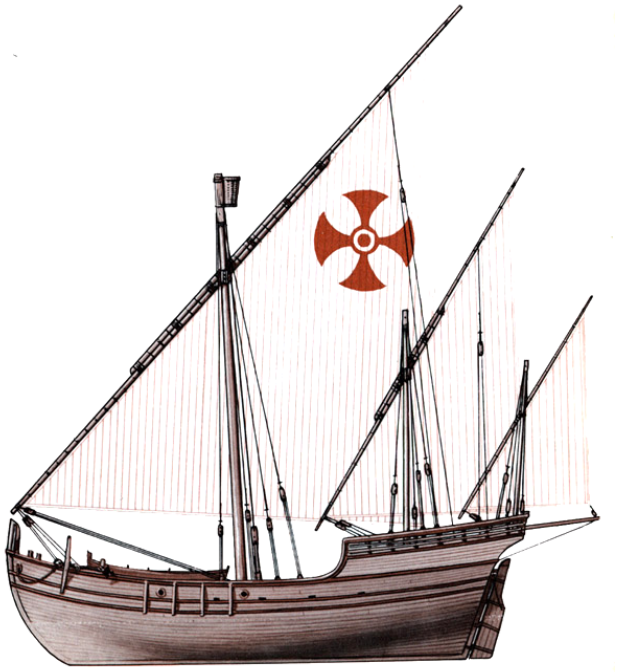

FIGURE 3-2. *Caravela latina* (After Landström 1961:107)

Beginning around 1440, *caravelas latinas* were being used to explore along the western coast of South Africa. After Gil Eanes doubled Cape Bojador in his *barcha*, the caravel was used extensively for exploration until the end of the century. In 1441, the Portuguese began using caravels for slave trade along the African coast. The change in ship type from earlier vessels seems to be related, at least in part, to increasingly larger availability of ships of this type, and their relatively smaller crews, which allowed for better transportation of thier slave cargos. The design was probably improved upon throughout the 15th century, and the ships obtained larger scantlings, better suited to Atlantic conditions, while still preserving their ability to sail windward by retaining the lateen sail (Chaunu 1969:141; Unger 1997:237, chap. 12).

Nau

Although nimble caravels were sent to carve an initial path down the west coast of Africa, there eventually was a need for larger vessels to transport trade goods to and from India. Since caravels were of relatively small tonnage, Portuguese shipbuilders and invested owners turned to *naus* for this demand. Initially, these full-rigged ships had twice the carrying capacity of caravels and could return a better profit to European investors. In the 16th century, the size of these vessels ballooned to many times the initial tonnage and sustained longer periods at sea.

The genesis of the *nau* lies in the advent of the full-rigged ship. Using a combination of Mediterranean and northern European methods, Portuguese shipbuilders in the High Middle Ages designed versatile craft. It is certainly possible that in the Late Middle Ages, Iberian shipwrights were among the first to string together the

combination of square and lateen sails on cargo carriers to produce the full-rigged ship. The earliest known illustration of such a vessel is found on a Catalonian document, dated to 1409, and the second seems to be a Spanish-Moorish plate dated to ca. 1420 (Figure 3-3), which depicts a Portuguese ship (Landström 1961:96; David 1966:167-168; Lane 1992:42; Mott 1997:146; Unger 1997:236, chap. 12). This type of vessel was made from modifications of the northern European cog which, according to the Florentine chronicler Giovanni Villani, was adopted by Mediterranean shipwrights in 1304, where it became known as the *cocca*. This vessel combined the driving power of the square sail with the maneuverability of the lateen rig found on Genoese and Venetian galleys as well as other vessels in the Mediterranean. This type of ship gained popularity partly

FIGURE 3-3. Spanish-Moorish plate depicting a 3-masted Portuguese vessel (After Landström 1961:78)

because it incorporated a less labor-intensive stern-hung rudder that, together with square sails, cut down crew sizes and therefore maximized cargo space. Soon it supplanted others of smaller capacity, and in 1340, the Genoese replaced all of their galleys used in voyages north to Flanders and England with *coche*, while the Venetian galleys continued to be used until the 1550s (Friel 2000:78).

The English term "carrack" was used as a designation for this ship type. Though this expression endured in that region, the usage of *cocche* lost favor in other countries to the general word for "ship": *nave* in Italian, *nao* in Spanish, and *nau* in Portuguese. This was probably due to its widespread and common use, for by the late 14th century the full-rigged cargo carrier was no longer an innovative concept (Friel 2000:82).

The use of the *nau* during the Age of Discovery may have been a response to the perceived desires of ship owners and buyers. Due to the rising income of artisans and the concentration of wealth that followed the Black Death in the 14th century, investment in overseas commerce appeared an attractive venture to nobles with falling incomes. Prince Henry, himself a relatively poor member of this class, looked toward fishing and trade as a way to supplement his own royal earnings. After the conquest of Ceuta, certainly a profitable venture from his standpoint, he invested in commerce, colonization, and expansion. This helps explain the need for a vessel with a larger cargo capacity (Godinho 1969:40-41; Marques 1976:108-109, 144; Unger 1997:236, chap. 12).

As mentioned in Chapter II, when Bartolomeu Dias returned from the Cape of Good Hope in 1488, he suggested a change in design for vessels bound for the East Indies. He recommended ships with more capacious hulls and higher freeboard, similar

to the Mediterranean round ships, but full-rigged craft that could still navigate in shallow coastal waters. Dias himself assisted in the design of two *naus* for the voyage of Vasco da Gama—*São Rafael* and *São Gabriel*. According to the sources, these vessels, hoisting both square and lateen sails, were between 100 and 120 *tonéis*, and they had length to beam ratios of approximately 3:1. Their forward masts had topsails with tops, and their bowsprits were rigged with spritsails. The *naus* had two decks; both forecastles and sterncastles, lofty half-crescent bows; and were decorated with short, recurved beaks. In time, these vessels would not be less than 500 *tonéis*, and some would reach over 1,000 *tonéis* (Figure 3-4; Lopes de Mendonça 1892:10; Brás de Oliveira 1940:25; Smith 1993:46).

Other types of craft were also used during the Age of Discovery, such as the *fusta*, *catur*, galley, *galeota*, brigantine, galleass, *taforea*, and galleon. These vessels, however, played a relatively minor role in the exploration and discovery phases of the Age of Expansion, and were used more in colonization and local trade, as well as the support of fleets bound to and from Asia (Brás de Oliveira 1940:28). The fragmented stories of the *barcha*, *barinel*, *caravela*, and *nau* are more important for the discoveries, however, and are pieced together to show the developing technology and growing economic interest in the Iberian Peninsula during this revolutionary age.

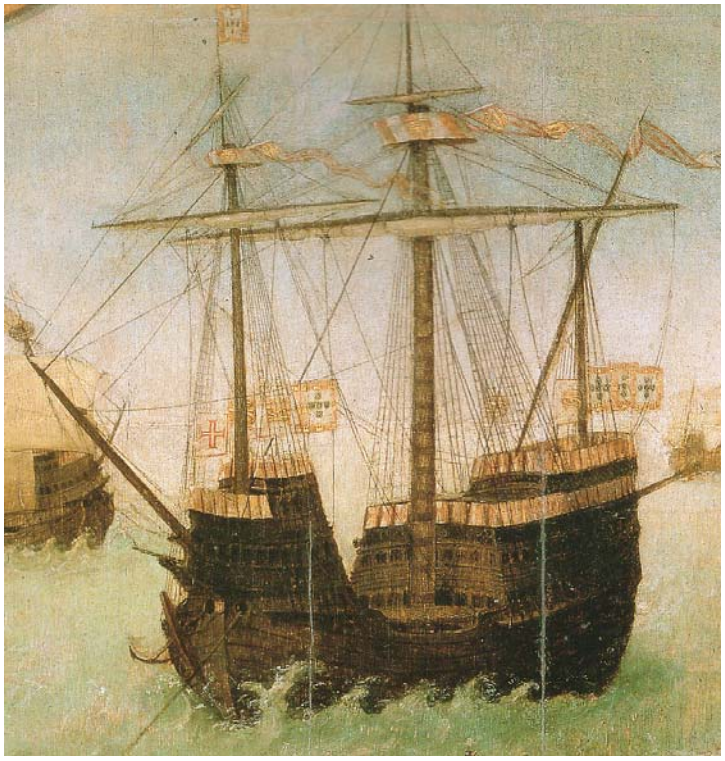

FIGURE 3-4. Painting of a Portuguese *nau* at anchor (After Bellec 2002:20)

CHAPTER IV

THE ETYMOLOGY AND POSSIBLE ORIGINS OF CARAVELS

The caravel of the 15th century was a ship with a distinctive shape and admirable qualities. According to contemporary iconographic images, a gently sloping bow and single stern castle were prominent features of this vessel, and it carried a main and a mizzenmast that were generally lateen-rigged. Although the caravel had already been in use for hundreds of years, it developed into a fast, easily maneuverable ship at the height of the Age of Discovery and was noticed by eminent people. Gaining fame with Spanish and Portuguese voyages of discovery, these vessels—initially outfitted for fishing and cabotage—were launched down around the west coast of Africa and into the New World, at first in search of gold and slaves.

In the latter part of the 15th century they were involved in trans-Atlantic voyages, a popular example being Christopher Columbus's caravels *Niña* and *Pinta* used for his epic voyage. In a logbook from his first voyage to the New World, the Admiral of the Ocean Sea frequently expressed admiration for his favorite ship, *Niña*, commenting on her exceptional speed, handling, and safety. After sailing in this caravel through violent storms on the return voyage, Columbus remarked, "if the caravel had not been very sound and well equipped, I fear we would have been lost" (Columbus 1987:184). Bartolomeu Dias also sailed in caravels during his famous rounding of the Cape of Good Hope in 1488. These well-known ships of discovery were far removed from the humble

caravels of the 12th century, however, and research has shown that not all caravels were designed the same way. In the medieval and post-medieval eras caravels were built and sailed in several places throughout the Mediterranean and northern European world, and diverse developments can be seen throughout the written history of the ship. For these reasons it is difficult to define the quintessential caravel (Elbl 1985:543).

Although this type of ship is well-known as the vanguard of European expansion, little is understood about its development. In spite of the fact that they were used almost exclusively as exploratory vessels during the 15th and 16th centuries, there is a paucity of data regarding construction and hull design of caravels.

Roots of the Word "Caravela"

Researching the development of any ancient ship begins with tracing its origins. By investigating the historical roots, scholars try to analyze the usage, development, and structural attributes of the ship. The caravel's beginnings are as elusive as the other ships of discovery described in the previous chapter. Since its development was a gradual transition and far from any unilineal model, the birthplace of the caravel may never be known for certain, but it likely evolved from some kind of tending or coastal craft in the Mediterranean. It is clear from historical records that there were Portuguese caravels used as fishing vessels in the 13th century (Fonseca 1934[2]:19). Looking into the etymology of the word "caravel," however, we see a possible earlier emergence of this ship type.

Research of 19th-Century Scholars

European scholars during the 19th century sought Roman and Greek terms that may have spawned the word *caravela*. Augustin Jal, in his work *Archéologie Navale*, suggested an Italian origin for *carabela* as *cara bella*, apparently owing to the beauty or grace of the vessel (Jal 1840). Later, in another often-cited publication entitled *Glossaire Nautique*, Jal alluded to the low Latin word *carabus* or the Greek *καραβζ* as a possible provenience, being terms originally designating a certain boat type of small dimensions. This seems to be one of the more accepted opinions among scholars of Iberian maritime history (Jal 1848[2]:212; Lopes de Mendonça 1892:41; Fonseca 1934[1]:21; Edwards 1992:420).

After carefully reviewing numerous dictionary entries for '*caravela*' and its many variations, Lopes de Mendonça (1892:42) was inclined to agree that the original form of the word had eastern Mediterranean origins, being Latin or Greek. The word '*carabus*', however, originally referred to an ancient elongated Roman craft with a light lath frame covered by skin, which was propelled by paddles. In time '*carabus*' was used as a general term for boat, and eventually the word came to be associated with a type of small vessel used by the Moors. This *qârib*, as the appellation morphed into, shows up in 13th-century records as having some connection to the caravel (Elbl 1985:545; Parry 2000:119).

This *qârib* was well-equipped to travel in shallow waters and was used as a fishing boat, coaster, and light warship. This vessel has been attributed to the Moors in the Mediterranean at least as far back as A.D. 700. A 14th-century document indicates

that these ships were capable of transporting as many as 60 horses. *Qâribs* were rowed with two banks of oars but also rigged with lateen sails. Few facts are known regarding the construction and hull characteristics of this Arab vessel, but it had preferred features that allowed it to transform into progressively larger forms, much like the caravel. Early documents also refer to the *qârib* as a relatively small boat that accompanied ships, carried up to 33 men, and possibly carried additional cargo for larger vessels. The early caravel is thought to have similar characteristics of the *qârib*, such as a shallow draught and lateen sail. For these reasons, some scholars speculate that '*caravela*' is derived from *qârib,* and, therefore, has Arabic origins (Jal 1848[2]:212; Lopes de Mendonça 1892:42; Parry 2000:119,479).

There have been other attempts to pin down the derivation of the word '*caravela*'. One such essay is found in F. Solano Constancio's *Novo Diccionario Critico e Etymologico da Lingua Portuguesa* (1836), in which he takes the vocabulary of two French terms, '*carrée*' and '*voile*', to form the genesis of '*caravela*'. '*Voile carrée*', however, translates to 'square sail' and cannot correctly designate a solely lateen-rigged vessel. Lopes de Mendonça (1892:46) suggests the possibility of an abbreviation of the words '*caravo de vela*' or '*caravo á vela*', given his acceptance of the Roman or Greek origin for the caravel ship type. Another hypothesis is that the *–ela* ending of '*caravela*' signifies a diminutive form of the *caravo* or *carabus*. As Fonseca (1934[1]:22) points out, however, the *–ela* ending has other denotations in the Portuguese language, such as collectivity, action, and depreciation; so, the suffix of the appellation remains a mystery.

Post-Medieval Dictionaries and Glossaries

References to caravels have been discovered in historical documents from several European countries under different words; *caravelum*, *caravella*, or *caravellae* in Italian, *caravelle* in French, *karawelle* in German, *caravela* in Portuguese, *karvel* in English, *carabela* in Spanish, and *karviel* or *kraveel* in Dutch, among others. Not only are these words found in the archives, they are also encountered in historic dictionaries and glossaries, another source for the description of caravels. Fonseca (1934[1]) listed various entries in *A Caravela Portuguesa* in an attempt to extract details about this type of ship from past philologists. Many of these entries are brief and hardly descriptive; others are detailed but misguided. In any event, a look at some characterizations from these references gives insight to common perceptions of caravels through time.

Rafael Bluteau's 1679 edition of *Glossário* describes the caravel as a lateen-rigged vessel of approximately 200 *tonéis*. If true, these later caravels would have hull capacities four or five times that of the caravels of discovery, which were no more than 50 or 60 *tonéis*. Fonseca (1934[1]:22) observes that Bluteau was not describing a caravela that was known as '*latina*', according to the tonnage that he stated for the vessel. *Caravelas latinas* were so called because they had only lateen sails, whereas at least some of the later caravels of the 17th century were rigged with a combination of square and lateen sails. A 1712 edition of the same *Glossário* defined the caravel as "embarcação redonda, que anda com velas latinas," denoting that the ship was round but sailed with lateens. This is confusing and contradictory since in the 15th and 16th centuries, '*caravelas redondas*' referred to caravels of three or four masts with square

sails on the main and fore masts and lateens on the mizzen (Leitão 1990:140; Elbl 2000:93). Father Fernando Oliveira (1555), in his manuscript entitled *Arte da Guerra do Mar*, describes the caravel as narrower than what is required to be a round ship. He asserts that the length to beam ratio of a round ship is 3:1, while the caravel is longer and the beam narrower. In view of the explanation described in Oliveira's manuscript, Bluteau was not correctly referring to the shape of the caravel's hull as an "embarcação redonda" either. The entry was probably a misconception of the characteristics of the ship type and is therefore deemed unacceptable by Fonseca (1934[1]:23) as an adequate description of a caravel. As shown in the next chapter regarding historical references to caravels, however, these ships did exist in their later stages with length to beam ratios of less than 3:1.

Domingos Vieira (1871), author of *Grande Diccionario Portugues*, refers to a caravel as a three-masted, lateen-rigged vessel between 120 and 140 *tonéis*. A much later entry, this description characterizes the caravel as an "embarcação cujo uso é particular de Portugal." It is well known that the vessel was used extensively in Portugal, but it has been shown that caravels were also widely used by Mediterranean seafaring nations, as well as northern Europeans, and was employed at least as far east as Turkey. And although it is accepted that caravels outfitted with three lateen-rigged masts existed, sometimes these vessels also carried one or two additional masts, some square-rigged, as previously mentioned (Fonseca 1934[1]:24). The tonnage listed in this entry is again much higher than the caravels used for exploration during the Age of Discovery. These tonnages may be closer to those of the *caravela de armada*, bordering on its nebulous

transformation into the higher, more capacious, and elongated galleon of the late 16th century (Elbl 2000:97). The definition of the rig is inconsistent with what is known of the history of this type of vessel; the *caravelas latinas* of the 15th century and earlier hoisted one, two, or three lateen sails, but were of slight tonnage. The later caravels used for war were of high tonnage, but, judging from the iconography, utilized square sails on the foremast and sometimes on the mainmast. Because of this incongruence, Vieira's definition appears unreliable.

Another interpretation, modified from an entry of the 1876 edition of *Dicionário Popular*, vaguely states the caravel is a ship type of small tonnage and lateen sails, principally used in the 15th and 16th centuries. In addition, it mentions that these vessels constituted the Portuguese fleets during the Age of Discovery (Chagas 1876; Pereira 1906; Fonseca 1934[1]:24). Other general statements on caravels are found in similar works from the 19th and 20th centuries, including *Enciclopédia Portuguesa* by Maximiliano de Lemos (1900-1909), in which it is again simply described as a craft of small tonnage with lateen sails used in the 15th and 16th centuries.

In *Dicionário dos Sinónimos*, an edited compilation of definitions by a 19th-century Portuguese literary group, there are statements about caravels that are slightly more revealing. One entry describes the ship as "a Spanish vessel, also used by other nations, of three lateen sails and a square stern, with swivel-guns, and of 200 ton capacity. It was used for both mercantile and fighting purposes" (Roquete 1848; Fonseca 1934[1]:25).

As Fonseca concludes, Portuguese dictionaries—though specializing in knowledge regarding Portugues history—do not accurately or adequately define the caravel ship type. The descriptions are contradictory and often anachronistic when compared to the information found in more reliable primary sources, such as the shipbuilding treatises by Father Oliveira and others.

Fonseca (1934[1]) also examined non-Portuguese dictionaries in search of entries for the ship of discovery. The French *Dictionnaire Historique Theorique et Pratique de Marine* (Saverien 1781) and *Dictionnaire de Marine* (Montferrier 1841), among others, describe the ship in the same manner: a small Portuguese vessel with lateen sails. Robert Lathan's (1871) *Dictionary of the English Language* describes the vessel as such:

> In Portugal it is a small vessel carrying lateen sails. The three vessels which composed the expedition of Colombus in the occasion of his discovery of America, were caravels which there is said to be no authentic account of their forme, sise or rig (Lathan 1871; Fonseca 1934[1]:29).

Conclusions of 19th- and Early 20th-Century Maritime Historians

Portrayals of the caravel by 19th-century maritime historians are particularly useful in this study, since many of these scholars did the vast majority of archival researching on these ships when interest in the subject first surfaced. Oliveira Martins (1891) refers to it as a small, fine-lined, swift round ship easier to handle than *naus*. He asserts that the initial type of caravel was similar to 19th-century *faluas* of the Tagus River and poetically claims "there was a flock of winged gulls that sailed out from the Portuguese coasts, hovering over the seas". He puts their length at 20 to 30 m, and their beam at 6 to 8 m. According to Martins, caravels had three masts without tops and were

rigged with lateen sails on long oblique spars which were suspended by a grommet at the top of the mast (Martins 1891; Fonseca 1934[1]:26).

João Brás de Oliveira (1940:21-24) gives the caravel a Moorish origin, rigged with lateen sails and between 50 to 150 *tonéis*. His estimate of length to beam ratio is 3:1 and sometimes more. Brás de Oliveira's caravel has finer lines than a *nau*, but when it needed to be larger in order to carry more cargo, the hull was enlarged; it was then outfitted with three and four masts, which might hoist square sails if they were sailing in tempestuous seas. Referring to craft of 19th-century Portugal, he comments that the *caíques* of the Algarve have much the same appearance as ancient caravels.

Lopes de Mendonça (1892:58) describes the caravel based on his extensive archival research by making three hesitant assumptions. First, Portuguese caravels, documentary vestiges of which can be found from the 13th century, were a specific type of vessel with special characteristics, at least until the beginning of the 16th century. They were swift ships of less than 200 *tonéis* with three and sometimes more masts, exclusively lateen-rigged. Second, they were chiefly used by the Portuguese for discovery and exploration on the western coast of Africa. Third, the rigging of these ships was later modified by putting square sails on the foremast. This was perhaps influenced by the Spanish, who were rearranging the sail plans since the times of Columbus.

Almeida d'Eça (1895) writes that the caravel was a ship with two, and later three, masts outfitted with bastard sails. Though originally lateen rigged, the mainmast later hoisted a square sail in place of the great lateen sail. The mizzenmast was much smaller

than the other masts on the vessel. The hull was high in the stern, but more level as it went toward the bow. D'Eça claims the maximum capacity in the 15th century did not exceed 80 *tonéis*. This last estimate slightly exceeds what historical documents have shown of the capacities of ships of discovery, which were not greater than 50 to 60 *tonéis*. This was evidenced by the writing of the Genoese adventurer Cadamosto in 1455, who notes that a new caravel of approximately 54 *tonéis* was outfitted for his voyage (Fonseca 1934[1]:27; Crone 1937:6).

Fonseca (1934[1]:44-46) provides an evolutional timeline for the caravel in its various forms. The first version was the *caravo primitivo*, the small Greek vessel built with rush and lined with skin, and moved by paddles. This comes from a passage by Saint Isodoro, written in the seventh century: "*carabus parva scapha ex vime facta quae contecta crudo corio genis navigiy probet.*" From this develops the *caravo* of large capacity, rigged with lateen sails and used by the Moors up to the beginning of the 14th century, as told by Portuguese chroniclers. Next, Fonseca presents the *caravela primitiva* or *pequeno caravo*. This is the type of vessel that was used for fishing and that which is referred to in documents from the middle of the 13th century. This design eventually advanced into the *caravela latina*, which was used throughout the second half of the 15th century for exploration and discovery. This ship was equipped with one, two, or three masts hoisting lateen sails and being generally around 50 *tonéis*. Fonseca likewise notes they were much like the *caíque* of the Algarve and other lateen-rigged boats along the coast of Portugal in his day.

Fonseca asserts that the *caravela redonda*, *caravela de armada*, and *caravela mexeriqueira* evolved from the earlier ship of discovery. They reached from 150 to 200 *tonéis* and were common in the 16th century. These caravels were used until the last quarter of the 17th century. In addition to the earlier types, the *caravelão* also shows up in documents. This vessel, though defined by Jal and the majority of early Portuguese dictionaries as a larger caravel based on the Portuguese augmentative *–ão* ending, was in fact a ship type of smaller capacity than the *caravelas redondas*, *de armada*, and *mexeriqueira* (Fonseca 1934[1]:46).

As the historical references and conclusions of maritime historians clearly show, there is no single definition for the archetypal caravel. This is because the development of the caravel was too long and too gradual for it to actually represent a single ship classification. The tonnages of these ships vary enormously, from 50 to 200 *tonéis*. The number of masts on the vessels range from one to four or more, and the rigging is described as either solely lateen, or a combination of lateen and square sails. Some authors profess the hull was round while others suggest the lines were much finer than those of a *nau*. A better assessment of these features can perhaps be gained by looking at some of the historical documents in which the caravel appears throughout the ages. In this way, we can trace the development of the ship and gain knowledge regarding appearance, size, sails, rigging, and other relative details. Instead of narrowing the focus of the caravel as a particular type of craft in an attempt to define it, a more fruitful approach may be to look at the caravel in a broader scope by examining its eventual

transformation throughout its history from a ship tender to a cargo carrier, and all of the evolved forms in between.

CHAPTER V

HISTORICAL DOCUMENTS AND THE CARAVEL'S SHIFT THROUGH TIME

Emergence of the Caravel

Twelfth-Century Italian Sources

Perhaps the earliest document that mentions this ship type comes from the state archives of Genoa. A citation from an ancient Genoese cartulary of Giovanni Scriba, dated to 1159, mentions a *caravellum coopertum* at the service of a *navis*, or large ship (Chiaudano 1935:doc. 578; Ciciliot 1992:72,80). This early reference indicates the use of the caravel as a ship tender. Scholar Hilmar Krueger (1985:19) asserts that the caravel was used as a *chiatta*, or lighter, to transport cargo and people from the ship to the land. It was perhaps maneuvered with oars and a small sail. The term *coopertum* signifies that this vessel had at least one deck, and was therefore not of extremely small dimensions (Ciciliot 1992:72). Since these are the only clues in the document relating to the caravel, however, its actual capacity remains unknown.

Another *caravellum* appears in a Genoese document from 1190 regarding merchant accounts (Chiaudano 1938:doc. 196-197; Krueger 1985:75; Ciciliot 1992:72,80). Maritime scholar Furio Ciciliot believes this vessel was of fairly small tonnage given the modest price attached to it. He suggests that throughout the 12th century, this ship type came to signify the same sort of vessel as the *barcharolii*, a small- to medium-sized transporter used in ports or for coastal trade (Ciciliot 1992:72).

Early Portuguese References

The first instance of a Portuguese caravel in an official document dates to 1226, which mentions its compulsory integration into an English fleet upon its return to Gascony. Considering the voyage it made from Portugal to the Bay of Biscay, this early caravel was probably not much smaller than later ones that sailed to northern Europe, reaching at least 20 to 30 *tonéis*. Since it is probable the venture to the Basque territory was at least partially commercial, a smaller vessel would not have been worthwhile (Michel 1876:1,153; Elbl 1985:546).

Another document, from 1255, mentions caravels several times:

> ...Item mando quod piscatores dent maiordomo de unaquaque *carauela* unum piscem postquam fuerint tres pisces…Item si piscatores uierint ad Galleciam ad piscandum et exiuerint de mari et fecerint pousades et salgauerint piscatum quando uenerint mando quaod dent maiordomo decem pissotas et de unaquaque *carauela* siue nauigo…et *carauela* extranea que intrauerit per focem de Portu cum mercaturis. Mando quod det maiordomo unum solidumde intrada et si uenerit ad Gayam de quanto uendiderit aut comparauerit duos denarios det maiodomo de marabitino: et de *Barca séeyra* que non fuerit de vicino det duos denarios de marabitino et si *burcardus tincatus* qui non fuerit de vicino intrauerit per focem cum mercatura det maiordomo: unum marabitinum de intrada et de quanto nendiderit siue comparauerit duos denarios det de marabitino de illo habare quod non fuerit decimatum et *Burcia* que uenerint cum *pannis* mando quod det maiordomo quatuor marabitinos de intrada...[emphasis added] (Marques 1944:7-8).

This *foral*, or chart, of Vila Nova de Gaia, shows the caravel as paying the lowest entry toll on a list among a *barca séeyra*, *burcardus trincatus*, *burcia*, and a pinnace. Because of the low toll paid in comparison with these other vessels, a relatively small size and capacity can be attributed to this early caravel form. The *barca séeyra* was the next largest craft on the list, and was probably comparable to caravels of the mid-13th century, though more heavily built to voyage in open seas. These ships were probably related to

the *barchas* described in Chapter III: two-masted, square-rigged vessels under 30 *tonéis*. Maritime scholar Martin Elbl (1985:547) estimates that the caravel and *barca séeyra* of these years probably had a keel to beam ratio of between 4:1 and 5:1.

This deduction for a smaller size of a caravel is logical, since during that period of their development they were used primarily for fishing and light cabotage along the Atlantic and Mediterranean coasts. Their shallow draught and low sides were efficient for such use. It is also conceivable that these ships were employed for trade and therefore could have been fully decked at this time. Since many ships during this period were likely similar to the caravel in size and rig, a tentative comparison can be made with other vessels regarding tonnage and keel to beam ratios. The 13th-century caravel is surmised to have been a lateen one- or two-master under 30 *tonéis*, with a keel to beam ratio of 5:1. This is rather high when compared to the ratio of the ship during its last stages of development in the 17th century, which had a keel to beam ratio of 2.64:1, based on instructions set forth for a caravel of 11 *rumos* in the 1616 nautical treatise *Livro de Traças de Carpintaria* by Manuel Fernandes (1995). The ratios and tonnages of the 13th-century vessel are speculative, but Elbl points to the only 14th-century record—dated to 1307—from the Biscayan area, which states the following: "item quatuor caravelli quorum cuilibet sunt necessarii novem hominis" (Jal 1848; Fonseca 1934[1]:21). This mentions small caravels with crews of nine men each. According to the research of Pedro Augusto de Azevedo, these 15th-century manning ratios represent vessels of 18-20 *tonéis* (Azevedo 1934; Elbl 1985:548).

Caravels are mentioned in other 13th-century documents, but only with regard to their use. There is no indication of size, appearance, or structural details in these early

texts. For example, an inquiry made in 1258 at the northwestern town of Pindelo, Portugal, refers to fishing, navigation, and commerce at the estuary of the Ave River. The document reports the taxation of salt, clothes, lead, tin, and other commodities, but it also lists a variety of ship types used for fishing, including a caravel, *barca*, and pinnace:

> …dixit quod qualibet pinacia et qualibet barca, dant, j, piscem de milioribus quando cumque exierit de mari, et si forte euenerit quod *carauela*, uel pinacia, aut barcus, non posit piscari plusquam unum piscem…(Marques 1944:12).

Similar brief glimpses of caravels are reported throughout the second half of the 13th century, but thereafter we find a peculiar absence in records for this type of craft. Though there is little doubt that caravels continued to be utilized as fishing and commercial vessels during the 14th century, their nonappearance in documents cannot be easily explained. As mentioned previously, other than the Biscayan record of 1307, caravels are unseen in historical accounts from the 14th century. They are also, however, absent from iconography of the period.

Continued Development and Early 15th-Century Sources

Despite the shortage of written or pictorial evidence, there was almost certainly a shift in the size of these ships as they took over the functions of another light Portuguese vessel, the *barinel*. The *barinel*, mentioned in Chapter III, resembled the Atlantic *balener* and was perhaps better suited to sail in the Bay of Biscay than other southern ships of the same size. This shift may indicate a general trend of transitions from coastal vessels to those capable of faring well in the high seas. An example of such a change was noted in Catalonia in the first half of the 15th century. The *saetía*, a light vessel with a long hull,

lateen sails, and a size comparable to a caravel, was mentioned in an ordinance of 1438 issued by Alfonso the Magnanimous:

> …we know that the *saetía* was in other times a light oared vessel and now it is the heaviest ship, of greater board and capacity for long voyages; the same for the bark…today it is taken in general as a vessel of lateen sail that consists of three masts… [author's translation] (d'Albertis 1892:41; Elbl 1985:549).

It is reasonable to assume that throughout the 14th century the caravel too underwent alterations, such as increases in carrying capacity, which made it more suitable for the oceanic voyages of the 15th century.

Records from the first half of the 15th century, however, show that the vessel type was still being employed regularly by fishermen. A mandate from 1434 stating rights for Lisbon fishermen, for example, cites their use in this trade:

> …quem nom tomem as barcas nem *carauellas* aos pescadores de lixboa…sabede que os pescadores da dieta cidade nos enujarom fazer recontamento em como lhes tomauuam suas *carauellas* e barcas em que conthinuadamente pescuauam ...[emphasis added] (Marques 1944:268).

These fishing vessels were common at this time but now existed alongside heavier caravels. This is seen in another document from 1434 mentioning a fully-armed, and therefore more robust, Portuguese caravel apprehended in Denia for piracy in Catalan waters (Piles Ros 1970:246; Elbl 1985:551).

From a technological point of view, Iberian shipbuilding seems to have developed during the 15th century , adapting vessels to meet the demands placed on ships of discovery. To illustrate the elevated preparation of shipyards and shipping of the 15th century, King João II of Portugal ordered a *nau* of 1,000 *tonéis* to be built, in a time when they rarely exceeded 300 *tonéis* (Barata 1987:161). There are records of other impressive ships from Portugal, such as *São João* of 1533/34, which was one and a half times the

length of the largest Portuguese Indiamen (Barker 2001:215). Such ambition also called for changes in the caravel as a ship of discovery. Rather than relying solely on the technical knowledge of naval architects, these demands were taken on by skilled craftsman, who were capable of transforming the geometry of the vessel to suit the requirements of a sea-going explorer (Barata 1987:167).

Caravels of the Discoveries

Early Reconnaissance Expeditions

Sometime before 1437 official documents show that caravels were used for the expeditions to Tangier, although their size is unknown: "Sereis lembrado que as carauelas por qanto vão muytas e he forçado que fação grande myngoa pera a gouernança da terra..." (Marques 1944:302, doc. 390). A few years later, historical documents reveal the first use of caravels in reconnaissance voyages along the African coast. The chronicler Azurara wrote about this incident in 1440, "…no ano de quarenta se armaram duas carauelas afim de irem aquela terra" (Azurara 1937[I]:80; Pico 1963:80). After this point, the caravel is referred to repeatedly and almost exclusively as a ship of discovery in the chronicles of the Portuguese crown during the second half of the 15th century, and were eventually known as *caravelas dos descobrimentos*. For example, in 1443, Azurara relates the arming of a caravel for Nuno Tristão's important voyage to Cape Blanco: "…o Infante armar outra *caravela*, na qual mandou aquele nobre cavaleiro Nuno Tristão...e seguindo sua viagem, chegaram ao Cabo Branco..." (Azurara 1937[I]:113; Pico 1963:80). Similarly, in the same period the chronicler wrote about another explorer's expedition to Guinea in a caravel: "...fez o Infante armar uma *caravela*, na qual mandou aquele

Gonçalo de Sintra por capitão, avisando-o antes de sua partida que fosse direitamente á Guiné..." (Azurara 1937[I]:164; Pico 1963:80).

As noted in Chapter III, earlier explorers used *barchas* of about 25 *tonéis*, which probably had a single mast. They also experimented with the longer and larger *barineís*, but neither of these vessels was adequate for the steadily increasing distances traveled. Documented references of these ships used for exploration suddenly disappear in the 1440s. Perhaps longer, lighter, and of shallower draught, the caravel replaced these earlier craft as the voyages of exploration down the west coast of Africa became longer (Unger 1980:212).

Ability to Sail Windward

Another commonly cited reason for the caravel's superiority is its ability to sail windward, an attribute of paramount importance for return trips from the African coast. How advantageous this was is a matter of debate, but the lateen sail certainly held more benefits when pointing into the trade winds than did square rigs. The issue remains, however, as to whether the effort of beating against the wind along the shoreline to the north was worthwhile. The basic method involved in changing tack was unwieldy, requiring timing and experience (Figure 5-1). As the vessel fell off the wind, the brace and sheet were loosened, and the parrel was given a bit of slack so that the yard was somewhat unbound from the mast. A crewmember then hauled on the yard until it was vertical and shifted the sheet to the other side, catching the wind once again. At this point, the shrouds now to windward were tightened and those now to leeward were loosened. As the ship again turned into the wind, the sail was sheeted aft on the leeward

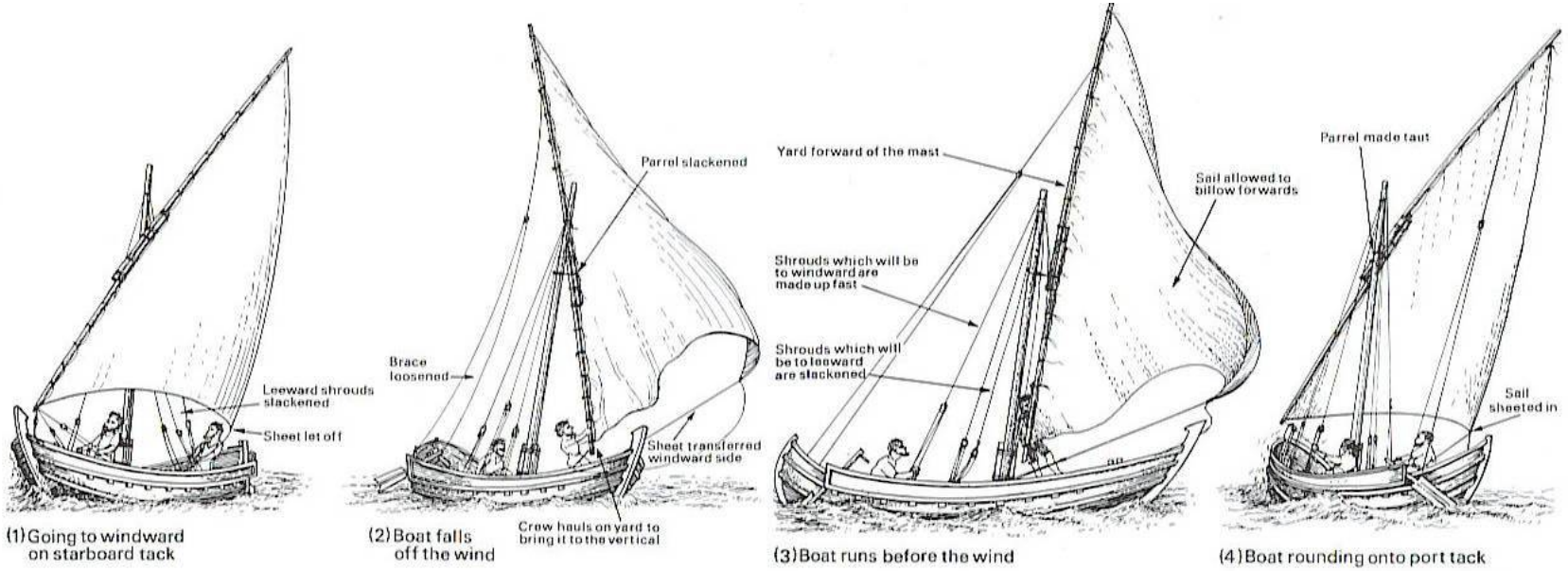

FIGURE 5-1. Tacking with a lateen-rigged vessel (After Pryor 2000:67)

side, and the yard was again made fast to the mast and trimmed with tacks and braces for the new tack (Landström 1961:83; Pryor 2000:67).

This maneuver could be especially tricky on particular ships. Some of the greater lateen-rigged Genoese *naves* of the 13th century had yards larger than 49 m in length (Friel 2000:78). Though the yards of caravels were not quite as long, the lateen sail prevented the construction of a forecastle on these vessels, since the swinging of the yard to the other side of the mast when tacking would be hindered by structures forward of the rig. Despite these impediments, Portuguese shipbuilders tried to improve the handling of the lateen by shortening the yards and setting them more upright. The combination of the hull form and adjustment to the rig made these ships quite maneuverable, and therefore fitting for the African expeditions (Unger 1997:234, chap. 12).

The process of changing tack was taxing and would be necessary for hundreds of nautical miles. As Elbl (1985:553) points out, even modern *caíques*, capable of sailing just as close to the wind as caravels did, often preferred a longer and wider arc through the Atlantic—the *volta do mar largo*. The stresses on the hull of the ship and crewmembers was extreme as the vessel crept tack for tack along the shoreline. Additionally, a lateen-rigged ship required more crewmembers to maneuver quickly, and experience was a key factor for success in harsh weather (Elbl 2000:93). Even Fernando Oliveira noted the hazards of tacking in *Arte da Guerra do Mar*, stating "…tambem a vela latina suas antenas trocando de hum bordo pero o outro sobolo mastro cõ grãde trabalho & perigo, como vemos, & suas uezes padecemos" (Lopes de Mendonça 1892:63; Oliveira 1555).

Tonnage of the Caravels of Exploration

These *caravelas latinas* used for exploration in the 1440s were considerably larger than the *caravelas pescarezas* of 20 to 30 *tonéis*, and were now in the range of 50 to 60 *tonéis*. Caravels listed in Portuguese waters between 1451 and 1454 ranged from 20 to 63 *tonéis* of minimum payload (Azevedo 1934[2]:347-348,358-359,674-675; Elbl 1985:556). This tonnage range stayed fairly constant throughout the second half of the 15th century. The caravels that served in the expedition of Bartolomeu Dias in 1488 did not exceed 50 *tonéis*, and the caravel *Bérrio* of Vasco da Gama's fleet in 1497 was also at a similar capacity (Fonseca 1934[2]:3). As seen earlier, the caravel that the Infante had fitted out for Cadamosto in 1455 was approximately 54 *tonéis* (Crone 1937:6). Although now a combination of *caravelas latinas* and *caravelas redondas*, Christopher Columbus's ships *Niña* and *Pinta* were estimated by Samuel Eliot Morison (1942:115) to be between 55 and 60 *tonéis*. In an expedition from 1499 Cristóbal Guerra embarked in a caravel of 50 *tonéis*, and three caravels from the captaincy of Solis were between 30 and 60 *tonéis*. Columbus's fleet for his fourth voyage to the New World in 1502 included four caravels of 50 to 60 *tonéis*. During the first half of the 16th century, these capacities rose dramatically, but even in 1523 voyages of exploration were still made in caravels of 50 *tonéis* (Fonseca 1934[2]:4).

Caravels of the discoveries, of the capacity described above, were probably between 20 and 30 m in length; 6 to 8 m in breadth; had a stern-hung rudder, two or three masts with lateen and, later, a combination of lateen and square sails, and a single

sterncastle (Smith 1993:41). Additionally, these vessels continued to use oars for maneuvering when it was convenient to do so (Figure 5-2; Fonseca 1934[2]:8).

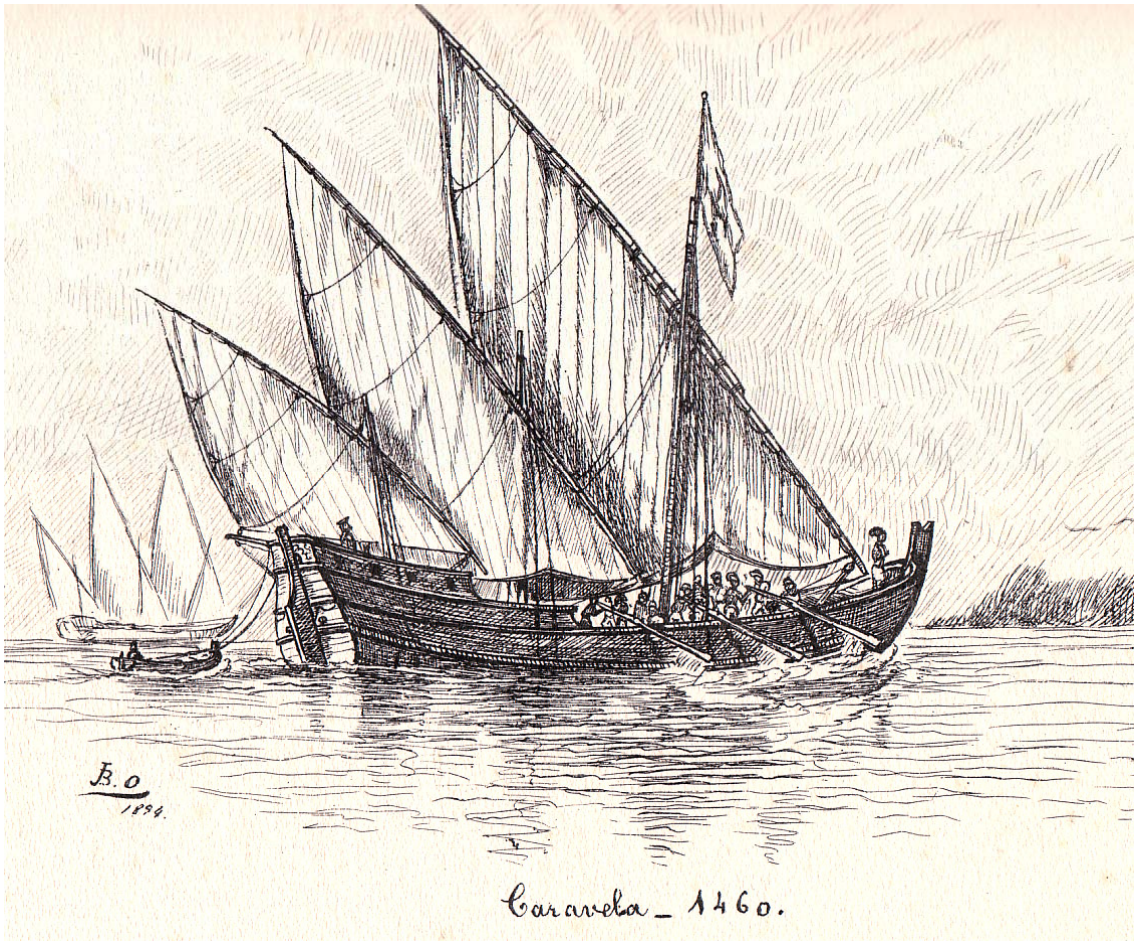

FIGURE 5-2. Caravel with oars (After Brás de Oliveira 1940:10-11)

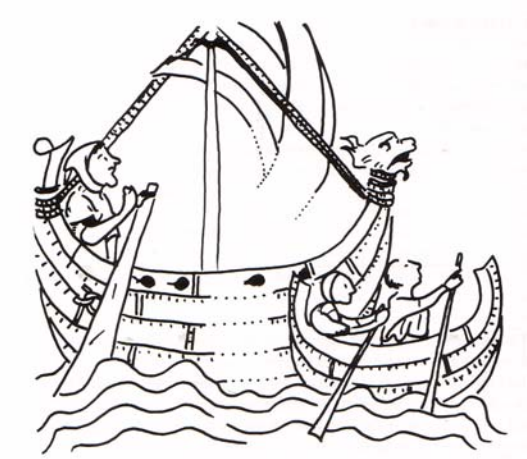

FIGURE 5-3. Steering oar fastened to the side of a medieval vessel (After Friel 1995:14)

Steering and the Stern-Hung Rudder

The stern-hung rudder was an advantageous feature of caravels. Earlier vessels utilized a side rudder for steering—an oversized oar fastened to the side of the ship at the stern (Figure 5-3). Although generally an effective tool for steering, the side rudder was susceptible to damage and could be lifted clear out of the water if the ship heeled too far to one side, thereby causing a loss of steerage. Evidence suggests that, beginning around 1300, the stern-hung rudder was introduced into the Mediterranean from northern Europe through the cog (Figure 5-4). By 1350-1370, this type of rudder was common on Genoese *coche*. The stern-hung rudder was fixed to the ship with pintles and gudgeons—iron hooks which fitted into iron rings attached to the sternpost. A tiller was connected to the top of the rudder and set inside the ship to enable steering. Although perhaps not as maneuverable as the side rudder, the stern-hung rudder did remain submerged, giving a more consistent and reliable performance (Friel 1995:81-82).

FIGURE 5-4. Stern-hung rudder on a cog from the town seal of Ipswich, ca. 1200 (After Friel 1995:80)

Crewmembers and Capacities of Caravels of Discovery

Though crew numbers on a vessel can often reveal an approximation of the size of a vessel, this is not always the case as it had been for earlier vessels. For caravels of the discoveries, especially, capacity is sometimes difficult to extrapolate from manning ratios. The total number aboard *Niña* for Columbus's first voyage was about 24 men and boys. *Pinta* carried about 26, while the flagship, *Santa María*, had 40 crewmembers. The caravels were, as noted before, approximately 50 to 60 *tonéis* (Morison 1942:148). Documents from Arquivo Nacional da Torre do Tombo, consisting of royal mandates to the tax collector of biscuit ovens in Lisbon, reveal interesting crew ratios for caravels. The biscuits under scrutiny were victuals for ships from various agencies that had put out to sea in the years between 1488 and 1499. The number of crew is inferred from the amount of biscuits per ship. These vessels, which were between 20 and 50 *tonéis*, had crew numbers ranging from six men on the *Santo Espírito* to 100 men on the caravel from Aires Correia. The majority of the 34 vessels listed had between 20 and 35

crewmembers each (Fonseca 1934[2]:6). Even so, there are some vessels listed at 50 *tonéis* with 100 crewmembers, four times the crew of *Niña* and *Pinta*. It is probable that the number of men and boys aboard these ships varied according to mission objectives rather than requirements for vessel operation.

During the Age of Expansion, there was a difference in the composition of crewmembers on expeditionary voyages between men-at-arms and mariners. The men-at-arms were sent on the expedition for the sole purposes of combat, whether it be on land or at sea. They took the highest risk during battle and had little to do with the duties on board the vessels. The mariners, in contrast, were occupied with sailing, cargo, small boat handling, steering of the rudder, throwing projectile weapons from the tops, and sometimes boarding enemy vessels (Brás de Oliveira 1971:24). Thus, there appear to be more men aboard vessels during this period than was common on earlier ships of similar sizes.

New Sail Arrangement and the *Caravela Redonda*

The Portuguese retained the lateen sails for their caravels because they better suited their purposes along the west coast of Africa, but others were making adjustments to the rig to maximize efficiency when sailing with the wind. In fact, northern caravels may have been rigged *redonda*, or with a combination of lateen and square sails, before the Spanish sailed across the Atlantic into the Caribbean. An English record dated to 1463-1467, refers to Sir John Howard's 'new carvel' which had three masts; a bonnet is also mentioned, indicating one of the sails may have been square (Burwash 1969:130; Elbl 1985:559).

For Columbus's first voyage, *Niña* was transformed from a *caravela latina* to a *caravela redonda*. *Pinta* is reported to have been rigged *redonda* from the beginning, and easily sailed to the Canaries for the first leg of the voyage alongside the flagship *Santa Maria*. Meanwhile *Niña*, lateen-rigged and sailing with the wind dead astern, was exhausting her crew tacking back and forth the entire way. Because lateen sails are more beneficial when sailing into the wind, *Niña*'s rig was deemed ineffective for the transatlantic voyage, through which she mainly sailed with the wind astern. Once in the Canaries, this caravel was converted by changing the placement of the main and second masts and fitting them out with square sails (Figure 5-5; Morison 1942:116). This new sail arrangement provided the necessary adjustments to make caravels what are referred to as the best sailing vessels of the time (Smith1993:38). The caravel continued to increase in size but was still small enough to be easily maneuvered. As the ship became heavier, it also became beamier in order to increase the carrying capacity for each meter of length. The length to beam ratios were now likely in the range of 4:1 to 3:1 (Unger 1980:214). This increase in size was also due to a new addition to the caravels of the last quarter of the 15th century: guns.

Inception of Guns Aboard Ships and the *Caravelas de Armada*

Light artillery had been used aboard vessels prior to the Age of Discovery. Venetian ships carried bombards in 1380, and Spanish vessels were equipped with ordnance in 1359 and 1372. In 1381, Catalan merchantmen likewise sailed with artillery (Artiñano 1920:43-44; Cipolla 1985:76). In contrast, Mediterranean fighting vessels consisted of oared galleys that would board enemy vessels and engage in hand-to-hand

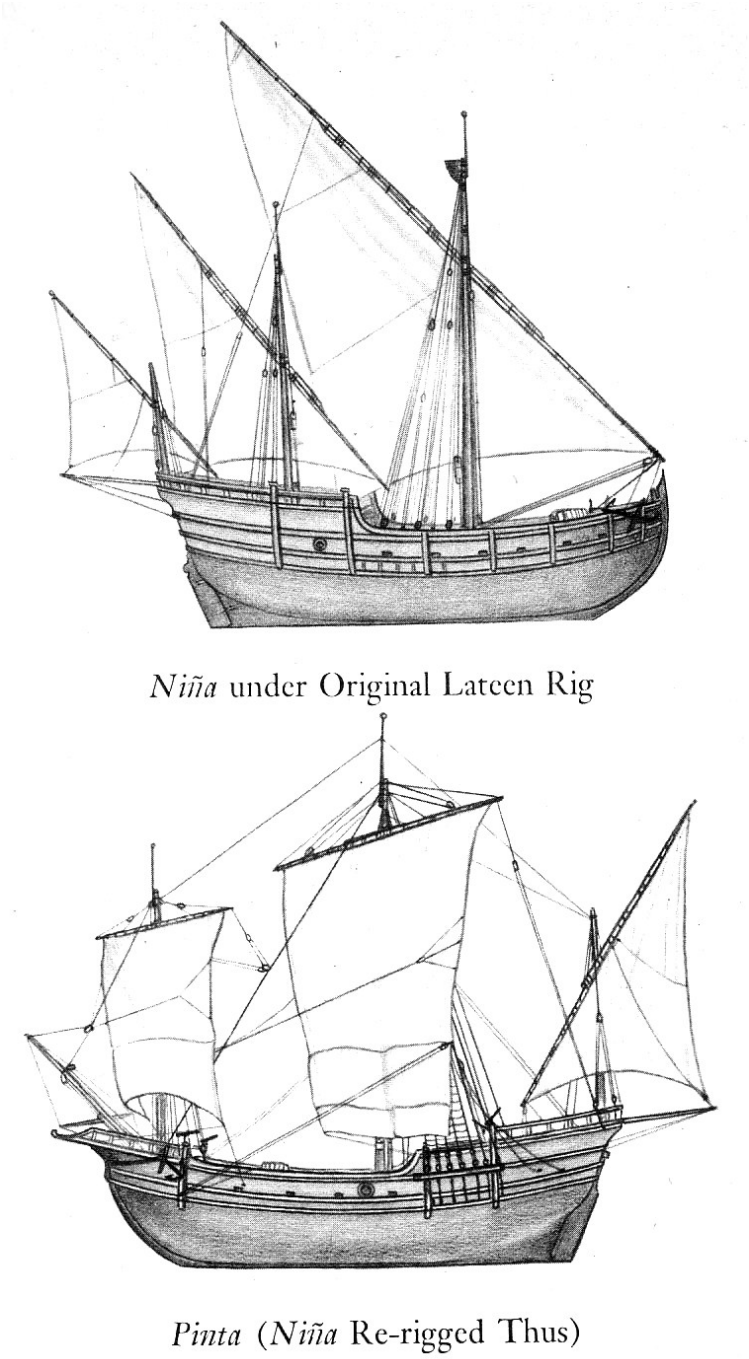

FIGURE 5-5. Hypothetical rigging of Columbus's *Niña* and *Pinta* at the beginning of his first voyage (After Morison 1942:115)

melee combat. In northern Europe, the cog was used for similar boarding maneuvers, with missile weapons hurled or fired from the high castles onto the enemy's decks. As voyages crept further out into the Atlantic, however, the galleys, deficient in seaworthiness, were unfit for such naval tactics in rolling waters. Consequently, as the capabilities of the sailing vessel gradually developed throughout the 15th century, Atlantic naval powers turned to these ships as the main force of their sea battles (Cipolla 1985:80).

English ships may have been the first to use cannon on their ships, as recorded in a 1338 account regarding the royal *All Hallow's Cog*, which carried a wrought iron gun capable of firing a large arrow (Figure 5-6). These types of weapons remained fairly insignificant for naval warfare, however, until the middle of the 15th century, when heavier and more advanced artillery were placed on ships (Friel 1995:152-153). Garcia de Resende (1470-1536), the personal secretary of King João II, described how his king was the first to place great cannon on small caravels in such a way that they could fire so low that their shot skimmed the water. "A few of such caravels could force many big ships to surrender because they were heavily gunned, but at the same time they were also small and highly manoeuvrable so that the big vessels could hardly hit them" (Resende 1902:181; Fonseca 1934[2]:47; Cipolla 1985:80).

Records show that the Portuguese used these armed caravels against Castile in 1476, and a year later Castile sent its own caravel warships against the Portuguese in Africa. These armed caravels, later referred to as *caravelas de armada*, were pivotal to

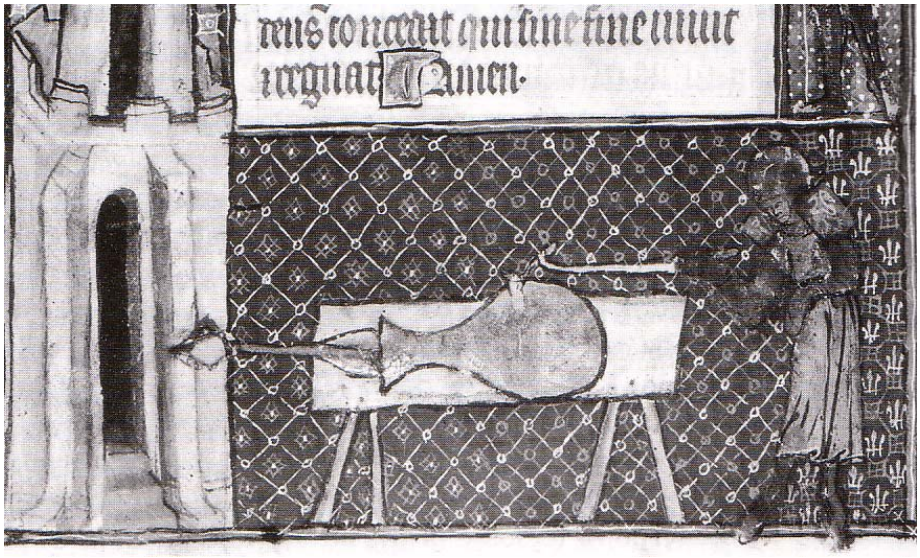

FIGURE 5-6. Representation of a cannon from ca. 1326, similar to the gun used on the *All Hallows Cog* (After Friel 1995:152)

the Portuguese crown for successful voyages along the southern African coastline, especially for maintaining control on African trade (Cortesão 1950[1]:471-473; Teixeira da Mota 1966:180; Unger 1997:241, chap. 12).

A reference to the swiftness of armed caravels, swarming 'like butterflies', is found in an account of the Earl of Essex's expedition to the Azores in 1597:

> Whilest we thus stayed about the Rocke, ye carvalls of Lyshbourne and of the parts thereabouts would daylie come swarminge about us like butterflies soe neare us as that we might cast a stone into some of them, and yet could we never catch any one of them, soe warie and nimble they are. But if we would have bestowed any muskett or great shott on such bables, we might phapps have killed some of theire men or suncke some of them, which we forbare in hope to drawe them to us oftner, and then if any calme had happened, we might have taken them with our boats and by them have gotten intelligence (Gorges 1604; Barker 2007, personal comm.).

Guns were initially placed on the weather deck of vessels, and the weight of these cannon limited the number carried on ships, as top heavy vessels were inherently

unstable. At the beginning of the 16th century, this problem was solved with the invention of the gun port and gun deck. This allowed placement of more heavy artillery aboard by positioning them below the weather deck and closer to the waterline, reducing stability risk factors. Cutting lidded ports on the sides of the ship below the open weather deck allowed for this new arrangement. This innovation may have also led to the transformation of a rounded stern to a square stern on these vessels. The square stern panel not only distributed the weight of the cannon better, but also improved the run of the stern through the water without having to reduce the breadth of the ship (Friel 1995:154).

Although guns were now placed closer to the waist of the ship, stability problems still existed as more and heavier ordnance were added to these war-modified caravels. Consequently, additional modifications to the hull were necessary to balance the offset imposed by the guns. Armed caravels acquired a wider, squared sterncastle with a bit of tumblehome to facilitate conning, defending, and steering the vessel. The length to beam ratios of these warships now drew closer to 3:1 as sturdiness and seaworthiness became more of an issue for construction (Smith 1993:43-44).

The sides of the 16th-century *caravelas de armada* were laden with gun ports, and these ships carried a variety of ordnance including several types of cannon, swivel guns, falconets, and versos (Fonseca 2003:124-125). At times, these vessels carried up to 30 or 40 pieces, but initially, at least, they were armed with around 15 of such weapons (Fonseca 1934[2]:49; Cipolla 1985:81).

These *caravelas de armada* were the caravels that composed da Gama's, as well as other admirals', fleets to India in the early 16th century, and are well-represented in the *Memoria de Armadas* (Figure 5-7). They were equipped with a large square sail on a foremast canted slightly forward. A second square sail was set on the topsail of this

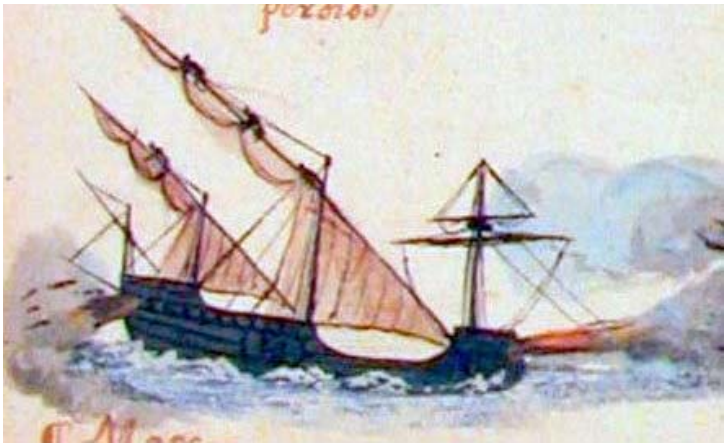

FIGURE 5-7. A *caravela de armada* firing cannon from the bow and stern; from an illustration depicting a 1524 fleet in India (After Academia das Ciências de Lisboa 1979:56)

mast. The remaining three masts were lateen-rigged, with the mainmast hoisting the largest of the three triangular sails. These ships were beamier than the earlier caravels of discovery, resulting from the above-mentioned stability modifications necessary for a more efficient warship, as well as the general desire for a more voluminous cargo vessel. A short beak was added to the bow to facilitate rigging for the foremast and placement of the *dragante*—a 'bowsprit pillow' affixed athwartship in the beak (García de Palacio and Bankston 1988:172). A small forecastle also appeared on this later caravel since the foremast—now square-rigged—would no longer require space for swinging the lateen yard (Edwards 1992:426). This form of the caravel was now reaching upwards of 80 to

100 *tonéis*. This was due not only to an increase in keel length to accommodate the placement of 3 masts with the mainmast in the middle of the keel, but also to hull reinforcements necessary for more and heavier artillery (Domingues 2004:264; Barata 1989[2]:30-31).

The Various Forms of Caravels in the 16th and 17th Centuries

Coastal and Riverine Iberian Caravels

Lopes de Mendonça (1892:70) did not believe that *caravelas de armada*, prevalent for purposes of trade and expansion in the Indies and Americas, were generally employed in Europe by the Portuguese. Variants of the caravel ship type coexisted alongside these vessels and were being used in other maritime communities for a variety of tasks. Historical documents reveal tonnages of caravels used on the rivers of Portugal during the first half of the 16th century. Table 5-1 is an excerpt from a compilation by Iberian maritime scholar Leonor Freire Costa (1997:420-436), giving an indication of the tonnages of riverine and coastal caravels during this era.

It is apparent from this short list of vessels that caravel tonnages varied widely. Although it is impossible to make generalizations from such a small sample, a pattern emerges in the table suggesting that throughout the first half of the 16th century, hull capacities increased. A caravel of 30 *tonéis* from Porto is listed in 1525, followed by the caravel *Salvador*, documented as a 60-*tonéis* vessel, in 1536. In 1543, *São João*, also from Porto, is recorded as having a capacity of 104 *tonéis*. The following year, however, Lisboa's *Misericórdia* is rated at 66 *tonéis*, and after that the tonnages generally decrease

TABLE 5-1
A LIST OF RIVERINE CARAVELS USED IN PORTUGAL DURING THE 16TH CENTURY

Ship	Tonnage	Origin of Ship's Master	Year
São Sebastião	36	Vila do Conde	1514
Unspecified	30	Tavira	1514
SM Cabo	53	Sesimbra	1516
Unspecified	30	Porto	1525
Salvador	56	Unspecified	1536
São Sebastião	48	Unspecified	1538
São Pedro	24	Unspecified	1539
Conceição	48	Unspecified	1540
São Tomé	60	Porto	1542
SM da Ajuda	60	Vila do Conde	1542
Santiago	98	Lisboa	1543
São João	104	Porto	1543
Misericórdia	66	Lisboa	1544
A Nazaré	38	Vila do Conde	1547
Unspecified	40	Aveiro	1552
Corpo Santo	20	Esponsende	1552
Unspecified	35	Fão	1552
Unspecified	35	Zurara	1552
Unspecified	20	Maçarelos	1558
São Tiago	20	Miragaia	1558
NS de Sete Fontes	20	Porto	1559

throughout the nation. In the late 1550s, for instance, there are several ships listed at 20 *tonéis*.

This table does not include all the caravels from Costa's compilation of vessels, and in fact, the full corpus of documents on her list shows a different pattern. When

comparing tonnages there is more of a connection to origin than time. For example, of the 31 caravels listed from masters originating from Aveiro, 28 were either 40 or 50 *tonéis*. Similarly, of the 25 caravels with masters originating from Esposende, 22 were between 20 and 35 *tonéis*. Nine of the 14 caravels with Vila do Conde masters were between 30 and 40 *tonéis*. There are, however, exceptions to this pattern as well. Caravels from Porto had fairly evenly distributed tonnages ranging from 20 to 104 *tonéis* between the years 1525 and 1559. Overall, however, it appears that ships built in particular geographical locations followed a trend with regard to carrying capacity, perhaps due to specialization in a particular trade niche within both the international and the European waterways.

Such patterns indicate that small caravels, simple and modified from the primitive *caravelas latinas*, continued to flourish in the riverine waterways of Europe as their larger, armed, ocean-going *de armada* cousins assisted the dueling Iberian crowns in their quest for trade domination in the Indies and Americas (Figure 5-8; Lopes de Mendonça 1892:70). Costa's (1997:439) second table listing tonnages of ships of the

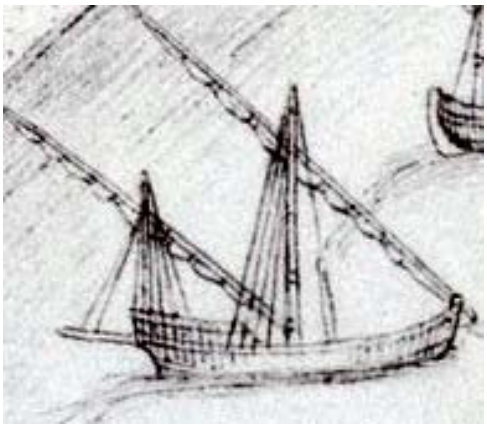

FIGURE 5-8. *Caravela latina* from *Livro das Fortalezas* (After D'Armas 1990:11)

Carreira da Índia shows two large caravels from Lisbon dating to 1588. *Santa Catarina* is listed as 160 *tonéis* and *Santo Espírito* as 180 *tonéis*. These caravels, owned by the crown and most likely *caravelas de armada*, were vastly larger than the caravels used in the rivers and along the coastlines of Europe.

Caravela Mexiriqueira

Another coeval form of the vessel type in use during the 16th century was the *caravela mexiriqueira* or *caravela de aviso*. These swift caravels were used during wartime as dispatch vessels to deliver messages to other ships, generally to warn them of an impending or possible attack. Among other duties, these caravels were important in relaying messages to parties in the Azores. A good example, found in the Archivo General de Indias, is the dispatch of a Spanish *carabela de aviso* to the Azores in 1547 to warn a Spanish captain of an attack by corsairs (Archivo General de Indias: Indiferente General 1964, Book 10, folios 199-200). They combined the speed and agility of fishing caravels with the capacity to carry the type of light artillery found in lesser ships of war. *Caravelas mexiriqueiras* differed from *caravelas de armada* in their armament and crew composition, and were named separately in lists with other caravels (Fonseca 1934[2]:10). A 16th-century budget made in Lisbon shows these *caravelas mexiriqueiras* to be as small as 20 to 25 *tonéis*. These lighter ships were probably used to transmit orders to larger vessels within a fleet (Leitão 1990:140; Lopes de Mendonça 1892:73).

Caravelão

Historical Portuguese and Brazilian records reveal another type of vessel derived from the caravel called a *caravelão*. This ship has been referred to as *carabelón* in Spanish documents and *carabellone* in Italian records. In all three languages, the suffix of the word usually takes an augmentative meaning, suggesting these vessels were larger forms of the caravel. Despite this linguistic denomination, *caravelões* seem to have been ships of relatively light tonnage, closer resembling *caravelas latinas* of the discoveries rather than the coeval *caravelas de armada*.

Speaking of ancient Portuguese vessels in Brazil, Iberian maritime scholar John Sarsfield proposed that the *-ão* ending of *caravelão* implied it was closer to the original caravel, or *caravela latina*, due to their comparative sizes (Sarsfield 1985a:1). As defined earlier, mid-15th-century *caravelas latinas* were generally around 40 to 50 *tonéis*. There are written instructions in *Livro Náutico* (1580-1609) for the construction of *caravelões* of 40 to 50 *tonéis*. This late 16th-century version of the ship was fitted with two masts which hoisted lateen sails, used oars for auxiliary propulsion, had a crew of 25 men, and was armed with two falconets and four versos. It was employed primarily for delivering messages and running errands, among other functions, and was probably not entirely different from *caravelas dos descobrimentos* (Domingues 1989:526).

Caravelões were the most commonly used vessels along the coasts of Brazil in the 16th century and continued to be built and sailed there until the mid-18th century. For several reasons, boat builders took to constructing rough coastal *caravelões* instead of large Portuguese ships like galleons and *naus*. Although Brazil had excellent timbers

for shipbuilding, the sugar planters wanted to conserve the hardwood for the machinery and buildings necessary for sugar plants. To transport the sugar, they preferred small, maneuverable vessels like the *caravelão*; not the larger, slower-moving *naus*. The *caravelão*, though of slighter tonnage and less defensible against corsairs, was speedy and could make two round trips to Lisbon each year. Moreover, there was a shortage of skilled carpenters in colonial Brazil who were trained to construct large ships, and laborers were desired for work on sugar plants, not boatbuilding. Finally, the coastline of Brazil was more easily defended by swift, agile, shallow-draughted craft instead of large armed vessels suited to face an armada. These views were shared by the Portuguese and subsequent Dutch invaders alike (Moura 1991:193-194; Unger 1997:239, chap. 12).

Gaspar Correia (1975) compared the *caravelões* with small fishing vessels from Lisbon, with the main difference being that the *caravelões* were decked in order to facilitate the storage of supplies. Archival records indicate that on a number of occasions *caravelões* were built from the wreckage of *naus*, again indicating their diminutive size. Two *caravelões* belonging to Álvaro Pessanha and Lisuarte Pacheco, which made up part of the armada of the viceroy Dom Francisco de Almeirda in 1508, had a 25-man crew each. This number corresponds to the crewmembers for a *caravelão* of 40 to 50 *tonéis* from *Livro Náutico* (Correia 1975[1,2]; Fonseca 1934[1]:34-37).

The first instance of a Portuguese *caravelão* in the archives is its employment as a shuttle running between São Tomé and Mina in 1484. They are mentioned in Arguim from 1508, 1510, and 1511; in São Jorge da Mina in 1511; and in Mazagan in 1533-1535. Tonnages of these vessels varied, and they may have stepped between one and

three masts. They were either outfitted with lateen sails or rigged *redondas*, the latter being more common. Later in the 16th century, Father Fernando Oliveira wrote that both large and smaller *caravelões* existed, built with and without castles (Elbl 1985:568).

In the Indies these ships were frequently employed in reconnaissance fleets and for river travel. They were also used for transport services, disembarkation, and mercantile traffic. Along the coasts of Brazil, *caravelões* engaged in exploration as well as occupation, sometimes grouping together to reinforce armadas. Six of these vessels were used during the conquest of Rio de Janeiro in 1567 (Fonseca 1934[1]:38). In the 1620s, the Spanish were using *carabelones*—the Spanish equivalent of the Portuguese *caravelão*—of 80 to 100 *tonéis* to enhance security in Portobelo, Panama (Archivo General de Indias: Patronato 270, No. 1, R. 28).

Late 16th- and Early 17th-Century Caravel Forms

Caravels in their various forms continued to be used during the 16th, 17th, and into the 18th centuries. As they continued to develop, their hull forms, capacities, and general uses drifted progressively further from the famous 15th-century *caravelas dos descobrimentos*, the icons of Portuguese national identity. The exception to this is the *caravelão*, used for similar purposes in both the Indies and Brazil. By the late 16th or early 17th century, the anonymous author of *Livro Náutico* describes how to build a caravel of between 150 to 180 *tonéis*, over three times the capacity of the mid-15th century caravels of exploration (Figure 5-9). In a similar fashion, Manuel Fernandes in 1616 put forth instructions in *Livro de Traças de Carpintaria* for constructing caravels

of 11 and 12 *rumos* of keel, corresponding to overall lengths of 23.17 m and 25.68 m and hull capacities of between 100 and 150 *tonéis* (Barata 1989[2]:36).

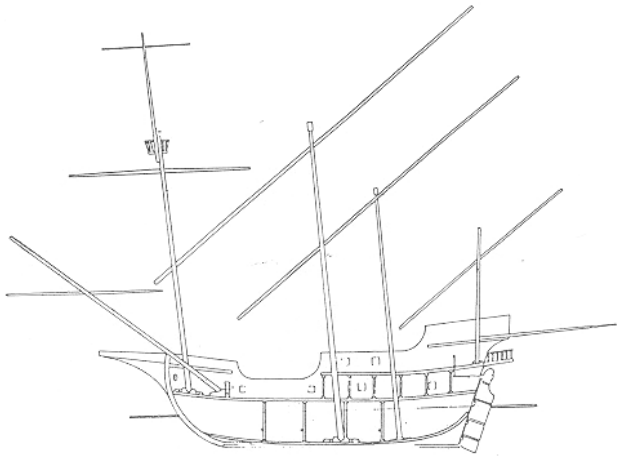

FIGURE 5-9. Representation of a four-masted caravel of 150-180 *tonéis* inspired from the instructions from *Livro Náutico* (After Fonseca 1934[1]:269)

In the first quarter of the 17th century, caravels were used by the Spaniards for exploration in the Straits of Magellan. A well-known example of this is from a document concerning the one-year provisioning of Bartolome Garcia Nodal's caravels. In the early months of 1618, Bartolome, his brother Gonzalo, and cosmographer Diego Ramirez de Arellano, among others, under the instructions of the Spanish crown, set sail from the Philippines to explore the Straits of Magellan (Archivo General de Indias: Patronato 33, No. 4, R. 5). The two caravels outfitted for the voyage were 80 *tonéis* and stepped four masts, with a square sail on the fore and fore top masts and lateen-rigged on the other three masts (Figure 5-10; Lopes de Mendonça 1892:54). They were also armed with four cannon and four swivel guns (Fonseca 1934[2]:115). Working in conjunction with

Nodal, Diego de Molina was sent with two caravels to reconnoiter and sound out the Straits of Magellan in 1618. These vessels, built in Peniche, Portugal, were 50 to 70 *tonéis* and had crews of 18 mariners along with 15 soldiers and 2 gunners (Archivo General de Indias: Patronato 33, N.5, R. 1; Navarrete 1971[20.2]: folio 503).

FIGURE 5-10. Sketch of a Nodal caravel dated to 1621 (After Fonseca 1934[2]:70-71)

These caravels were of a slighter tonnage than those found in the late 16th-and early 17th-century Portuguese shipbuilding treatises. As mentioned above, instructions for the fabrication of caravels show vessels of between 100 and 180 *tonéis*. Perhaps these smaller caravels remained closer to the tonnages of caravels of discovery because they were employed for similar purposes—exploring unknown waters in often shallow depths. Caravels used for the Carrera de Indias for the mercantile trade were more prosperous if they were capacious and able to transport more goods. The instructions for building caravels in the Portuguese manuscripts most likely represented this latter form of the vessel.

Written evidence describing some characteristics of these caravels can be found in a manuscript from Portugal's Arquivo Geral de Marinha under the full title *Das Coisas Tocantes á Arte Militar: Instruções sobre Services a Bordo das Navios da Guerra*. This document, mostly a collection of records regarding the victualling of ships, is dated to 1659, but much of the information within it dates to earlier periods. A chart dated to 1627, listing ships in a fleet destined for the Carrera de Indias, shows that six of the 56 vessels were caravels of varying tonnages (Figure 5-11; Archivo General de Marinha: No. 2461). The caravels *Conçeisão*, *Rodairo*, *Remedios*, and *São João* were 139, 93, 120, and 90 *tonéis* respectively. They each had an equal number of 22 crewmembers, in addition to 10 armed soldiers wielding pikes. These ships are listed as having zero propelled artillery, suggesting they were designed not for war but rather transportation of cargo and soldiers. Perhaps these caravels bear a close resemblance to the ones described in the 17th-century treatise by Manuel Fernandes, with rounder hulls and low length to beam ratios.

In the 1630s, caravels were used in fleets sent from Lisbon to assist the armada in Pernambuco against the Dutch. One particular flotilla dispatched in 1631, noted by Quintela in *Anais da Marinha Portuguesa* (1840[2]:281), consisted of Portuguese and Spanish vessels, five of which were caravels used for transport. These ships, *Senhora da Ajuda*, *Santa Cruz*, *Nossa Senhora da Guia*, *São Jerónimo*, and *Nossa Senhora do Rosário* were 100, 120, 150, 100, and 120 *tonéis* respectively (Fonseca 1934[2]:157). Such caravels of higher tonnage were probably closer to the lower length to beam ratios

found in the ships described in the shipbuilding treatises rather than those used for reconnaissance in the Straits of Magellan.

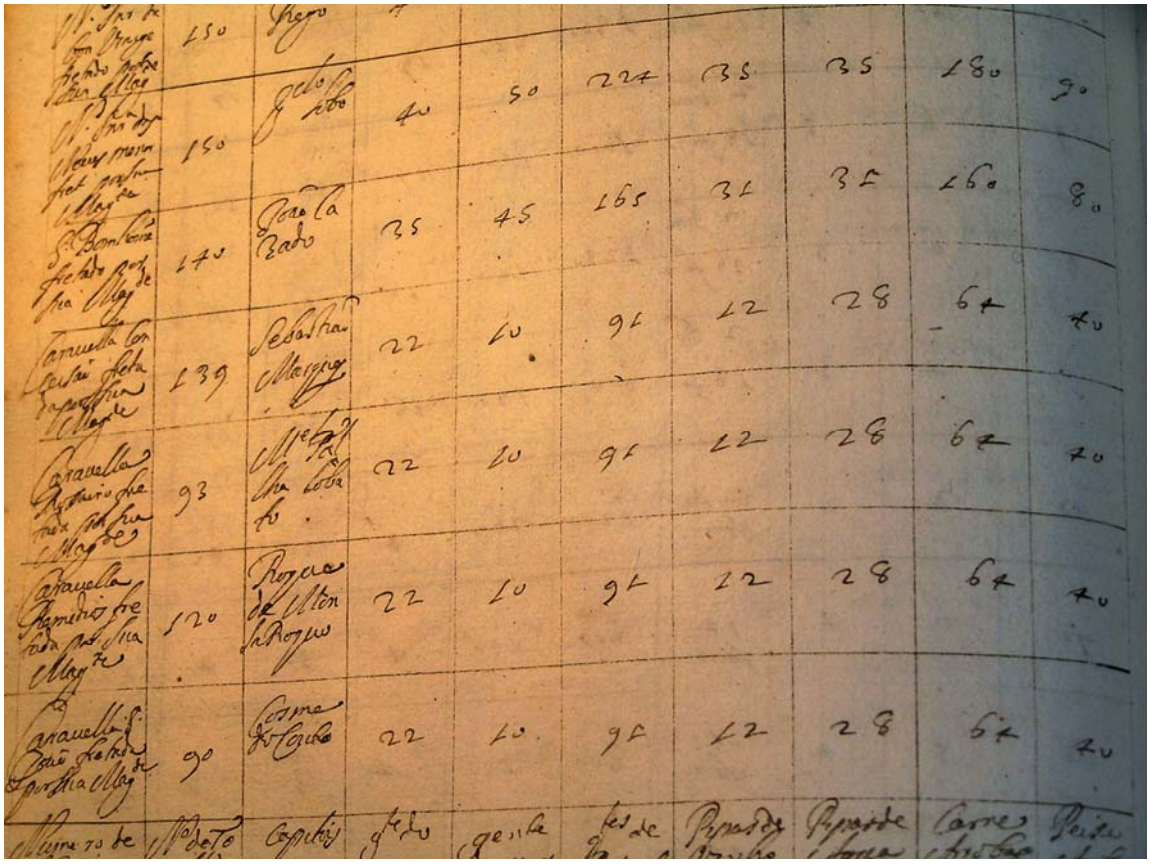

FIGURE 5-11. A chart detailing the vessels in a fleet destined for India, dated to 1627 (Photo by author 2005; courtesy of Archivo Geral de Marinha)

Final Phases of Caravel Design

The tendency for a heavier, beamier construction of caravels can be observed in a critique of Spanish naval architecture written between 1630 and 1650: "…the entry and exit should be broad and open as it is in the caravels and in the Flemish ships, for that makes possible a reinforcement with bulwarks from the inside…" This period was,

essentially, the last phase of design and development of the caravel (Navarrete 1971[1]:fol.131-132; Elbl 1985:570). These 100 to 170 *tonéis* ships had length to beam ratios of approximately 2.9:1, and were basically hybrids of *naus* and caravels. They were square-rigged on the sprit, fore, and fore top masts, and had an additional three lateen-rigged masts. This later type of caravel had a reinforced hull form that was excellent for the placement of guns but naturally lacked the fine lines of its predecessors (Elbl 2000:97).

Once the route to India was established by Vasco da Gama at the turn of the 16th century, caravels were not called upon as frequently as they were during the earlier years of the discoveries. Although they continued to be used regularly in Portuguese riverine environments, other European and Mediterranean seafaring nations were using them less routinely. For example, by the 1530s the number of caravels in the port of Valencia dramatically declined, and in 1552 Spanish regulations for the Carrera de Indias banned the use of ships less than 100 *tonéis* with crews of less than 32 men. This may not have been regularly enforced, but by 1587 this limit was raised to ships of less than 300 *tonéis* (Elbl 2000:98). While other documents, such as the ones mentioned above, show that caravels were still employed in this run to the Americas, the fact that there was a regulation shows the desire to use larger vessels for the transatlantic crossings.

In the last quarter of the 16th century the frequent use of smaller ships resurfaced in Europe, and caravels were once again commonly seen. They were gradually supplanted over the next two centuries, however, by barques, *saetìas*, *pataches*, and *bergantínes*, effectively ending the long developmental history of the caravel ship type

(Elbl 2000:98). Some scholars and small craft specialists, however, claim that many features of the famous 15th-century *caravelas dos descobrimentos* survive in Portuguese waters to this day in the form of the *caíques* of the Algarve (Figure 5-12; Fonseca 1934[1]:46; Brás de Oliveira 1940:24).

Probably the last known reference to an Iberian caravel comes from a passage in the 1738 newspaper *Gazeta de Lisboa*. It describes a Portuguese caravel on its way to Setúbal being chased by an enemy vessel and finally running aground. As the enemies attacked, Portuguese knights and passersby gathering on the Esmoriz beach returned fire and eventually captured 17 Moors (Fonseca 1934[2]:158). There is no description of the ship itself, and its size and features cannot even be estimated.

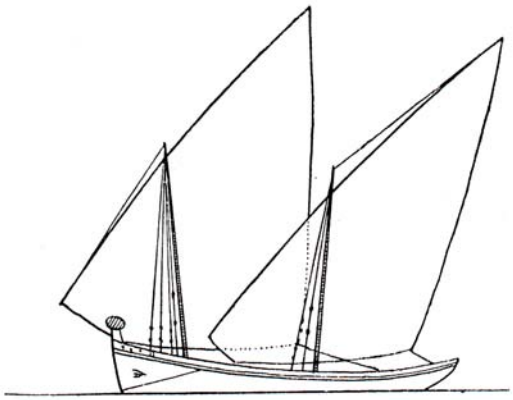

FIGURE 5-12. Drawing of a *caíque* from the Algarve (After Fonseca 1934[2]:87-88)

Conclusions

As demonstrated in this chapter, a review of documentary evidence from a wide array of sources gives a scattered but reliable history of the development of the caravel. The historical record shows a gradual development of this ship type from its humble

12th-century origins as a ship tender to the final bulky 17th-century transporter that was eventually replaced by better qualified vessels of the time. These documents reveal a branching progression which spawned a variety of forms of caravels throughout five centuries. They developed independently and often overlapped in their existence. Caravels, in essence, were designed according to the specific niche they fit into in the era in which they existed. Such a large degree of modification in hull form and appearance occurred throughout these five centuries that it is doubtful that the two versions of the vessel mentioned above shared much of anything except nomenclature. Nonetheless, these multifarious views of caravels help delineate the type of ships found in the archaeological record and give scholars of Iberian seafaring a significant body of knowledge with which to compare other lines of evidence relating to the development and diversity of caravels.

CHAPTER VI

SHIPWRIGHTS, NAUTICAL TREATISES, AND DESIGNING AN IBERIAN SHIP FROM THE LATE 16TH AND EARLY 17TH CENTURIES

Early Shipbuilding Documents

Throughout the course of their existence, caravels were designed and built according to a diversity of methods. As 13th-century documents have shown, caravels were likely used primarily as coastal fishing boats. They may have been adapted from a variety of small water craft, such as the Arab *qârib* and other models of lateen-rigged craft, which were made to suit Atlantic sailing conditions (Elbl 1985:545). In any case, as they became more qualified for voyaging in the high seas, caravels became more robust, and methods of construction changed along with the morphology of the ship. Unfortunately, little is known of early Iberian shipbuilding techniques. Until records of such practices were kept, this information was safeguarded in the minds of seasoned boat builders who passed on the traditions both orally and by sharing practical work experience through generations. As Iberian maritime scholar Casado Soto (2001:131) points out, the combination of the short life expectancy of that era and the unyielding secrecy that was practiced regarding this specialized knowledge prevented these early traditions from surviving in written form.

Prior to the reign of Catholic kings in the Iberian Peninsula, there was little mention of shipbuilding in documents, and when ships do appear, it is only with regard to their names, types, and occasionally tonnage. With the reign of Charles V (1516-

1558) and the expansion of foreign policy, however, there was an improvement in efficient management techniques. During the reign of Phillip II (1556-1598), an effective system for measuring the hulls and capacities of ships was established. He was, in fact, the first European monarch to use a prototype to build ships for the armadas, using the galleon as the model (Casado Soto 2001:135).

It was also during the reign of Phillip II that the production of documents recording shipbuilding techniques grew the most. Several documents concerning ship manufacture have survived from this era, either published or in original manuscript form. Examples of these works are: *Espejo de Navegantes* (Alonso de Chavez 1536), *Papeles* (President Visitador ca. 1560), *Ytinerario de Navegación de los Mares y Tierras Occidentals* (Juan Escalante de Mendoza 1575), *Discusión de Prototipos de Galeón* (Cristobal de Barros 1581), *Arte para Fabricar, Fortificar y Aparejar Naos* (Tomé Cano 1611), and *Ordinanzas de Fábricas de Navios* (1605, 1607, 1618) (Casado Soto 2001:136). These documents are useful for studying the history of shipbuilding, but the authors were often influenced by their unrelated professions, so the extent of their actual experience in shipbuilding is unknown. Nevertheless, these works represent an early attempt at describing shipbuilding processes and give information on raw materials needed for construction, as well as the dimension and tonnage of ships.

More helpful in understanding how Iberian vessels were designed during this period are manuscripts and treatises written specifically about the art of shipbuilding. These works offer more details on how to construct certain types of vessels and appear to have been written by individuals who spent at least some time in the shipyard. Though

there are more sources, five shipbuilding treatises deserve particular attention in this study due to their specific mention of caravels or their detailed instructions on ship construction: *Instrucción Náuthica* (Garcia de Palacio 1587), *Livro da Fábrica das Naus* (Oliveira 1580), *Livro Náutico* (ca. 1580-1609), *Livro Primeiro da Arquitectura Naval* (Lavanha 1609), and *Livro de Traças de Carpintaria* (Fernandes 1616). Since these are among the best surviving written Iberian sources, parts of these treatises are briefly discussed here in order to understand the basic methods involved in constructing a 16th- and 17th-century caravel.

Earlier shipbuilding manuscripts either did not exist or have not survived. Thus, aside from archaeological interpretation of limited Iberian shipwreck finds, the exact methods involved in the construction of earlier vessels is presently unknown. Through the analysis of these later treatises, however, shipbuilding trends are found that were probably vestiges of more ancient methods of ship design. This information, combined with details from other lines of evidence—such as similar surviving shipbuilding traditions, explored in the next chapter—leads to at least an elementary understanding of how caravels were likely built during the Age of Discovery.

O Livro da Fábrica das Naus

This treatise was written by Father Fernando Oliveira and dates to 1580. It is a remarkable corpus of information concerning shipbuilding in the 16th century and extremely valuable to scholars of Iberian shipbuilding. Although it was never completed, it contains information on a variety of nautical themes, including advice on suitable wood for shipbuilding, materials required for the construction of a vessel, details on

several types of watercraft, and construction and measurement of ships. The work appears to be a continuation of an earlier treatise written in Latin by the same author, entitled *Ars Náutica* (ca. 1570). Because *O Livro da Fábrica das Naus* contains a fairly complete section on shipbuilding methods, it is the one used here to describe in detail how Iberian vessels were designed in this era.

In the autobiographical section of this manuscript, Father Fernando Oliveira mentions that he had traveled the world, working and studying in shipyards in Spain, Italy, France, and England. It is likely that Oliveira studied the Thames shipyard during his time in England, and very possibly met his contemporary in shipbuilding practices, Matthew Baker. Many of Oliveira's drawings are similar to the ones represented in *Fragments of English Shipwrightry*, a coeval collection of shipbuilding documents started by Matthew Baker (ca. 1570) that gives information about English shipbuilding during the 16th century. An example of parallels in the books includes the analogy of a ship's hull and the body of a fish (Figure 6-1). This hull morphology, according to the authors, is what is attributed to the smooth sailing capabilities of the vessels (Barker 1992:8-9).

Father Fernando Oliveira was knowledgeable on a diversity of intellectual fronts and composed a variety of instructional works during his life. His free-thinking mind is revealed in some of his compositions. Oliveira's first written work is a textbook on the Portuguese language, entitled *Gramática da Linguagem Portuguesa*. He then authored *Arte da Guerra do Mar*, a book detailing methods of naval warfare, in which he blamed the Portuguese for introducing slavery in Europe and severely criticized them for it.. He

also commented on the advent of firearms as “an invention certainly more infernal than human” (Oliveira 1991:39). Considering his background, it is a justified assumption that Father Oliveira’s work is reliable for the purposes of understanding elements of the art of shipbuilding during his era.

FIGURE 6-1. The body of a fish superimposed over the hull of a ship (After Kemp 1988:31)

His practical experience and cosmopolitan view suggest a sophisticated intellect and considerate authorship. His diverse career path offers further substance to this conclusion: Dominican priest, grammarian and historian, cartographer and pilot, adventurer and occasional diplomat, and theoretician of war and shipbuilding (Oliveira 1991:41).

O Livro da Fábrica das Naus is divided into a prologue and nine chapters. The prologue places deep significance on ships and navigational science in the history of Portugal. Oliveira mentions that information on shipbuilding had not been properly taught in the past and that the methods behind this art had been hidden. Thus, the author decided to produce this instructional manuscript as a guide to shipbuilders.

Chapter two, for example, describes the types of woods that are suitable for shipbuilding, and Oliveira suggests the two most appropriate kinds of wood for a ship were cork-oak (*Quercus suber*) and pine (*Pinus pinea*). The cork-oak was used for frames, and the pine for planking. Chapter four gives instructions on the materials that are used in shipbuilding. Oliveira mentions iron nails, oakum and pitch for caulking, and grease used in lubricating the vessel. Chapter five briefly describes various kinds of vessels, including *naos*, galleys, galleons, and caravels. Although all chapters of this book offer important insight to aspects of Iberian shipbuilding practices during the 16th century, the eighth chapter is the most instructive for the study of the structural characteristics and construction of an Iberian vessel from this era.

The type of ship that Oliveira generally refers to is a *nau*—a larger, broader vessel than a caravel of discovery. Nevertheless, because he is describing proportions, Oliveira's ship design instructions can be applied to all Iberian ships of this period.

Oliveira begins the eighth chapter by asserting that the beamier the ship, the more cargo it can carry and the more buoyant it will be. Likewise, the vessel must be strong, a good sailor, and of good capacity (Oliveira 1991:163). He warns the reader, however, that although a fairly beamy ship is preferred, it should not exceed the limits of

its proper dimensions. The size of ships depends on the purposes for which they are built and the voyages they are meant to undertake. Certain considerations must be taken, such as the length of journey, degree of safety, and anticipated weather patterns. These variables and others help determine how a vessel should be constructed. Larger ships, for instance, should be built for the purposes of longer journeys to accommodate for the larger quantities of victuals and materials that are needed. In this section, Oliveira comments that small ships are not a good choice for trips to India because the expenditure would exceed the gain, and also because they are not as safe for long journeys as are the larger vessels (Oliveira 1991:163).

As mentioned previously, during the second half of the 16th century, when Oliveira's book was written, caravels were no longer the prime exploratory vessel they had been just fifty years earlier. After the routes to the Indies and Americas were discovered, and cartographers recorded these routes, there was less need for a vessel to cautiously sail into uncharted waters and rocky coasts. Oliveira also mentions other reasons why smaller ships are not practical for long journeys at this time. For example, larger ships have a better ability to defend themselves against pirates than do smaller craft. A ship's size alone is enough to intimidate an enemy, and smaller ships cannot carry enough men to be feared by an adversary (Oliveira 1991:163). He also states that the journeys to India were always made with ships of over 500 *tonéis*, which have made the safest journeys due to their ability to handle better at sea. Thus, it is easy to see why late 16th- and early 17th-century treatises on shipbuilding place less emphasis on smaller vessels such as caravels.

Despite this, the manuscript is still very informative and applicable to the study of caravel construction because Oliveira describes the dimensions of ships in a relative way. He asserts that all ships, regardless of shape or size, can be built by using one part of the vessel as a proportional basis from which to derive other parts of the vessel. He refers to this as *rata pars*, which means "certain part" in Latin. Oliveira likens this concept to the proportion of the human head to the rest of the body. If the head is large, other parts of the body will also be large, in a proportion corresponding with the size of the head. He then assigns the keel as the part of the ship by which all other members of the same vessel are measured. He writes that once the length of the keel is known, shipbuilders can get the width and height of the vessel, the bottom, bow and stern rakes, and other major components of the ship (Oliveira 1991:165).

Oliveira gives the keel to beam ratio of a ship as 3:1, with a width that is slightly greater than the height of the vessel. The ship that Oliveira refers to in his examples is a theoretical *nau* of 18 *rumos*. Thus, a ship with a keel of 18 *rumos* would have a beam of 7 or 8 *rumos*. Its depth would then be a bit less than that of the beam (Figure 6-2) . Oliveira writes that the exact measurements would be up to the discretion of experienced carpenters (Oliveira 1991:166).

The author describes the keel essentially as the backbone of the vessel, and declares that it should consist of a thick piece of strong timber, such as cork oak, since all of the vital structures of the vessel are set upon it (Oliveira 1991:169). This is a principle that has been utilized since ships started integrating keels into their longitudinal

framework; but a strong, thick keel is especially important for an ocean going vessel that must withstand the intense pressures of Atlantic sailing conditions.

Next, Oliveira expands upon the bow and stern rakes, which are also proportional to the length of the keel. The rake of the bow is approximately one-third the length of

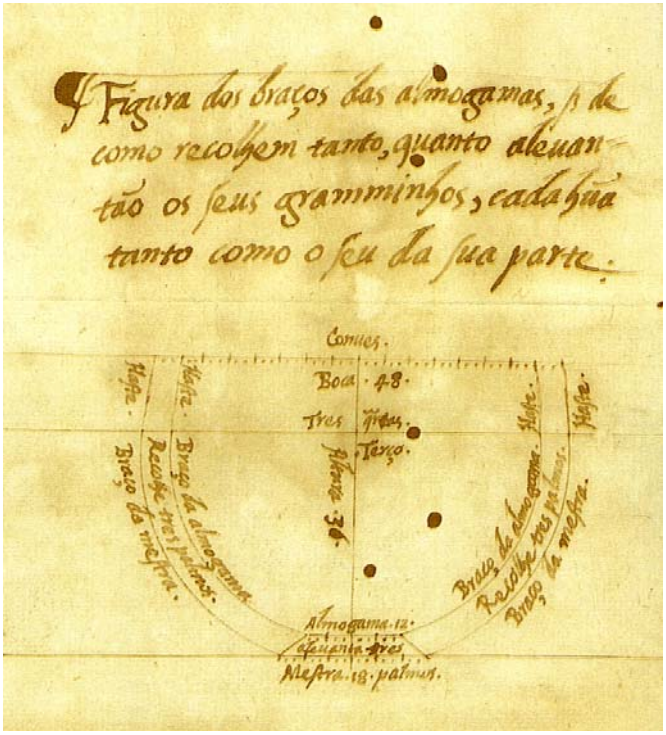

FIGURE 6-2. Proportions of keel height and beam width (After Oliveira 1991:folio 114)

the keel. This rake is obtained by erecting a vertical line at the butt of the keel, forming a perpendicular reference which reaches a height of one-third the length of the keel, which is also the height of the deck. After this measurement is taken, a compass is used to swing an arc from the bottom of this perpendicular where it meets the keel, to the height of the predetermined deck line (Figure 6-3). Oliveira asserts that this method is the best

in existence, because the more one utilizes parts of a circle, the more efficient the bow of the vessel will be (Oliveira 1991:171).

The rake of the stern is not as great as that of the bow. It is, however, formed in a similar way. The perpendicular is created at the point on the keel where the sternpost begins. An arc is then drawn from this perpendicular down to the keel. This arc is subsequently divided into seven parts, each of which is the same length as the rake aft of the perpendicular (Figure 6-3; Oliveira 1991:171).

Next, Oliveira briefly mentions the placement of the *gio*, or wing transom. Essentially, his main emphasis lies in the leveling of the timber, which is fundamental for the balance of the vessel. He continues with the strengthening of the keel, which is achieved through the placement of the keelson and deadwood timbers. He stresses that

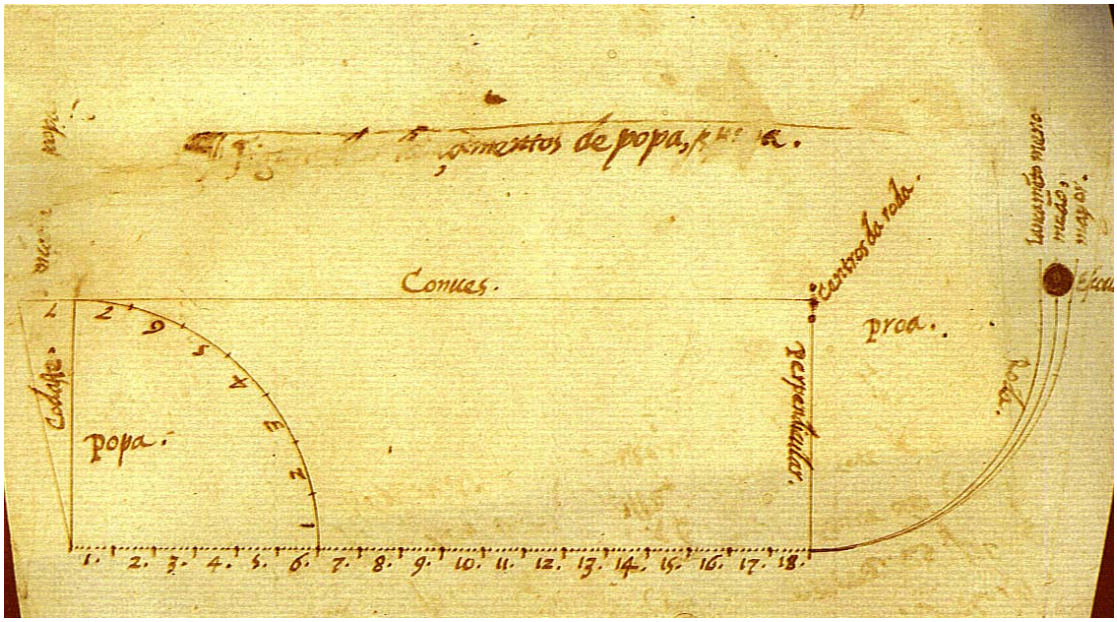

FIGURE 6-3. Obtaining the arcs for the bow and stern rakes (After Oliveira 1991:folio 82)

these timbers must all be thick and strong because the structural integrity of the vessel relies heavily on these components (Oliveira 1991:172).

Oliveira then demonstrates how to lay the bottom of the ship. This is an extremely important part of the manuscript, for it shows how the shape of the vessel is conceived. Described for the construction of *naus*, evidence suggests that this method was used for caravels and other watercraft as well. The laying of the bottom is a fairly involved process which will only be briefly discussed here. First, the master frame, which is the center of the predetermined section of the hull, must be situated forward of the middle of the keel. As Oliveira notes, this is mainly to obtain a longer run in the hull, which provides the vessel with better maneuverability. The floor timbers, or flat timbers forming the bottom of the frame, are essentially flat on the master frame. As the frames are placed fore and aft of the master frame, however, the floors are raised according to a predetermined scale. As these floors are raised, they are simultaneously narrowed in order to give the vessel the necessary curves that allow for good sailing capability. This narrowing is achieved in the same manner as the rising of the floors, by a geometric algorithm from which shipwrights obtained a measuring gauge, called a *graminho* in Portugal (Oliveira 1991:174).

There are various ways to make a *graminho*, but the end result is always a scale obtained by the division of the length of the keel by the number of predetermined frames that will be placed on the keel. The *compartida* is this value that is divided, and indicates the amount by which the turn-of-the-bilge points are to rise and narrow. This *compartida* is distributed proportionally throughout the portion of the keel upon which the pre-

designed frames are placed, and is what gives the vessel the shape desired by the shipbuilders (Oliveira 1991:175; Castro 2007:149).

Frames along the keel, fore and aft of the master frame, often used a separate *graminho*, or gauge, to determine their respective rising and narrowing. Using a half mold of the master frame, one gauge was used for measuring the rising of the floors and another gauge for measuring the narrowing of the floors. The first floor aft of the master frame, for instance, was designed by using the pattern of the master frame and narrowing one point on the gauge while simultaneously raising one point on the gauge. The second frame was narrowed by two points and raised by two points. This method was continued all the way to the *almogamas*, or tail frames, which are the last predetermined frames on the keel (Figure 6-4; Castro 2005:161). The remaining frames were called *enchimentos*

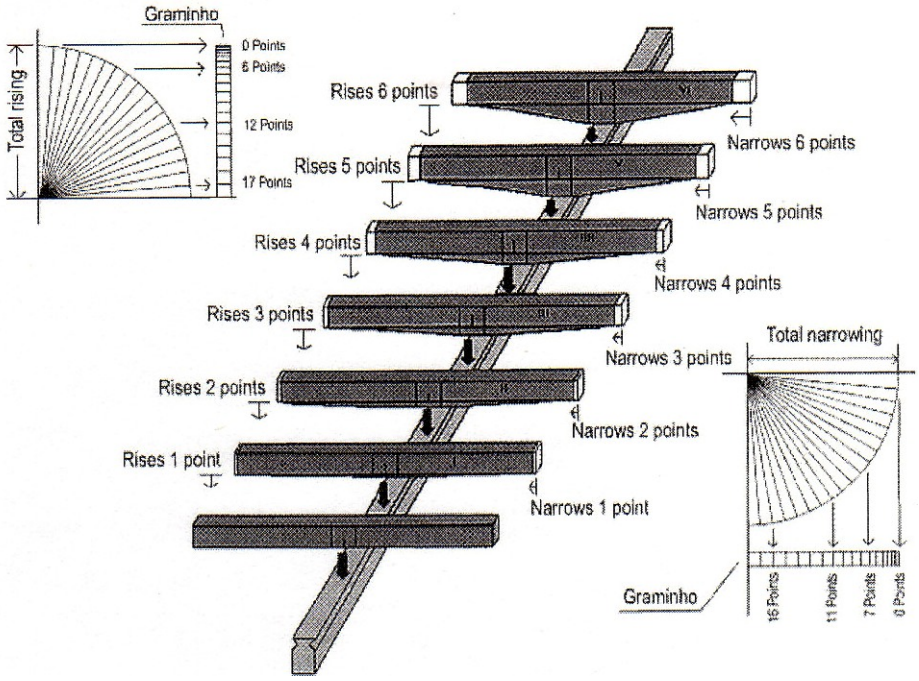

FIGURE 6-4. Rising and narrowing of the floor timbers using *graminhos* (After Castro 2005:162)

and were shaped according to a series of battens that were laid along the length of the vessel across the erected predetermined frames from sternpost to stem (Sarsfield 1985b:66-69). This practice is seen in recent Brazilian boat building techniques as discussed in Chapter VIII of this thesis.

Oliveira also describes how to loft the frames of the vessel, which are comprised of the aforementioned floors, and the corresponding futtocks which are fastened to these floors by iron nails driven transversally through the corresponding members. The design of the futtocks and top timbers that make up the upper part of the master frame is conceptualized through the geometry of a circle. Ancient shipbuilders used circular arcs to form the shape of the frame, which is based on a set of rules that is explained in detail and illustrated by Oliveira. Subsequently, the other predetermined frames are fabricated using the master frame as a point of reference, rising and narrowing its bottom accordingly (Oliveira 1991:176).

Oliveira asserts that the formation of the bow should be full and not narrow, as a fuller bow facilitates better steering than a narrower one. If the bow is too narrow, it will be a poor sailor and will more easily fall off course. He adds that a narrow bow will cause more turbulence and will not break through waves as easily as a wider bow. He stresses that the frames and timbers that form the bow and stern of the vessel outside of the predetermined frames—those not designed through the use of the *graminhos*—must run smoothly so as to not create any irregularities in the form of the ship (Oliveira 1991:190).

The author then describes the positioning of the beam of the vessel, which is the widest point at the main deck, and says that it is situated at a height equal to one-third of the keel length. This beam is narrowed equally both forward and aft until it reaches the tail frames. He states that this reduction is equal to one-eighth of the greatest beam. Outside of the tail frames, the reduction is equal to three-eighths of the greatest beam (Oliveira 1991:193).

In his description of the vessel's outer planking, Oliveira advises that the timbers be of a thickness suitable for the purpose of the ship, heeding much attention to the voyages it will make as well as the conditions it will need to endure. The wales, or larger external longitudinal timbers that provide additional support, should be at least two fingers thicker than the planking but not as wide (Oliveira 1991:199).

Oliveira continues discussing other details of construction which generally apply more to vessels larger than the caravel, and will not be mentioned here. It is apparent that the information provided in this manuscript gives scholars of Iberian seafaring an invaluable look into the theories and practices of ancient shipbuilders during the 16th century. By examining Oliveira's manuscript in detail, general traits of Iberian ships are revealed, which is an important step in the understanding of the structural characteristics of the caravel. Most of the shipbuilding methods and features described in *O Livro da Fábrica das Naus* would be expected to appear on an Iberian caravel from the early 17th century, and many would likely be found on earlier caravels of discovery. Oliveira's manuscript on the construction of *naus* was the forerunner of nautical treatises. Later

treatises, such as *Livro Primeiro da Architectural Naval*, describe and demonstrate many of the same shipbuilding methods and ideas as *Livro da Fábrica das Naus*.

Instrucción Náuthica para el Buen Uso y Regimiento de las Naos, su Traza y Govierno

This Spanish manuscript, licensed in Mexico in 1587, was composed by Doctor Diego García de Palacio, of His Majesty's Council and Judge in the Royal Audiencia of Villa Manrique. This is actually the first published treatise on shipbuilding, since *Livro da Fábrica das Naus*, though written earlier, was not published until the late 19th century (Phillips 1987:294).

The book is largely concerned with navigation and techniques used to acquire navigational information. This primarily includes geometric divisions and astronomical observation and calculations. García de Palacio describes how to get information from celestial objects in order to make calculations and charts to aid in navigation. He also gives instructions on the use of the compass, the quadrant, the astrolabe, and other scientific instruments.

The treatise is comprised of a preface and four books, with each book composed of a varying number of chapters. The first chapter of Book Four is entitled, "Of the Calculation and What Pertains to the Hull of Any Ship," and has the most relevance for this study. Instead of fish, García de Palacio compares ships to human bodies, and likens timbers to bones, rigging to nerves, sails to membranes and tendons, hatches to mouths, and the hull to the belly of a man. The calculations of ships, according to the

author, is generally made in *codos de ribera*, the Spanish shipwright's cubit (see Appendix A). He suggests that 400 *tonelados* is an ideal size for a vessel, whether for war or trade, and thus refers to a *nao* of this size through the course of his analysis on proportion (García de Palacio 1988:114-115).

Along with his descriptions of principal measures, García de Palacio provides drawings of the ship, illustrating the instructions put forth in his work (Figure 6-5). For a 400 *tonelado* vessel, he claims it should have 34 *codos* of keel, 16 *codos* of beam, and a depth of 11.5 *codos* (García de Palacio1988:115). This equates to a length to beam ratio of 2.95:1, which is close to the proportions given by Oliveira. The third measurement, however, is incongruent with the traditional Mediterranean proportions for a merchant

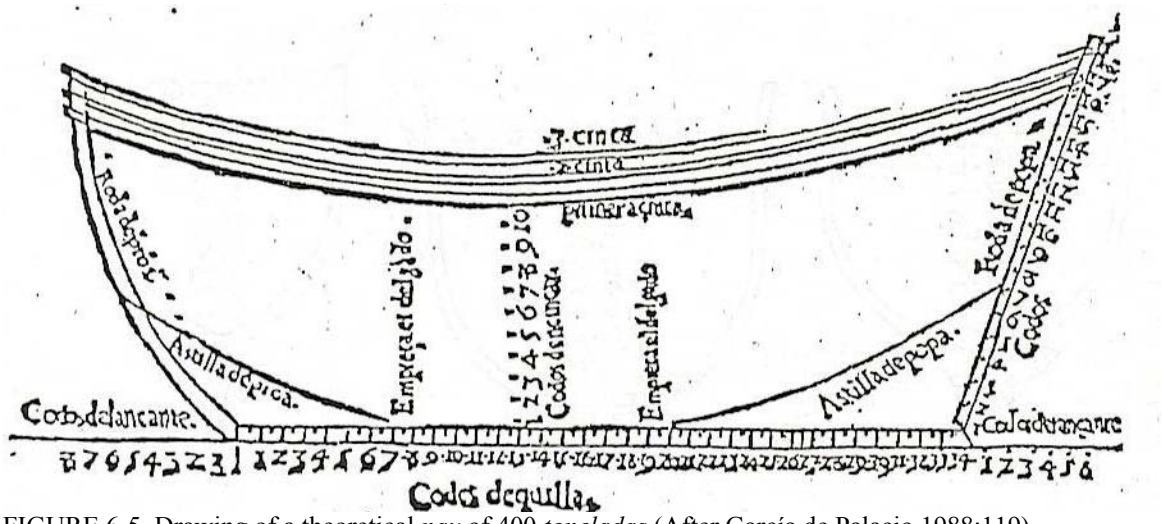

FIGURE 6-5. Drawing of a theoretical *nau* of 400 *toneladas* (After García de Palacio 1988:119)

vessel of "as, dos, tres," in which each unit of beam corresponds to two units of keel and three units of length on deck. Maritime historian Carla Rahn Phillips's (1987:296)

interpretation of this is that García de Palacio included all the enclosed area of the hull in his depth measurement. This is in contrast to a slightly earlier work by Escalante de Mendoza (1575), entitled *Ytinerario de Navegación de los Mares y Tierras Occidentals*, in which he defined depth as the distance between the floor above the keel and the first fixed deck. As Phillips (1987:294) explains from her analysis of *Instrucción Náutica*, we are dealing with a discrepancy in the definition of depth rather than a major change in ship design.

Like his contemporary Father Oliveira, García de Palacio explains that these proportions can be used for practically any sized vessel. He does, however, give examples of proportions for ships of less burden—between 50 and 100 *tonelados*—which were used along the coast of New Spain in fairly shallow water. This is useful information because caravels were also used in coastal waters during the discoveries, and likewise were in the range of 50 to 100 *tonelados*.

The author states that such vessels were made with the floor measuring one-fourth of the widest beam, the depth of hold one-half of the widest beam, a sharp stern and bow deadrise, and a reinforced lateral resistance. This structural form was desired because they always sail close-hauled, or as near to the wind as possible to maximize speed to windward. To facilitate easy steering, the deadrise for the run should begin six timbers toward the stern from the first timber placed on the keel, which is the master frame. The deadrise should end six and two-thirds *codos* high upon the sternpost, which is one-fifth of the keel and formed in the shape of an arch. Likewise, the bow deadrise should start nine timbers ahead of the master frame and terminates somewhat arched at

the stem. García de Palacio (1988:116) emphasizes that the placement of the master frame should be two *codos* forward of the middle of the keel (Figure 6-6). He continues with the placement of frames and other members of the ship, including the rudder, tiller,

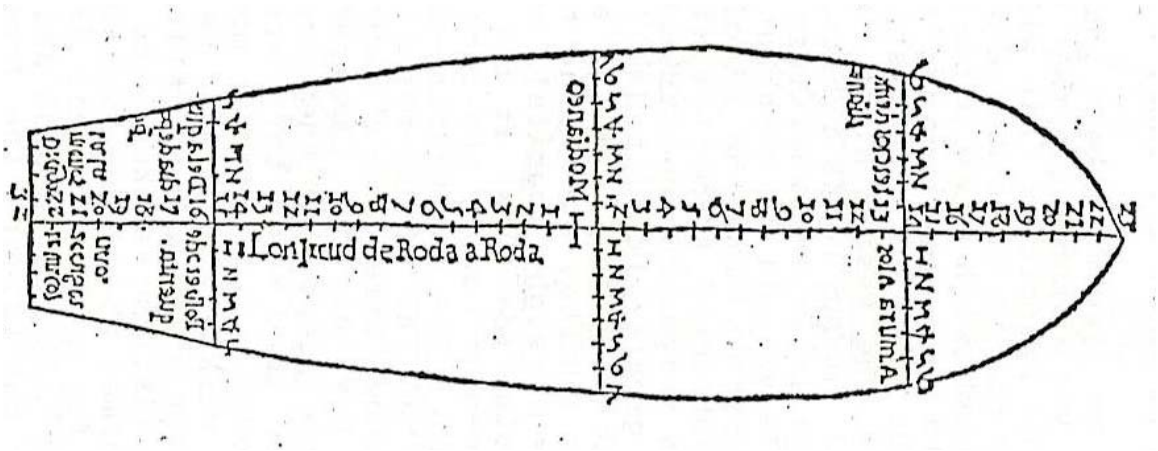

FIGURE 6-6. Placement of the frames upon the keel (After García de Palacio 1988:122)

stem, planking and wales. Though instructions for a general ship, the construction sequence and description of proportions is a good indication of some of the rules that were followed when building a caravel.

Though not discussed here, García de Palacio divulges a wide array of information in the remaining chapters of Book Four regarding masts and sails, yards and tops, rigging and tackle, shallops, pumps, cables, anchors, provisions, the roles of sailors, and the adjustments made when constructing a war vessel. The treatise is an invaluable source for the overall understanding of shipbuilding and navigation during the second half of the 16th century, and provides an informative look at how ships were constructed, outfitted, manned and sailed during the Age of Expansion.

Livro Náutico

Codex 2257, housed in the Reserves of the Biblioteca Nacional of Lisbon, is actually a collection of documents pertaining to the arming, maintenance, manning, outfitting, and construction of ships toward the end of the 16th century. The authors are unknown, and details about its compilation and collection are not well understood. The dates for this collection are nebulous, but fall somewhere between *Livro da Fábrica das Naus* (1580) and *Livro Primeiro da Architectura Naval* (ca. 1609) (Domingues 2004:174). Despite their elusive origins, these scattered documents can provide maritime scholars with a vast amount of knowledge regarding nautical matters of the era.

Lopes de Mendonça (1892) was the first to publish some of these documents in his seminal work *Estudos Sobre Navios Portuguesas dos Séculos XV e XVI*. The papers in *Livro Náutico* stipulate and budget for work that needs to be completed, fleets to be outfitted, and ships to be built. As Domingues (2004:178) observes, in this way the documents in this collection permit us to typify the ships, the crew and armaments, and the functions of ship types and their tonnages. The ship types that are discussed in the papers are multifarious in nature. There are numerous papers on the vessels of large tonnage, such as the great *naus* and galleons of the end of the 16th century that were principally destined for the Carrera de India. Also included are fleet vessels of medium tonnage that were often used for guarding coasts. Additionally, there is information on oared craft, such as the galley and brigantine. Finally, among the papers from *Livro Náutico* are instructions for fabricating a caravel of between 150 and 180 *tonéis*, as well

as measurements for a type of vessel for which this has the only known reference—*caravelas antigas meãs*, or middle-sized caravels of the old style (Domingues 2004:179).

The documents are not reviewed in great detail here, but a comparison of ratios can be made between these last two vessel types. According to Fonseca's (1943[1]:253) analysis of the document, the caravel of 150 to 180 *tonéis* has a length to beam ratio of 2.09:1, and the *caravela antiga meã* has a length to beam ratio of 3.3:1. Lopes de Mendonça (1892:71), however, estimates these length to beam ratios at 2.93:1 and 3.33:1, respectively. Fonseca's ratios for the caravel of 150 to 180 *tonéis* seem much too low for any vessel of this period, and may be attributed to a typographical error, actually intending a ratio of 2.90:1. In any case, it seems likely that the 150 to 180 *tonéis* caravel was attaining hull characteristics and capacities closer to the *naus*, while the latter style may represent a vessel type with lines closer of those of earlier caravel types—hence the appellation *antiga meã*. In spite of this higher length to beam ratio, however, the *caravela antiga meã* is estimated by Fonseca (1934[1]:255) to be a vessel of between 100 to 120 *tonéis*—much larger than any of the *caravelas dos descobrimentos*. Barata (1989[2]:36) actually calculates the tonnage of the *caravela antiga meã* at 150-180 *tonéis*, and gives it an overall length greater than that estimated for the caravel of 150 - 180 *tonéis*, and a length to beam ratio of 3.4:1. Evidently, the rules set forth in these treatises are up for a certain degree of scholarly interpretation, but the *caravela antiga meã*— at least with regard to size and capacity—is still far removed from the earlier caravel forms used for exploration.

Livro Primeiro da Architectura Naval

This work on nautical science was authored sometime at the beginning of the 17th century by João Baptista Lavanha, the mathematician of both Phillip II (1556-1598) and Phillip III (1598-1621) in the Academy of Madrid. Born in the middle of the 16th century, probably in Lisbon, Lavanha is the most well-known of the authors of Iberian shipbuilding treatises. He was a scientist, technician, and professor of cosmography, geography, and topography in Lisbon during the Scientific Revolution. Lavanha's contribution to our knowledge of the history of shipbuilding technology has been well acknowledged by scholars of Iberian seafaring (Barata 1965:23; Domingues 2004:107-135).

His book is divided into 12 chapters, although only the first seven are labeled as such. The first three chapters deal with architecture in a general sense, referring to its universal attributes and the divisions of the subject. The fourth and remaining chapters are dedicated to naval architecture, and, much like Father Oliveira's treatise, include a multitude of themes such as proper wood selection, timber cutting techniques, necessary fasteners for construction, and planning of timbers.

Although *Livro Primeiro* is incomplete, Lavanha's composition does include the instructions for building a *nau* with a keel of seven and one-half *rumos* (Figure 6-7). The formula presented by the author permits researchers to reconstruct the hull of a *nau* up to the first deck. The details included in the manuscript provide fascinating insight to the techniques employed by shipbuilders of this era. Through the course of his discussion, Lavanha guides the reader on how to deduce the forms of the keel, stern post, floors,

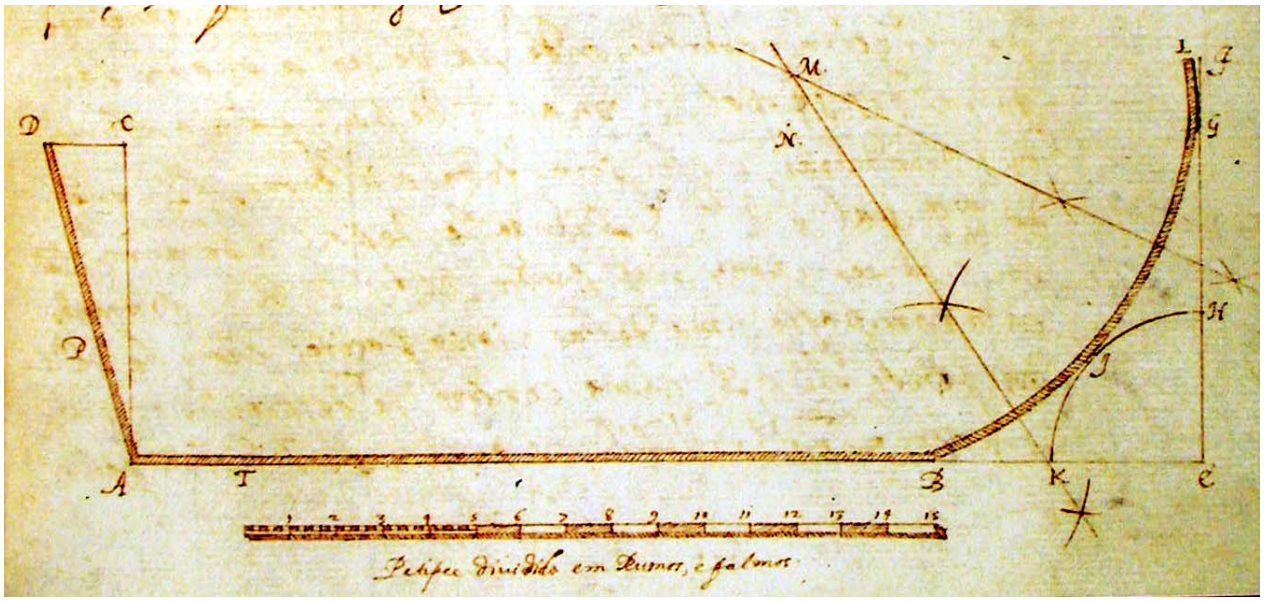

FIGURE 6-7. Drawing of a theoretical *nau* with 7 ½ *rumos* of keel (After Lavanha 1996:folio 57)

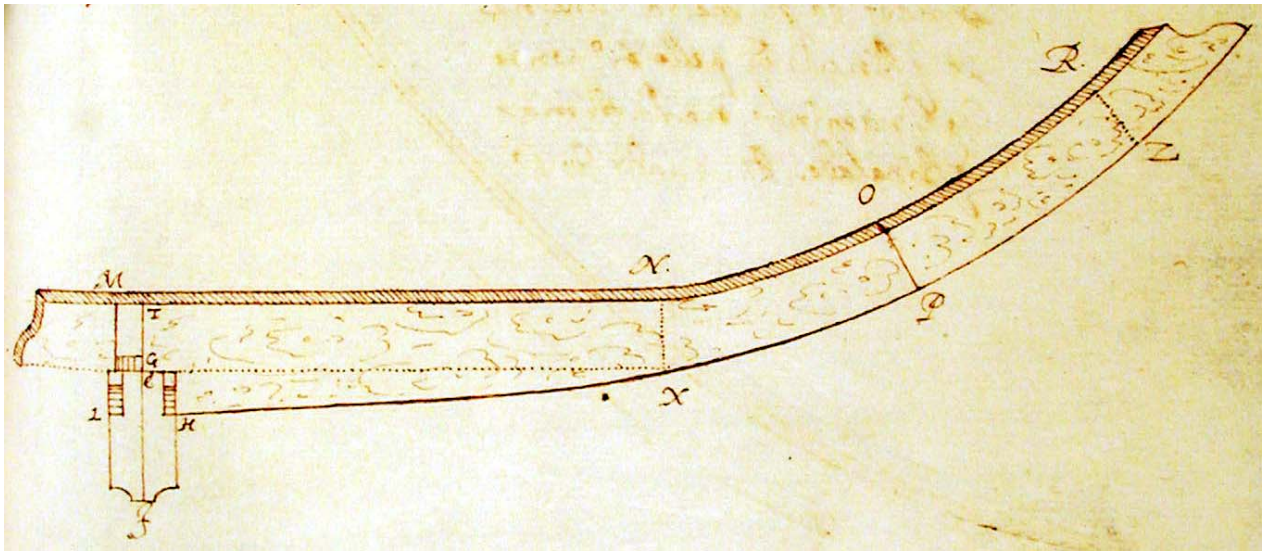

FIGURE 6-8. Using a graminho to loft the frames (After Lavanha 1996:folio 69)

futtocks, *gio*, and other members of the vessel. He gives advice on making a *graminho* and divulges how to use it to mark and subsequently cut the frames (Figure 6-8). The

author also tells how to mark and plane the futtocks and riders, and shows where to place the ribs on the keel (Lavanha 1996).

Lavanha describes useful techniques for assembling the keel of the vessel as well, which, like several other features from these nautical manuscripts, is supported by the archaeological evidence. Because longer timbers tend to warp, Lavanha suggests keels be made of composite pieces that are scarfed together and fastened with long iron nails (Figure 6-9). Due to shortages of timber and the large scantlings required for these ships, short sections for the keel are a natural result (Castro 2005:155), and as such they appeared in the recovered remains of *Nossa Senhora dos Mártires*, a 17th-century Portuguese Indiaman that wrecked in the mouth of the Tagus River (Figure 6-10). This

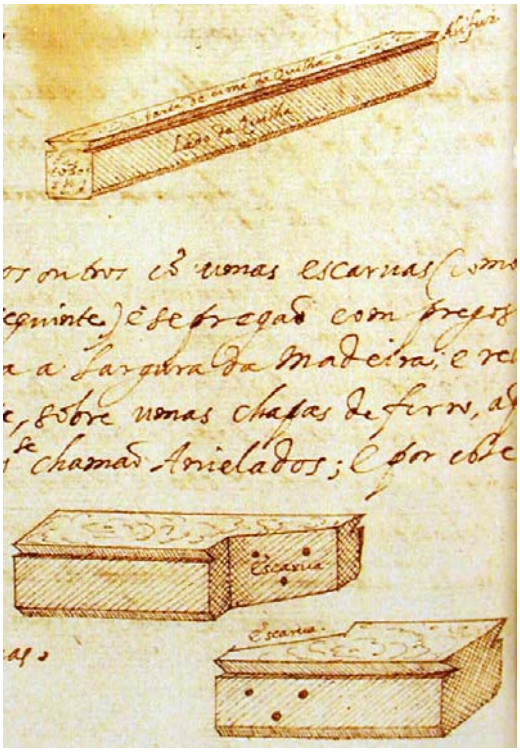

FIGURE 6-9. Joining of keel sections from *Livro Primeiro* (After Lavanha 1996:folio 62)

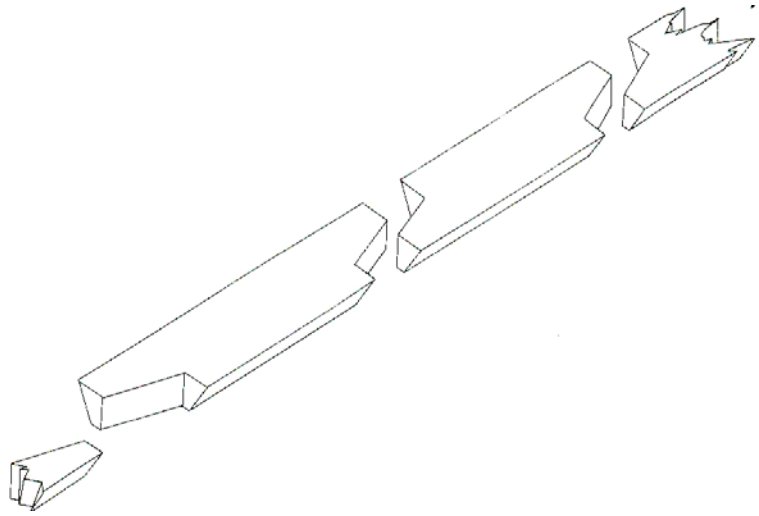

FIGURE 6-10. Joining of the keel from *Nossa Senhora dos Mártires* (After Verbo 1998:202)

type of information abounds in Lavanha's treatise, and in many cases reveals features that would be expected on a 15th- or 16th-century caravel.

It is evident that many other shipbuilding details can be extracted from *Livro Primeiro* and other nautical treatises, and can then be compared with the available archaeological evidence to better understand the methods involved in building a vessel during this era. These are important studies because there are, at times, discrepancies between the guidance found in these ancient texts and the actual methods evidenced in the recovered archaeological timbers. This gives rise to questions regarding the information in the treatises—whether it was procured from genuine shipyard experience or derived chiefly from a theoretical perspective.

Livro de Traças de Carpintaria

This particular work is a shipbuilding treatise composed by Manuel Fernandes, and is dated to 1616. Very little is known about the author of this work, but many

scholars of Iberian shipbuilding suspect that he was a Portuguese shipwright with a fair amount of practical experience in the shipyard. The extent of Manuel Fernandes's

FIGURE 6-11. Portrait of Manuel Fernandes (After Fernandes 1989:folio 2)

knowledge of the art of ship design is conjectural, however, since the only certain biographical information regarding his life is provided in the manuscript itself. The first page of *Livro de Traças de Carpintaria* translates from archaic Portuguese to English in the following way: "Book of draughts of shipwrightry with all the models and dimensions required to build all the navigation, both high-sided and oared, drawn by Manuel Fernandes, official of the same art" (Fernandes 1989:folio 2; Fernandes et al. 1995:113). Essentially he is a self-proclaimed shipwright, further emphasizing this in his self-portrait—included on the same page—which shows the author with the tools of his trade (Figure 6-11).

There are two parts to this treatise: the first section lists dimensions of various ships and their primary components, such as keel, stem, and sternpost; the second part is a collection of drawings of the ships described in the first part of the manuscript. In the first section, Fernandes gives detailed instructions on how to build a variety of Portuguese vessels, including galleons of varying tonnage, carracks, warships, brigantines, and caravels.

Unlike the treatises by Oliveira and Lavanha, the treatise by Fernandes is complete, and contains a plethora of useful guidance for shipbuilders, as well as for nautical archaeologists and maritime historians. Fernandes provides the reader with detailed information about the dimensions of wooden members of ships, and displays these particulars in the form of a list. This treatise does not, however, dwell on ship design. This example is from the section entitled, "Calculation and dimensions of a four-decked carrack, as will be seen hereafter":

> The keel shall be seventeen and a half, or even 18 *rumos* long between perpendiculars and this length shall therefore be 105 palms. If the keel length is seventeen and a half *rumos,* the vertical height of the sternpost shall be forty-four palms, the length along the post being forty-six palms and the rake thirteen palms, which by calculation is between one third and the quarter (Fernandes et al. 1995:117).

This passage is essentially a scantling list and does not provide clear directions on how to construct the vessel. This section also contains rules for the rudder, tops, masthead, foremast, ship's boat, and other elements of the carrack. Fernandes even includes rules for an ordinary crane used in the construction of these ships.

Other sections of this manuscript give calculations and dimensions for galleons of varying tonnages, two caravels, a brigantine, *patacho*, warship, royal galley, barge,

falua, and a *frigatta*. Each of these sections is structured differently according to the information Fernandes provides for each of the individual ships. For example, the rules for galleons of 350 *tonéis* include a variety of information beyond the basic scantling list. It also includes calculations that are required to loft the mould on the ground, as well as the order in which to place the wales of the galleon. In addition, this section includes a list of timbers that are needed for the ship. This is a valuable source of information for scholars, for it gives the number of pieces required for the various components of the vessel. For example, two pieces are needed for the sternpost, 12 pieces for mast partners, 26 floor timbers, and 54 futtocks. The list is much longer, but this kind of information can further substantiate assumptions that must sometimes be reached by archaeologists and historians when complete archaeological evidence is unavailable.

Other parts of the treatise are equally as valuable, for there are sections on methods for lofting the main frame, rules on giving the rakes of the stem and sternpost of ships less than 300 *tonéis*, readying a carrack for launching, and rules for constructing the launch-ways used to cradle the vessels.

I drafted the lines drawings of a caravel under the guidance on folio 16 of the manuscript, entitled “Calculation and dimensions for a caravel with a length between perpendiculars of eleven rumos” (Figure 6-12; see Appendix B). Although Fernandes outlines the instructions for building one of these vessels, he omits a vast amount of information which would be helpful in determining the ship’s lines. Closely following his rules for construction, I discovered several mistakes and irregularities in his manuscript, and some alterations and guesswork were necessary to create a sound and

plausible vessel. Since Fernandes included scale drawings of his vessels, I was able to take some of the measurements from his illustrations and convert them to 1:20 scale. Although not entirely accurate, most of his illustrations give a good sense of proportion, which was useful in creating the lines and construction drawings.

Little is known of the life of Manuel Fernandes, but it is believed that he was a shipwright who had the presence of mind to record the general rules and procedures for designing Portuguese, Spanish, and even Dutch vessels. Although the information presented in his treatise is useful, parts appeared inaccurate and difficult to utilize

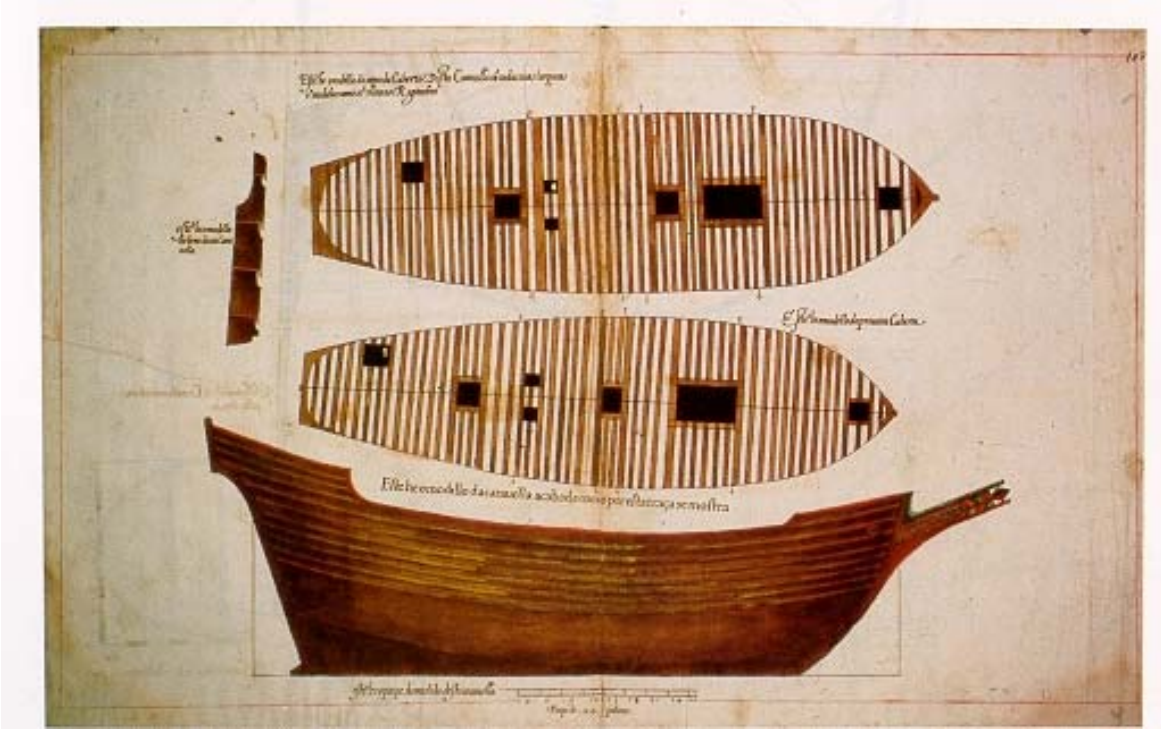

FIGURE 6-12. Caravel with a length between perpendiculars of 11 *rumos* (After Fernandes 1989:folio 108)

practically. Even though he possessed a diversity of knowledge pertaining to naval architecture, Manuel Fernandes may not have been a shipwright. This caravel, with a length between perpendiculars of 11 *rumos*, turned out to be much beamier and capacious than I anticipated, and in my opinion little resembles the swift, easily maneuverable vessel that gained so much praise during the Age of Discovery—even accounting for the gap in time. On the other hand, it is possible that the development of the caravel leaned heavily in the direction of a boxy cargo carrier and, by the 17th century, became that which is represented in my lines and construction drawings.

As this manuscript is studied further and compared with contemporary nautical treatises and archaeological evidence, scholars of Iberian seafaring and shipbuilding will better understand the complexities of 16th-and 17th-century shipbuilding techniques. The information presented by Manuel Fernandes remains an incredible asset to scholars and gives a rare opportunity to study and attempt to understand the thoughts, traditions, techniques, and technologies of ancient shipwrights.

Conclusions

These nautical treatises represent the great diversity among ships and shipbuilders during this era. As has been shown, there is a good deal of knowledge embedded in these treatises, and much research still needs to be conducted in order to paint a clearer picture of Iberian shipbuilding practices in the 16th and 17th centuries. This overview simply brings to light the available resources for understanding ship types that are as yet under-represented in the archaeological record. When this material

evidence becomes available, a corpus of data will be at the fingertips of archaeologists to better understand how caravels were designed and built.

CHAPTER VII

ARCHAEOLOGICAL EVIDENCE FOR IBERIAN SHIPS

Several Iberian shipwrecks from the Age of Expansion have been discovered by archaeologists in the recent past, but none of these have been conclusively identified as a caravel of any type. In most shipwrecks of comparable size to a caravel of the era, the hull remains are too scant to distinguish many key features diagnostic to a caravel. Furthermore, although a large number of these vessels were reported in period documents to have been lost at sea, the wreck sites are as yet unknown. A small number of the Iberian shipwrecks that have been studied, however, do exhibit a few traits that scholars would expect to find on a 15th-or 16th-century caravel.

One example is the Aveiro A shipwreck, discovered in 1992 during a survey of the Ria de Aveiro, a large lagoon on the west coast of Portugal (Figure 7-1). Partial remains of a mid-15th-century hull were identified and recorded, and a preliminary analysis of the shipwreck was published (Alves 2001a:317). To illustrate the archaeological evidence available for Iberian ships of the Age of Discovery, this chapter examines the few cases that have been so far studied. Due to its preservation, the Aveiro A shipwreck is probably the best example of a possible caravel from this era. Based on the ship's size, constructional features, and probable function, it could indeed have been one. The purpose of this chapter is to look at traits that are characteristic of an Iberian-Atlantic shipbuilding tradition, as well as those that most likely correspond to caravels, in an effort to determine whether the Aveiro A shipwreck represents this type of vessel.

FIGURE 7-1. Ria de Aveiro, Portugal (After Google 2007)

For the purposes of identifying the type of ship represented in the Aveiro A wreck, it is necessary to first describe known attributes which define a caravel of the medieval and post-medieval eras. Naturally, this list would vary throughout the development of the vessel. Several features, however, would have remained the same from its inception as a ship tender in the 12th century and fishing vessel during the 13th and 14th centuries, through its years as a ship of discovery and war vessel in the 15th and 16th centuries, to its final years in the late 17th century as a cargo carrier and transporter. Iconographic representations of caravels show its shape and features throughout these developmental eras. Unfortunately, these two-dimensional images do not permit the inspection of hull elements below the waterline. The few extant 16th- and 17th-century shipbuilding treatises illustrate constructional features that can help answer perplexing questions, although these were composed over a century after the era of ships

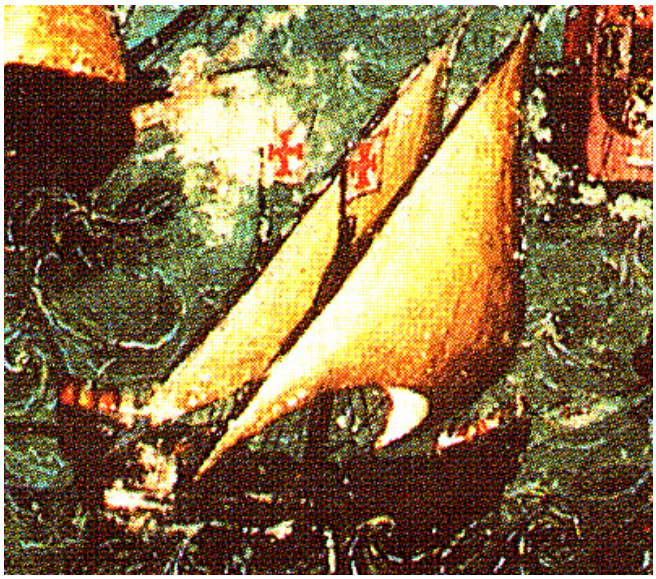

FIGURE 7-2. Portuguese caravel in the port of Lisbon, dated to 1515-1525 (After Barata 1989:95)

of discovery. Notwithstanding this apparent anachronistic aspect of the study, surviving diagnostic characteristics of earlier caravels are found in these manuscripts and are an important asset for identification.

Most depictions of caravels show a graceful vessel with a gradually-sloping bow and low sterncastle (Figure 7-2). There is typically a stern hung rudder and square transom, although early portrayals of *caravelas pescarezas* may show a round transom. As described in Chapter VI, shipbuilding treatises reveal that these ships were shallow-draughted and built in an Iberian tradition, with fairly robust scantlings. The limited constructional details described in these manuscripts are treasure troves of information when there is an opportunity to compare them to archaeological evidence. Contemporary descriptions state that early caravels were generally lateen-rigged, and had one, two, or three masts which employed these sails. As mentioned earlier, the vessels did not have forecastles, which would have inhibited the use of the long yard required for the lateen

sail. Later, caravels used square sails when making long journeys to windward, but could replace the square sail with a lateen rig when circumstances warranted this exchange. Given these data, a caravel built for voyaging in the Atlantic Ocean for reconnaissance would probably be equipped with a stern-hung rudder, shallow draught, and robust scantlings in order to be adequately prepared for travel in the open seas. Does the Aveiro A shipwreck exhibit some of these traits? A survey and comparison of archaeological remains, detailed below, suggests that it does.

In order to establish whether or not the Aveiro A shipwreck could represent a 15th-century caravel, it is imperative to identify both the function of caravels in general, and the occupation of the vessel that was wrecked. From its inception, the Portuguese caravel has been associated with fishing and commerce. The foral of Villa Nova de Gaya, from 1255, alluded to in Chapter V, contains the following passage:

> …et caravela extranea que intrauerit per focem de Porti cum mercaturis,mando quod den mayordomo unum solidum de intrada, et si uenerit adGayam de quanto uendiderit aut comparauerit duos denarios det mayor-domo de marabitino.
>
> […and a foreign caravel that enters the mouth of Porto with merchandise, I order that he give the steward one *solidum* of entry, and if he should come to Gaya and when he sells or trades he should give the steward of *marabitino* two *denarios*] (Lopes de Mendonça 1892:43; Smith 1993:35).

The artifacts recovered from Aveiro A wreck indicate its employment as a merchant vessel. Ceramics constituted the bulk of the cargo, which were of 40 varieties and included cups, plates, pots and pans, clay bowls, earthen mugs, earthen pots or canteens, pitchers, chamber pots, lids, and money boxes. A majority of the cargo was spilled over the starboard side of the vessel, upon which the ship came to rest. The ceramics were

packed between layers of pine and white birch branches. Additionally, foodstuffs such as grape seeds, chestnuts, and nutmeg were recovered, which were probably used to feed the crew. A wooden shovel, rope of diverse patterns, a porringer, and lead weights for a fishing net were also reclaimed from the wreck (Alves 2003:8). All of these items support the conclusion that one of the functions of this particular ship was a merchant cargo carrier.

Clearly, the fact that the Aveiro A wreck was carrying trade goods does not identify it as a caravel, but since early caravels operated as trading vessels throughout the rivers and along the coasts of Portugal, the wrecked ship fits within the parameters of such a craft. Naturally, there were a wide variety of other craft performing the same function in the Portuguese waterways, and for this reason these types of vessels should be compared to the remains of the Aveiro A shipwreck. It is instructive, however, to first examine the archaeological evidence of Iberian wrecks from the Age of Discovery that have been found outside of the Iberian Peninsula.

There are seven wrecks in particular that have features comparable with the Aveiro A shipwreck, and these are examined in an effort to determine whether the size and construction of the Aveiro A ship indicate a vessel capable of reconnaissance in the oceanic conditions of the Atlantic. When possible, the scantlings and constructional details of Aveiro A are also compared with the rules for constructing a caravel set forth by Manuel Fernandes in *O Livro de Traças de Carpintaria* (see Appendix B), as discussed in chapter VI. Although a later type of caravel, the Fernandes vessel would still contain vestiges of the *caravela latina* that was used for discovery. It is also relevant

to compare the differences between these two types because it helps illustrate part of the eventual transition from a light scouting craft to a cargo carrier of wider berth. The features of an Atlantic vessel suggest a sturdily built craft capable of sailing extensively in the high seas. Therefore, if the Aveiro A wreck demonstrates traits indicative of this capability, as listed above, it would be reasonable to assume that it could have been used both inside and outside of the frequented Portuguese waterways, perhaps even for reconnaissance.

A Comparison of Iberian-Atlantic Vessels and the Aveiro A Shipwreck

The following shipwrecks have constructional features that help define a shipbuilding trend referred to here as the Iberian-Atlantic tradition. This "Iberian-Atlantic" concept has been adopted from studies conducted by maritime archaeologist Thomas Oertling, and represents a tradition in which certain shipbuilding characteristics are present that facilitate voyaging in high-seas. Oertling analyzed the archaeological evidence of most of the shipwrecks described below, in addition to others not mentioned here, and assembled a list of traits of which ocean-going Iberian vessels had in common. The studies made from the remains of the following shipwrecks are compared with the archaeological remains from Ria de Aveiro: the 16th-century Molasses Reef wreck, discovered in the Turks and Caicos Islands; the 16th-century Highborn Cay wreck, found in the Bahamas; the 16th-century *San Juan*, a Basque whaler from Red Bay, Labrador; the 15th-century shipwreck at Cais do Sodré, Lisbon; the 16th-century *San Esteban*, discovered at Padre Island, Texas; the 16th-century Cattewater wreck from Portsmouth, England; the 14th-century Culip VI, found in Catalonia. Table 7-1 contains

scantlings for all ships considered in this study, as well as particular Iberian-Atlantic shipbuilding traits, for quick cross-referencing.

Keel and the Overall Length

The extant portion of the Aveiro A shipwreck constitutes a little more than the after half of the vessel, and covered an area approximately 10.4 m long and 2.5 m wide. The vessel was heeled over to starboard and was buried slightly deeper at its after end (Alves 2001a:320). The hull planking on the starboard side is preserved over the entire 10.4 m, but the keel is only preserved over a length of 9.15 m. The square keel has a cross-section of 12 cm by 12 cm, which is relatively small compared to other examples of the Iberian-Atlantic shipbuilding tradition. Smaller keels are found only on the Culip VI (9 by 7 cm molded by 9 by 9 cm sided), which has a comparable hull length to Aveiro A (Alves 2001a:322). The Cattewater keel is monstrous in comparison, measuring approximately 30 cm in square cross-section (Redknap 1984:21). Although Fernandes does not give exact dimensions for the cross-section of the keel, the scale drawings provided in his work show approximate molded and sided dimensions of 25.67 cm (1 *palmo de goa*) and 17.42 cm (4 *dedos*), respectively.

The length of the keel is a major indicator of the size of a vessel, and the total length of the Aveiro A shipwreck keel was estimated at 12.32 m. This estimation was based on the identification of the master frame and its location on the keel, which was 7.4 m from the heel—the after end of the keel. Following the rules for an 8 *rumo* (12.32 m) keel as set forth by Oliveira in the 16th-century *Livro de Fábrica das Naus*, the

TABLE 7-1
FEATURES, ESTIMATED MEASUREMENTS, AND PROPORTIONS OF 14TH- TO 17TH-CENTURY IBERIAN WRECKS

	Age	Total Length	Keel Length	Keel Cross-Section	Length to Beam Ratio	Avg. Pre-Made Frame Dimensions/ Joinery	Frame Spacing	Mast Step Expanded Keelson	Keelson Notched Over Floors	Mast Step Reinforcement	Outer Hull Planking Thickness
Ria de Aveiro A	Mid 15th century	*c.* 17m	12.35 m	12 cm sided x 12 m molded	1:4.81	12 cm sided x 12.5 cm molded Joinery: mortise-and-tenon with treenails and iron nails	33 cm	Yes	Yes	Bilge stringers	5-5.5 cm
Cais do Sodré	15th century	unknown	27.72 m	27 cm sided x 25 molded	unknown	19.3 cm sided x 30.5 cm molded Joinery: dovetail mortise-and-tenon with long iron nails	unknown	unknown	Yes	Bilge stringers	7.5 cm
Culip VI	14th century	16.35 m	12.86 m	9 cm sided x 7 cm molded	1:3.98	11 cm sided x 13 cm molded Joinery: unknown	24.5 cm	Yes	Yes	No	3 cm
Highborn Cay	Early 16th century	19 m	12.6 m	15-16.5 cm sided x 21 cm molded	Approximately 1:3.5	16 cm sided x 16.5 cm molded Joinery: dovetail mortise-and-tenon with treenails and iron nails	40 cm	Yes	Yes	Buttresses and stringers	6 cm
Molasses Reef	Early 16th century	20 m	unknown	unknown	1:2.6	16cm sided x 16 cm molded Joinery: dovetail mortise-and-tenon with treenails and iron nails	32.5 cm	unknown	unknown	unknown	4.5 cm
San Esteban	Mid 16th century	20.12 m	14.48 m	31 cm sided x 27 cm molded	1:3.66	21 cm sided x 25 cm molded Joinery: unknown	unknown	unknown	unknown	unknown	10 cm
San Juan	Mid 16th century	22 m	14.75 m	unknown	1:2.93	20 cm sided x 22 cm molded Joinery: dovetail mortise-and-tenon	25-30 cm	Yes	Yes	Buttresses and stringers	unknown
Cattewater	Early to mid 16th century	27.7 m	19.8 m	28 cm sided x 30 cm molded	1:2.86	20 cm sided x 20 cm molded Joinery: dovetail mortise-and-tenon	37 cm	Yes	Yes	No	6-7 cm
Caravel from *Livro de Traças de Carpintaria*	Early 17th century	25.14 m	16.94 m	17.42 cm sided x 25.67 cm molded	1:3.92	25.67 cm sided x 17.42 cm molded Joinery: unknown	*c*. 50 cm	unknown	unknown	Unknown	6.42 cm

master frame should be set one-eighth of the length of the keel forward of the middle point, which corresponds to 5 *rumos* or 7.7 m forward of the stern (Oliveira 1991:94; Alves 2001a:330). Since the master frame of the Aveiro A shipwreck appears to follow this rule, with its master frame set 7.4 m from the heel, the total length of the keel could then hypothetically be estimated at 12.32 m, or 8 *rumos*.

A total length for the Aveiro A vessel may be obtained by further consultation of 16th-and 17th-century shipbuilding treatises. By following the rules given by Fernandes, all vessels between 80 and 100 *tonéis* with a single deck should have a stem post rake equal to one-quarter of the keel length (Fernandes 1989:folio 18). Since the mortises on the upper surface of the keelson were likely made to facilitate deck stanchions, it may be presumed that this vessel was decked. Thus, an approximate theoretical length 3.08 m—one quarter of the keel length—can be added to the length of the keel, arriving at a length of 15.38 m. The rake of the stern, however, must still be accounted for. Father Oliveira indicates how to ascertain this rake based on further proportions of the keel. He asserts that the rake of the stern is not as great as that of the bow but formed in a similar way. The perpendicular is formed at the point on the keel where the sternpost begins. An arc is then drawn from this perpendicular down to the keel. This arc is subsequently divided into seven parts, each of which is the same length of the rake aft of the perpendicular (Oliveira 1991:82). Unfortunately, not enough of the sternpost survived to extrapolate this value, but Oliveira gives a minimum rake of 4.5 *palmos* (1.15 m). Adding this minimum rake to the lengths of the keel and stem rake gives a total theoretical overall length for the Aveiro A wreck of 16.53 m. This length is extremely

close to the Culip VI wreck, which has a keel length of 12.86 m, and an overall length from end to end of 16.35 m (Palou et al. 1998:195).

Some of the surviving keels from Iberian shipwrecks were made of several parts that were joined together, as described by João Baptista Lavanha in his ca. 1609 shipbuilding manuscript entitled *O Livro Primeiro de Architectura Naval* (Lavanha 1996:44). This was a normal practice at this time due to shortages of suitable wood. The pieces were united with a flat, vertical scarf and reinforced transversally with iron bolts that ran all the way through the timber, and were then riveted, as seen on *Nossa Senhora dos Mártires* in Chapter VI of this thesis. The Aveiro A shipwreck keel exhibits this vertical scarf with four iron reinforcing nails, but probably was not riveted as recommended by Lavanha (Figure 7-3; Alves 2001a:322). Similar composite keels are found on the Highborn Cay wreck and *San Juan* (Oertling 2001:247; Grenier 1988:72), while the remains of the keels of the other wrecks are too scant to provide conclusive evidence for this feature.

The heel of Aveiro A shipwreck is typical of many Iberian wrecks, and illustrations of this trait can be found in both Lavanha's and Fernandes's shipbuilding treatises (Figure 7-4 and 7-5). The heel of the keel and the lower portion of the sternpost form a single piece, and a skeg protrudes at the junction of these pieces. A similar skeg is found on *San Juan* (Figure 7-6; Alves 2001b:347; Grenier 1988:74).

The presence of a flat transom would help in identifying the vessel as a caravel built for Atlantic conditions, since this type became common for sea-going vessels in the

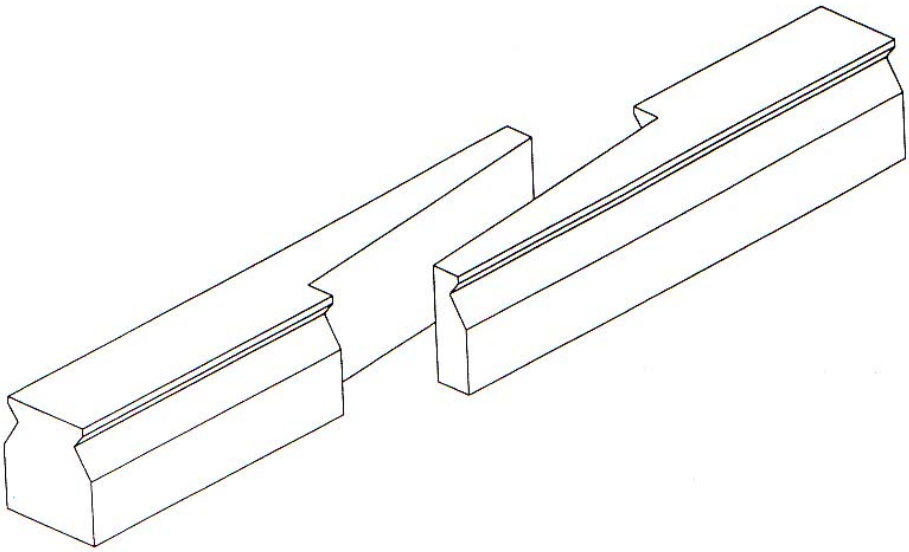

FIGURE 7-3. Joining of the Ria de Aveiro A keel sections (After Alves 2001a:323)

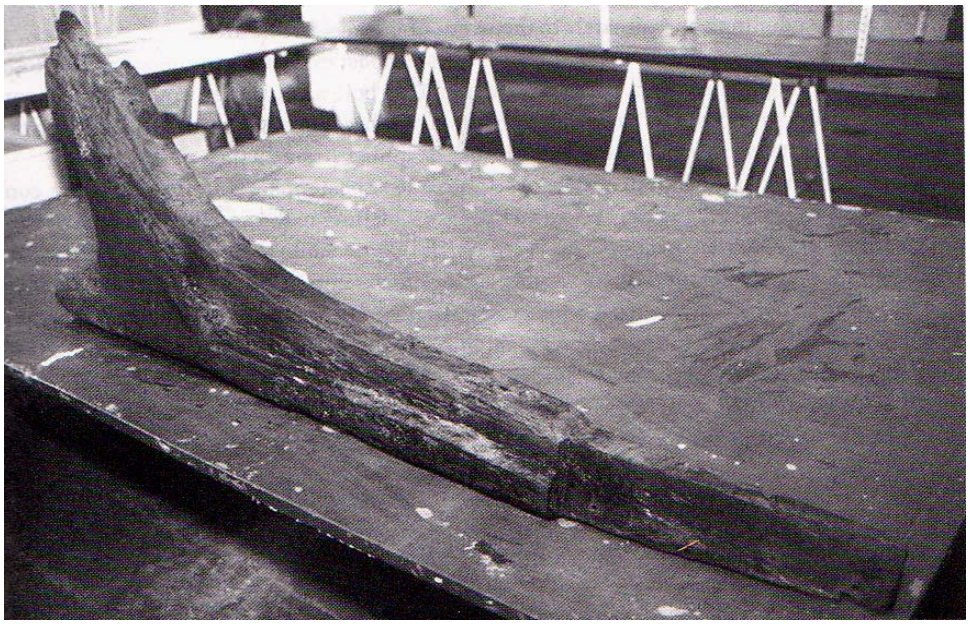

FIGURE 7-4. Heel from the Aveiro A shipwreck (After Alves 2001a:325)

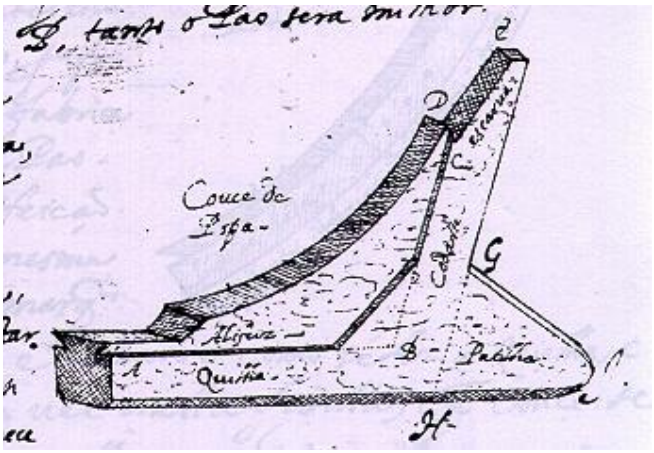

FIGURE 7-5. The heel of an Iberian vessel, as illustrated by Lavanha (After Lavahna 1996:folio 63)

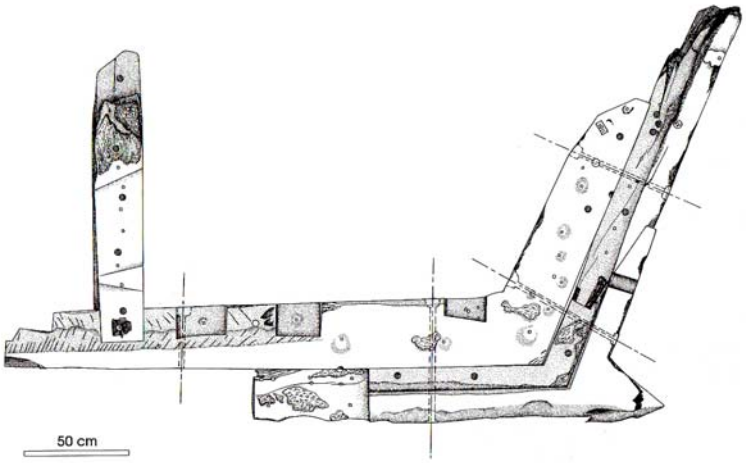

FIGURE 7-6. The heel of *San Juan* (After Grenier 2001:283)

15th-century to facilitate the use of a stern-hung rudder. Due to the limited sternpost remains, however, it is difficult to determine if the Aveiro A ship had a square transom or a round stern.

Floor Timbers

The floor timbers of the Aveiro A vessel are preserved over a distance of 7.4 m from the heel, and the maximum breadth for a combination of floor timber and first futtocks is 2.35 m at frame 9 (Figure 7-7). According to maritime archaeologist Francisco Alves, this breadth may indicate a maximum width of the hull, which he extrapolates at 3.4 m (Alves 2001a:326). This measurement would give a length to beam ratio of 4.81:1. This ratio is close to the length to beam ratios of fully decked 15th-century Portuguese caravels, which, according to Elbl's estimation, may have been around 5:1 (Elbl 2000:92). The length to beam ratio for the 17th-century Portuguese caravel described by Fernandes, for comparison, was less than 4:1, which gives some indication of the caravel's later function as a cargo vessel, built beamier to transport a larger freight.

The average spacing between floor timbers of the Aveiro A wreck is 33 cm, which parallels the 32.5 cm intervals of the Molasses Reef wreck. From the known values of the wrecks examined here, this distance seems fairly typical; mostly between 30 and 40 cm, with *San Juan* slightly lower at 25-30 cm. This is one indication that the construction of the Aveiro A ship's frames, like those of the other Iberian ships in this study, was sturdy enough to enable travel on the high seas.

The Aveiro A vessel was built in the Mediterranean way, as described in Chapters VI and IX of this thesis, comprised of a number of preassembled frames that determined the shape of the entire vessel (Figure 7-8). From the remaining floor timbers and their corresponding futtocks, frames 1 through 8 represent the preassembled frames,

while frames 9 through 21 were assembled and inserted, after the vessel was planked, with the assistance of ribbands. The evidence for the preassembled frames comes from the method of joinery as well as their larger dimensions. The first eight floors were attached to their respective futtocks by the use of mortise-and-tenon joinery, and then strengthened using two treenails driven on either side of the mortise-and-tenon joint. These were further reinforced with the use of two iron nails, driven horizontally—fore-and-aft—through the components. This method of fastening is typical of the Iberian-Atlantic shipbuilding tradition described earlier, although the mortise-and-tenon joints are usually fabricated in the dovetail style, as in the examples from Highborn Cay, Cattewater, Cais de Sodré, Red Bay, and Molasses Reef. Interestingly, the mortise-and-tenon joinery observed on the floors and futtocks of the Aveiro A shipwreck are nearly

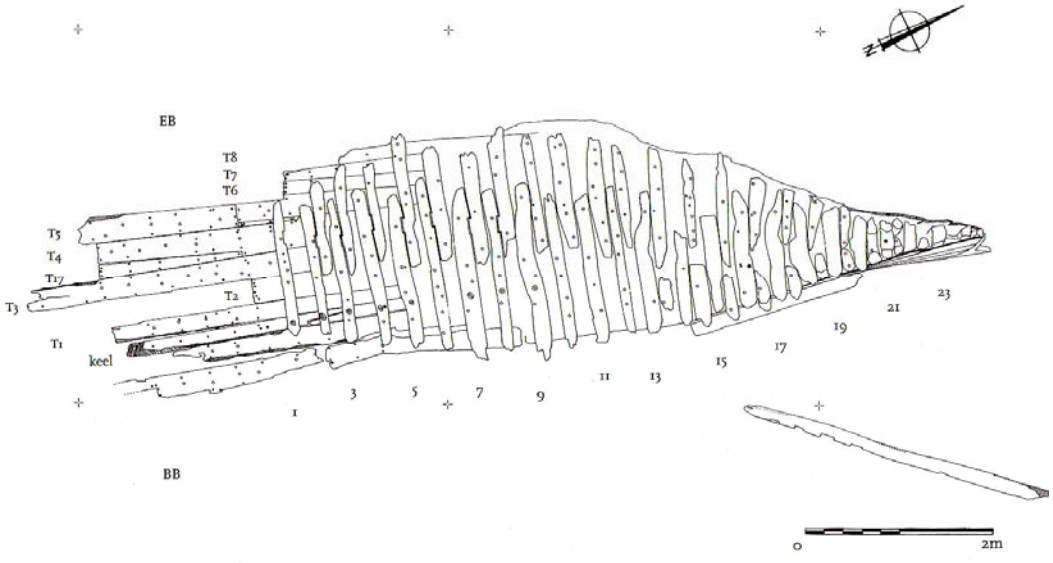

FIGURE 7-7. Aveiro A shipwreck site plan showing maximum beam at frame 9(After Alves 2001a:327)

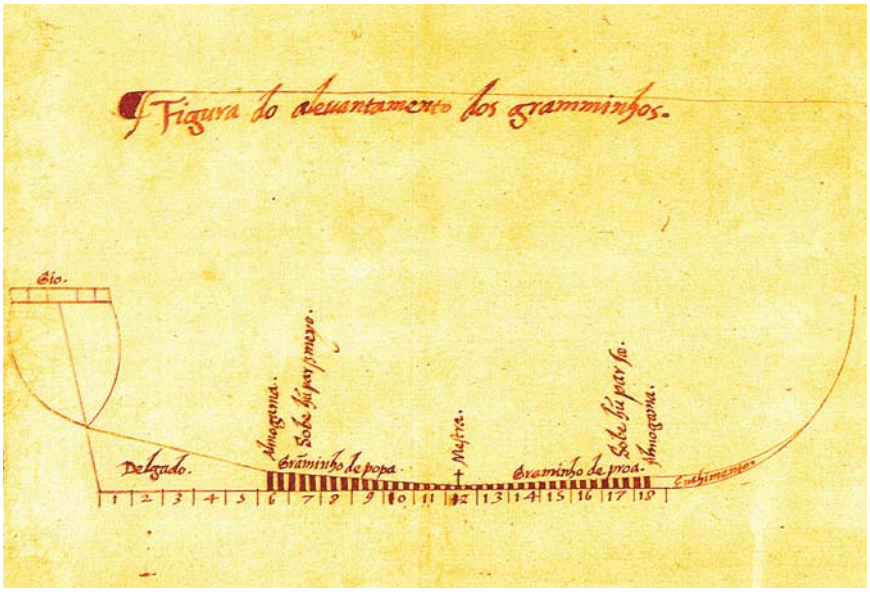

FIGURE 7-8. Diagram from Oliveira's manuscript showing the position of the preassembled frames (Oliveira 1991:folio 99)

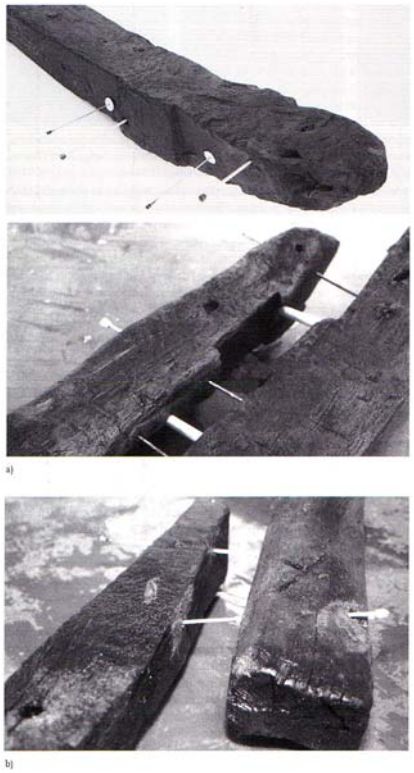

FIGURE 7-9. Dovetail mortise-and-tenon joinery of the frames of the Aveiro A shipwreck (After Alves 2001a:332)

square rather than trapezoidal (Figure 7-9; Alves 2001a:331).

The floor timbers of the preassembled frames, and frame 9 from the second group, of the Aveiro A ship were fastened to the keel with large iron nails, driven from above. Excluding frame 9, frames 10 through 21 from the second group were simply toe-nailed into the keel through triangular notches in the floor timbers. The method of connecting the floors to the futtocks was simplified by using two nails driven diagonally from opposite ends (Figure 7-9; Alves 2001a:333). This reduced support at the extremities shows the elevated role of the preassembled frames, which were designed to carry the brunt of the mechanical stresses involved in open seas travel.

Keelson

A section of the keelson 3.5 m long was discovered at the Aveiro A wreck site, which revealed cross-sectional dimensions of 12.5 cm molded by 13 cm sided. The types of mortises found on the upper surface of the keelson suggest that they were intended to fit the heels of deck-supporting stanchions, as mentioned previously. Parallel examples of keelson mortises also survived on the remaining portions of the Cais de Sodré keelson. The section of the Aveiro A keelson was bolted to the keel in two places, through frames 4 and 16, and then riveted inside a countersink in the bottom face of the keel (Alves 2001a:336).

Also characteristic of the Iberian-Atlantic shipbuilding tradition, the underside of the keelson was notched to fit over the floor timbers. Examples of this notching can be seen in examples from the Highborn Cay, Cattewater, and Culip VI shipwrecks, as well as from *San Juan* (Oertling 2001:234; Palou 1998:28).

Another trait of the Iberian-Atlantic tradition of shipbuilding is that the main mast step is actually an expanded portion of the keelson (Figure 7-10). Furthermore, buttresses are usually placed against the expanded portion in order to further reinforce the mast step. Almost all of the wrecks in this study, for which there is evidence for a mast step, have these features, with the Cattewater and Culip VI wrecks being the only exceptions having no additional support for the mast step (Oertling 2001:234). Although the mast step of Aveiro A ship did not survive, a carved out portion of floor timbers 1 to 3 reveals that this area was designed to seat a mast step (Figure 7-11). There is no evidence for buttresses set against the mast step, although two bilge stringers were found, which laterally and longitudinally reinforced this area (Alves 2001a:338-340).

Planking

The extant hull planks found at the Aveiro A site consist of nine strakes on the starboard side and three on the port side. The average width of these planks is 22 cm. The thickness of the surviving planking is between 5 and 5.5 cm, which is comparatively thin for an ocean-going vessel. Of the available examples, only the Molasses Reef and Culip VI wrecks have thinner planking: 4.5 cm and 3 cm, respectively. (Alves 2001a: 341).

Structurally Sound for Exploration?

Archaeological evidence, as well as 16th-and 17th-century shipbuilding treatises, show that the Aveiro A shipwreck was built in a manner similar to ocean-going vessels of its day. The wreck exhibits many of the characteristics of the Iberian-Atlantic

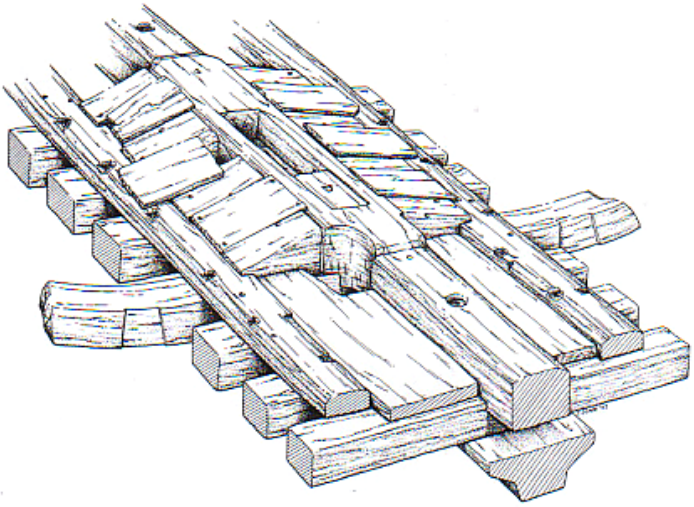

FIGURE 7-10. Reinforced mast step from *San Juan* (After Grenier 2001:281)

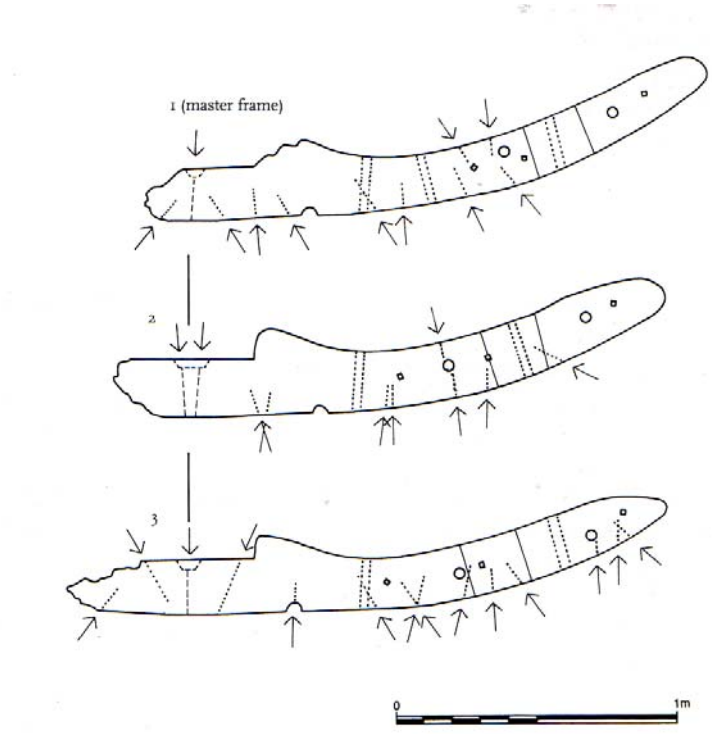

FIGURE 7-11. Floors 1 through 3 of the Aveiro A shipwreck, showing molded protrusions cut to surround the mast step (Alves 2001a:334)

shipbuilding tradition, indicating that it could have been built to withstand the extreme forces delivered to the hull by the high seas. Caravels built for the purposes of exploration clearly required such structural soundness to be effective in the Atlantic Ocean. Although the mid-15th-century Aveiro A ship is fairly small in comparison to other Iberian-Atlantic vessels that have been found, the first caravels used for exploration were in their initial transitional stages from fishing and cargo vessels to expeditionary craft at this time. The Highborn Cay wreck, with only slightly larger dimensions than the Aveiro A (see Table 7-1) ship, was an exploratory vessel discovered thousands of miles from its point of origin. Although its original purpose remains unknown, it seems plausible that the vessel discovered in the Ria de Aveiro, with comparable scantlings and Iberian-Atlantic construction elements, could have traveled a similar distance if commissioned for exploration.

Comparison of Local Ria de Aveiro Craft with the Ria de Aveiro A Shipwreck

The Ria de Aveiro was rife with small riverine and coastal craft when the Aveiro A ship sank in the mid-15th century. Unique to Portugal, quite a few of these boats were still in use in the 20th century, and several survive even to today. These vessels have distinct constructional features which depend upon their individual function. Since there is no direct evidence that the Aveiro A shipwreck was used for exploration, it is just as plausible that it thrived as one of these local Ria de Aveiro boats. Is it possible that these more modern boats show vestiges of the Aveiro A shipwreck features? This question warrants a comparison of Portuguese riverine craft to help identify the type of vessel the Aveiro A wreck represents, or at the very least, exclude it from these groups.

Like other coastal and riverine societies, there are numerous maritime occupations that can be found in Ria de Aveiro, including farming, fishing, trade, and the production of salt. Accordingly, a number of specialized watercraft have been developed there. Examples are the *moliceiro*, used to rake up seaweed in the lagoon; the *barco do mar* for beach-seining; the *erveira* for grass collection; and *bateiras* employed for fishing and hunting wild fowl (Leitão 1988:253). The vast majority of the craft found recently in Ria de Aveiro, with the exception of the *varino de pau de aresta* and *varino de carga*, are flat-bottomed, double-ended, chined vessels (Leitão 1988:255). Assuming these Ria de Aveiro vessels were chine-built in the 15th century, and since the Aveiro A wreck evinced no indication of these features, it is logically permissible to exclude its membership in such a group.

The small craft of the Ria de Aveiro were easy to build and often constructed in a short time. For example, a *bateira do mar*, with a total length of 9 m, could be assembled by two men in just eight days (Leitão 1988:255). This is contrary to the sophisticated production of the Aveiro A ship and its structural elements reflecting those found in shipbuilding manuscripts, and which most likely was built in a shipyard according to rules similar to those documented by shipwrights from the 16th and 17th centuries. Thus, it is probable that the Aveiro A ship was not built in the Ria de Aveiro area in the same manner as the local craft mentioned above, but rather in a shipyard from that area.

In a different light, vessels with characteristics more comparable to the Aveiro A shipwreck were found to be in use, until quite recently, in the Tagus River. These are round-bilged boats characterized by two wales on either side of the hull. They are of

heavier dimensions and employ transom sterns, as the Aveiro A ship probably did if it was deployed in the high-seas. Such craft include the *fragata* (21.50 m), *bote* (14.20 m), *bote de meia-quilha* (12.10 m), *falua* (13.66 m), *bote da tararanha* (12.25 m), and the *bote-fragata* (11.50 m). All of these vessels were one-or two-masters outfitted with fore-and-aft sails (Figure 7-12; Leitão 1978:8).

Although the Aveiro A wreck could potentially have similarities to any of these vessels, the *fragata*, in particular, had dimensions closest to those extrapolated from this shipwreck, and is the craft to which it is compared here. A small-sized *fragata* (50 *tonéis*) had an overall length of 17 m and a breadth of 4.2 m, giving it a length to beam ratio of 4.05:1 (Leitão 1978:20). A model of a *fragata* created by master shipwright Henrique Fonseca, reveals some constructional details that can be compared with the extant remains of the Aveiro A wreck. The older *fragatas* were constructed by using a small number of preassembled frames positioned at the center of the vessel, with the remaining frames shaped according to the curve of the ribbands that were bent around the preassembled frames, much like the Aveiro A shipwreck remains suggest. The keel consisted of a single timber, although it was extended forward by the gripe and stem, and aft by the heel and sternpost. All of these components were fitted together by hook scarfs (Leitão 1978:27). Additionally, the *fragata* had the characteristic skeg seen in many of the Iberian-Atlantic vessels in this study, including the Aveiro A shipwreck (Figure 7-13).

The floors and futtocks of the *fragata* overlapped one another, but mortise-and-tenon joinery was not used, at least in the recent past, as in the Aveiro A ship. Instead

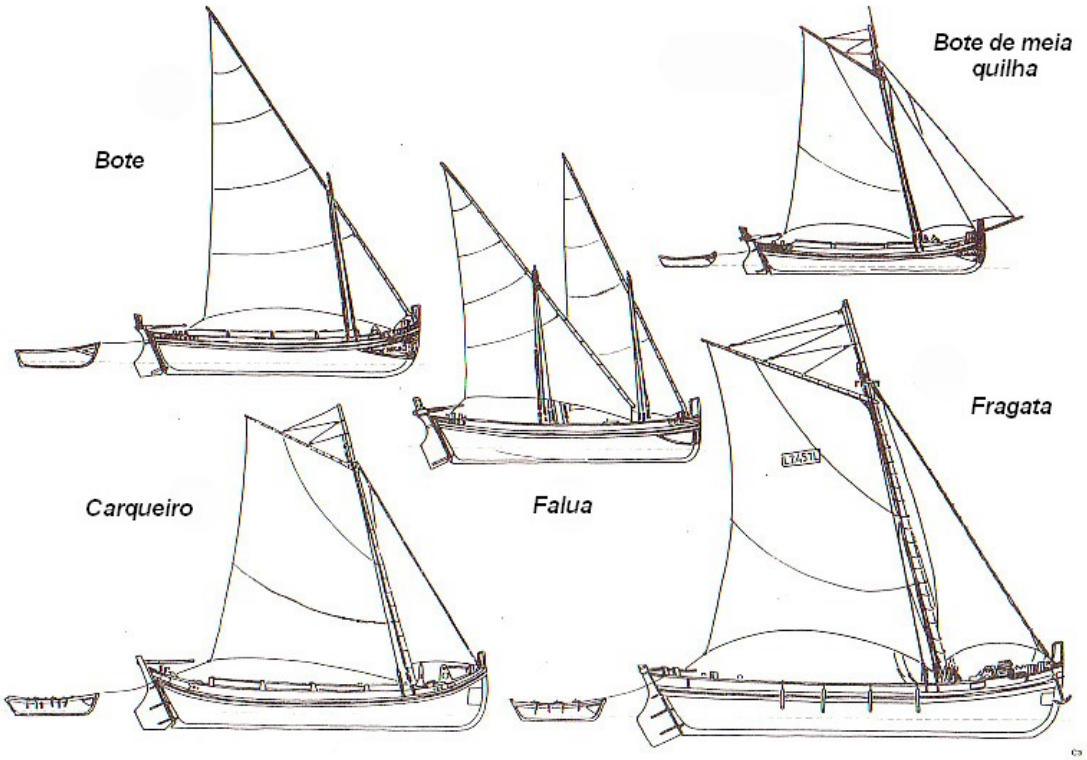

FIGURE 7-12. Vessels of the Tagus River (After Leitão 1978:8a)

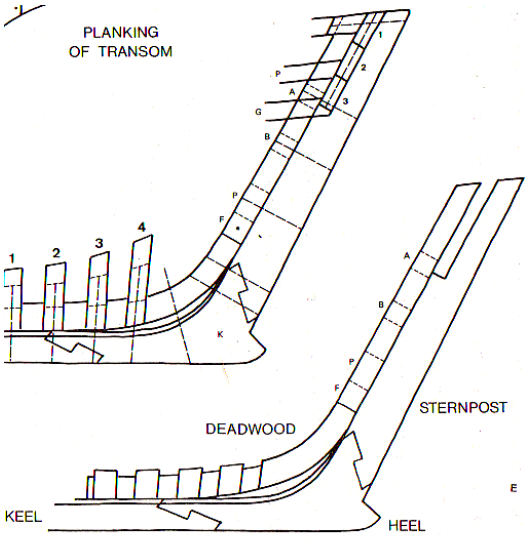

FIGURE 7-13. Heel of the Tagus *fragata* (After Leitão 1978:27a)

they were joined solely with fasteners—two treenails and two iron nails. The frames were 16 cm sided and 16 cm molded, approximately 4 cm larger than those of the extant Aveiro A remains. They had a spacing of 20 cm between frames, which is 13 cm less than the spacing of the Aveiro A shipwreck (Leitão 1978:31).

The mast step of the *fragata* was not an extended portion of the keelson, as seen on Iberian-Atlantic vessels. Rather, slots are cut into the frames beneath the mast step to receive it. The molded dimensions of these frames are increased in order to provide the same amount of timber as the other floors. The slots cut into the frames are 8 cm deep, and the mast step is similarly notched, providing an overlap of 16 cm. For transversal reinforcement, U-shaped iron bands are placed over the mast step and each held in place by four spikes (Figure 7-14; Leitão 1978:32).

Although there exist observable congruencies in construction methods, the Aveiro A ship was clearly not a *fragata*; nor was it built in a similar manner. As shown by such features as the relatively thick frames and small spacing between them, the sturdy barge-like qualities of the *fragata* were probably meant to withstand the stresses involved in its function as a ship tender moving cargo to various parts of the harbor of Lisbon. These traits, however, were probably not sufficient to frequently withstand the inherent forces exerted upon the hull while sailing in the high seas. The evidence for this conclusion is in the lack of characteristics such as a reinforced mast step, rigid mortise-and-tenon joinery of the frames, and a keelson—elements which the Aveiro A shipwreck does exhibit. This comparison suggests that the *fragata* is not a ship type with vestiges

of the Aveiro A ship type, which, based on its possession of the above-mentioned traits, appears to have been capable of both oceanic and riverine travel.

Concluding Remarks on the Ria de Aveiro A Vessel Type

After examining the evidence, the question remains whether or not the Ria de Aveiro A shipwreck represents a caravel of the mid-15th century. An in-depth look at

FIGURE 7-14. Drawing of the notched frames and mast step from a Tagus *fragata* (After Leitão 1978:30a)

contemporary archaeological remains of similarly built ships provides many clues as to the construction and purpose of such a vessel. Based primarily on their size and length to beam ratios, the Cattewater and Cais de Sodré shipwrecks, along with *San Juan* and *San Esteban*, are all presumably larger, beamier ships known as *naus*. Larger vessels that exhibit the Iberian-Atlantic shipbuilding features are a good comparison for the Aveiro A wreck because their structural characteristics had the capabilities to withstand mechanical stresses of rough waters. It is clear from the scantlings, however, that the Aveiro A shipwreck does not represent a *nau* or large whaler. In these terms, the Aveiro

A ship more closely resembles the Highborn Cay, Molasses Reef, and Culip VI wrecks. The shipwrecks at Highborn Cay and Molasses Reef, with dimensions similar to the Aveiro A ship, are considered by some scholars to be caravels or *naus* used during the Age of Discovery, although presently this cannot be substantiated (Keith 1988:60). Thus, with shared scantlings and features of the Iberian-Atlantic shipbuilding tradition, it is reasonable to approach the Aveiro A shipwreck as a possible ship of discovery, and more specifically as a vessel similar to a caravel. Again, more evidence is necessary to transform this hypothesis to accepted fact.

The closest resemblance to the Aveiro A ship, with regard to general dimensions and length to beam ratio, is the 14th-century Culip VI ship, which was also carrying a cargo of ceramics (Palou et al. 1998:41). Although the exact type of vessel the Culip VI wreck represents is undetermined, this ship, along with the Aveiro A wreck, may reflect the type of coastal trading vessel that was being produced alongside slightly more sturdily built ocean-going ships of a similar size and capacity. Furthermore, since caravels were often built according to their intended function or a particular voyage, they varied in scantling size and capacity. This is to say that there is no quintessential caravel type that would be discovered archaeologically. Rather, we would expect to find a shipwrecked vessel with a combination of particular Iberian-Atlantic shipbuilding features, fairly robust scantlings, a length to beam ratio over 3:1, a shallow draught—based on lines extrapolated from extant frames—and evidence of a square transom. Presently, a shipwreck with enough archaeological evidence of all these traits has not yet

been discovered, though the Aveiro A shipwreck does exhibit many of the expected features.

A brief comparison of 20th-century local craft in the Ria de Aveiro suggests that the mid-15th-century vessel found in this same lagoon was probably not of the local variety examined in this chapter. Aveiro A shipwreck was too large and had too many sophisticated characteristics, as discussed previously, to be considered local specialty craft. On the other hand, the *fragata* of the Tagus river exhibited several attributes of an Iberian-Atlantic vessel, such as preassembled frames and sturdy dimensions. It lacked other important structural reinforcements, however, which were found on the Aveiro A shipwreck, such as the expanded keelson mast step and mortise-and-tenon joinery of the frames. Although the ancestral forms of the modern *fragatas* could have been constructed more to the standards of an ocean-going vessel, it is probable that the ship type represented in the Aveiro A wreck and the *fragata* were two different types of craft altogether.

Throughout this chapter, it has been shown that there are difficulties in the process of identifying a caravel based on archaeological evidence. Although the Ria de Aveiro A shipwreck is among the best examples of a possible caravel, in terms of particular ship type, the identification of the Aveiro A wreck remains unknown. Nonetheless, this brief study has shown the real possibility that it was a caravel built as a coastal and riverine workhorse capable of being employed as a reconnaissance vessel. This is akin to the *caravela latina* that gained prestige among historians and has been the focus of many shipwreck surveys by archaeologists in the recent past. Further

archaeological evidence must be located and analyzed in order to determine whether this vessel is truly an example of a mid-15th-century caravel.

CHAPTER VIII

RECONSTRUCTING SHIPS OF DISCOVERY THROUGH ETHNOGRAPHIC STUDIES

Early Replicas of Caravels

Due to their historical significance and immense popularity, several "replicas" of caravels have been designed and built over the past 115 years or so. Beginning in the last decade of the 19th century, interest in ships of discovery resurfaced with the coming quartercentenary of Columbus's first voyage to the New World. Spain and the United States celebrated this event by constructing replicas of *Niña*, *Pinta*, and *Santa Maria*. Due to money and time constraints resulting from poor planning, the caravels *Niña* and *Pinta* were built from the hulls of two wooden derelict ships from a yard in Spain. *Niña* was launched on 28 August 1892, and was found "absolutely unmanageable under sail, and she could, under no circumstances, be kept off the winds sufficiently to fill her sails" (Smith 1992:38). Completed in September, the hull of *Pinta* was filled with cement, presumably used for ballasting. After much refitting, it was determined that neither of these vessels, nor the replica of *Santa Maria*, would be able to cross the Atlantic on their own and they were eventually towed by U.S.S. *Bennington* and U.S.S. *Newark* (Figure 8-1; Smith 1992:38).

The next generation of caravel replicas started with the preparation of the 1929 Ibero-American Fair in Seville. One such caravel was designed by Julio Guillén y Tato,

then a lieutenant in the Spanish Navy, and was based on extensive library and archival research. At that time, many notable Iberian seafaring scholars—such as Fonseca and

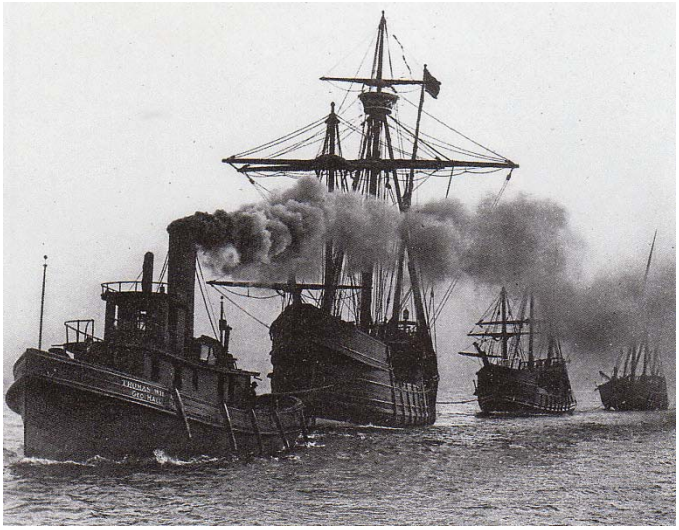

FIGURE 8-1. Replicas of Columbus's ships under tow (After Bass 1996:49)

Enrico d'Albertis—were questioning seriously the authenticity of the earlier replicas. Instead of duplicating *Niña* or *Pinta*, however, Guillén y Tato reconstructed *Santa Maria*. Despite a general scholarly consensus for the opposite conclusion, he considered her a *caravela de armada* rather than a *nao* (Figure 8-2). Despite the effort of staying true to the 16th-century Iberian shipbuilding treatises and other sources on the subject, the caravel performed poorly as she attempted to sail up the Guadalquivir River to Seville. Her captain compared her to "a barrel rolling in the surf," and she was ultimately towed to the exposition (Pastor 1992:11; Smith 1992:39).

Another attempt was made in 1962 by Spanish naval Lieutenant Carlos Etayo Elizondo to recreate *Niña* and sail Columbus's 1492 route. In spite of a valiant effort by

Etayo and his crew, the voyage failed miserably, taking 43 days longer than it took Columbus in 1492 (Smith 1992:40).

FIGURE 8-2. Reconstruction of *Santa Maria* as a caravel (After Pastor 1992:23)

More recently, new versions of *Niña*, *Pinta*, and *Santa Maria* were constructed and launched in Spain for the quincentenary of Columbus's voyages (Figure 8-3). These were based on designs by José María Martinez-Hidalgo y Terán, who had created a replica of *Santa Maria* which was exhibited at the New York World Fair of 1964-1965. Because his reconstruction plans for *Santa Maria* were so well-received by eminent scholars of the Iberian seafaring community, the new replicas for the 1992 celebration were based closely on his work (Pastor 1992:13).

Other attempts to build caravels were made by Portuguese shipbuilders who followed in earnest the known shipbuilding treatises and ancient methods of construction. *Bartolomeu Dias* was built for a commemorative voyage from Portugal to South Africa in 1988 and is now a floating museum stationed in Mossel Bay, South

FIGURE 8-3. Replicas built for the quincentenary of Columbus's first voyage (After Pickering 2006)

Africa. Caravel replicas *Boa Esperança* and *Vera Cruz* were likewise designed with some knowledge of ancient shipbuilding techniques (Figures 8-4 and 8-5). These last two ships were built specifically for use as sail-training vessels, and, consequently, involve certain associated restrictions to authentic reconstruction (Barker 1993:162).

FIGURE 8-4. View of *Boa Esperança* from forecastle (Photo by author, 2007)

FIGURE 8-5. *Vera Cruz* docked in Lisbon (Photo by author, 2005)

They are reportedly excellent lateen-rigged sailors, however, and possess a viable hull form highly capable of making transatlantic voyages (Mestre Afonso 2007, personal comm.). The *mestre*, or ship's master, of *Boa Esperança* related the history and sailing characteristics of his vessel. It was built in Vila do Conde, north of Porto, by boat builders using what they believed were traditional methods of construction, except they employed powered saws for cutting the timbers. To the *mestre*'s disgust, after completing the hull the builders poured concrete into the floor timbers, thereby rendering repairs to the wood impossible. *Boa Esperança* was built from several types of timber, including wild pine for planking and masts, eucalyptus for the yards, and oak and cork ash for the frames. Like all caravel replicas destined for public sailing ventures, an auxiliary engine is required on board; but it is only used when inexperienced volunteer sailors lose control of the sails and the ship falls off the wind. The engine, a 190 hp diesel, is used to point the caravel replica back on course, for otherwise the tiller would be useless for steering the ship. A seasoned navigator, the *mestre* voyaged to Brazil,

South Africa, and the inland waterways of Europe in *Boa Esperança* and, despite the modern additions which slightly offset the balance of the vessel, he claims she is an excellent sailor (Mestre Afonso 2007, pers. comm.).

Despite efforts to follow guidelines set forth in shipbuilding treatises and other documentary sources, probably none of these replicas resemble the efficient coastal and oceanic exploratory vessels of the 15th century. This is due in part to the fact that they all required certain modern amenities and safety modifications to comply with insurance demands and personal comfort. Another problem was that, in most cases, these ships were conceived with the perspective of the scholar and not necessarily of the boat builders themselves. Knowing the theory and practice of shipbuilding and how these vessels *should* appear is only one end of the spectrum. Practical experience in a shipyard and understanding the compromises that must be negotiated when constructing a ship is another important aspect of designing a 15th-century caravel.

John Patrick Sarsfield, with this boat builder's view in mind, designed another version of *Niña* in the late 1980s. His approach combined several lines of evidence, including archaeology, history, iconography, and traditional boat building methods. His replication of Columbus's favorite caravel is regarded by many scholars of Iberian seafaring to be the most faithful reconstruction of a caravel to date. Constructed in Bahía using traditional Brazilian methods of boatbuilding, Sarsfield's project was more an undertaking of experimental archaeology than anything else. Because of its investigative nature, it has contributed tremendously to the study of nautical archaeology and the history of shipbuilding.

John Sarsfield's *Santa Clara*

Located on the northeastern coast of Brazil, Bahía is steeped in seafaring history (Figure 8-6). Sixteenth-century discoverers voyaged there in caravels and *caravelões,* which were perfectly adapted for these reef strewn coasts. Soon, gaff sails were substituted for lateens in these coastal vessels, which retained the windward ability and required a much smaller crew. Up until 1960, fishing and transportation of cargo was still carried out in wooden sailing vessels, including *barcos, lanchas, saveiros,* and *canoas*. Most of these craft were vestiges of the ships of exploration, although they made adaptations to the coastal environment. In the 1960s, however, when highway construction and large commercial ferries began to dominate, the traditional way of life changed, and boat building began to wane. In spite of this, the ancient boat building traditions managed to survive. Some of the old boats were bought and repaired for recreational purposes. Many were re-rigged as schooners and before long became

FIGURE 8-6. Map of Bahía, Brazil, where Sarsfield's project took place (After Google, 2007)

increasingly popular. Soon, all the old boats were sold, and there was a growing demand for this new pleasure schooner. Once again the boatbuilding industry began to thrive, and although the boats were built for pleasure instead of utility, many of the traditional methods of construction were retained and can still be seen today (Sarsfield 1985a:85).

After working with the Peace Corps and later as an air pollution Engineer in Brazil, Sarsfield returned to the country to conduct research on the local schooners for an article he was writing for *Wooden Boat*. Familiar with a few ancient shipbuilding manuscripts such as Oliveira's *Livro da Fábrica das Naus*, Sarsfield realized that these boat builders were using methods that were similar to an ancient technique known as "Mediterranean whole-moulding," in which the whole vessel was molded using one set of templates. This was the same technique used by Iberian shipbuilders to construct caravels, *naus*, and other vessels during the Age of Discovery (Sarsfield 1985a:87).

Learning the secrets of master boat builders in Brazil was no easy task, but through previous boatbuilding experience, fluency in Portuguese, and persistence, Sarsfield was able to gain the confidence of the boatbuilding masters (Sarsfield 1985b:64). He was taught by *mestre* Waltinho, a boat builder from a yard in Valença, who himself had learned the methods of ship design from his father. So well-guarded is this art that Waltinho himself learned from clandestine observation rather than direct instruction (Barker 1993:162).

Soon afterwards Sarsfield devised a plan, funded by the Columbus Foundation, to build a replica of Columbus's *Niña*, or *Santa Clara*, as the ship was formally named. Combining the traditional boatbuilding methods of the Bahian *mestres* with scholarly

knowledge, his goal was to create as close to an authentic rendition of a caravel as possible, which he could then test in a controlled manner to determine its validity. These tests included mast location, rigging, sail configurations, hull trim, and other capabilities and limits of the ship that would become immediately apparent upon voyaging. He intended to evaluate performance of windward sailing ability, stability, speed, capacity, and durability, so that future ships could build on the successes and failures of *Santa Clara*. Unfortunately, Sarsfield died before the completion of the vessel, in a road accident while on a trip to select a main mast. Due to the hectic pace at which the project was moving, Sarsfield did not have time to record the construction process nor draft plans for the rest of the caravel. Despite this fact, the ship was finished in his honor and tested as originally intended (Carrell and Keith 1992:284; Nance 1992:295).

Sarsfield decided to build the caravel in Valença, employing the Brazilian shipwrights and their traditional tools and construction methods (Figure 8-7). He decided not to use design or construction shortcuts in order to stay true to ancient traditions,

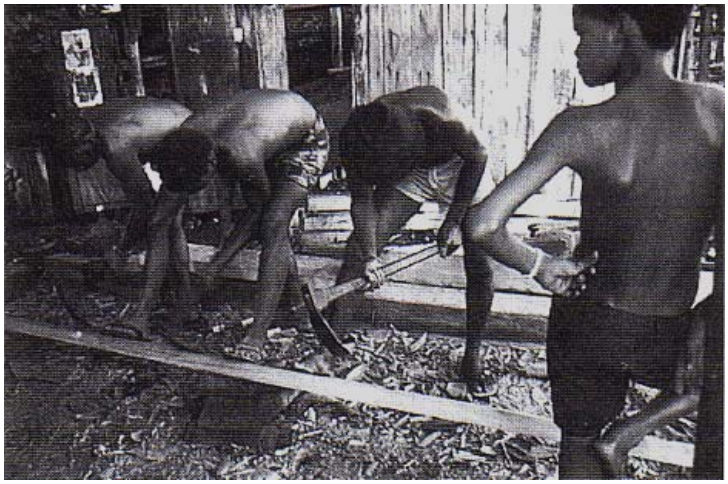

FIGURE 8-7. Brazilian boat builders adzing individual planks (After Carrell and Keith 1992:291)

although some compromises had to be made in the interest of money, available resources, and the fact that some parts of ancient shipbuilding texts were ambiguous or contradictory (Carrell and Keith 1992:282). Although it is not the intention of this chapter to detail the entire shipbuilding process, some key methods are discussed here for the purposes of demonstrating the type of practical information that can be gained from Sarsfield's project.

The dimensions of *Santa Clara* came from multiple lines of evidence, partially based on the archaeological remains of the early 16th-century Highborn Cay and Molasses Reef shipwrecks and the available shipbuilding manuscripts. Sarsfield planned to design a ship between 55 and 60 *toneladas*, with a keel length of 15 m, a beam of 5 m, and a 2 m depth of hold. It would carry two lateen and two square-rigged masts, along with 200 m² of sail (Figure 8-8). The ratios for the construction of the hull, adopted from local Bahian proportions and rules collected by Pimental Barata, were: floor equals one-

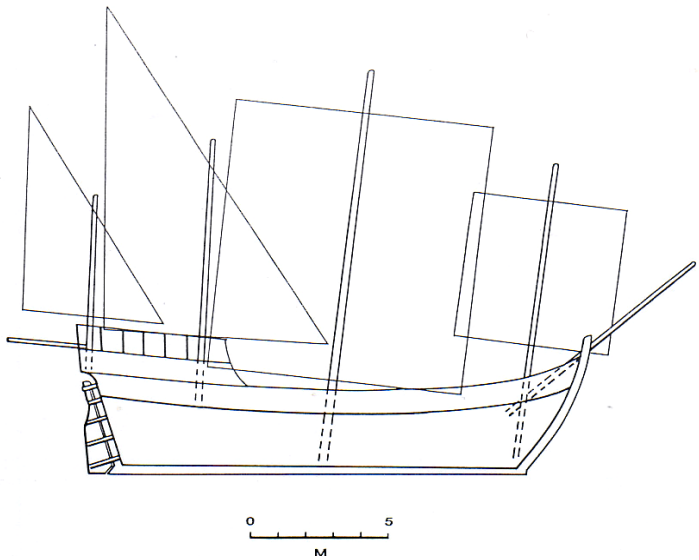

FIGURE 8-8. Profile drawing of the caravel by Sarsfield (After Carrell and Keith 1992:285)

half the beam; transom equals two-thirds the beam; depth equals two-fifths the beam (Carrell and Keith 1992:284; Barker 1993:162).

Sarsfield described the manner of construction of Bahian boats:

> First the keel, usually hewn from a singe tree, is set up. Next, sternpost and stem are fixed upon the keel, together with their respective knees. The angle made by the stem with the keel in conjunction with the knee provides a large caravel surface of deadwood that gives these boats, and very possibly their caravel ancestors, a certain amount of windward ability (Sarsfield 1985a:87).

After these elements were arranged and assembled, the next step was to use *graminhos* to create patterns for the floors and futtocks. The *graminhos* for *Santa Clara* were designed by Waltinho, based on Sarsfield's measurement specifications. The floor, futtock, and rising square gauges were used to determine the rising and narrowing of the frames in the ship (Figure 8-9; Sarsfield 1991:141; Carrell and Keith 1992:284). Once the patterns were designed, they were traced directly on the wood, then flipped over to complete the tracing on the other side. This was performed for the 13 preassembled frames, including the *almogamas*, or tail frames, after which they were placed on the keel and nailed in place through the floors (Figure 8-10). The master frame was positioned at the midpoint of the keel, keeping with Bahian tradition but differing from instructions found in manuscripts. Oliveira, for instance, states that the master frame should be placed one-eighth forward of the middle point of the keel (Oliveira 1991:94). After the rest of the pre-made frames were installed, ribbands were run from sternpost to stem across these erected members to guide the placement of the remaining floors and futtocks. The method of joining the floors and futtocks was unknown in Bahía until introduced by Sarsfield. He decided to use the dovetail mortise-and-tenon joinery found

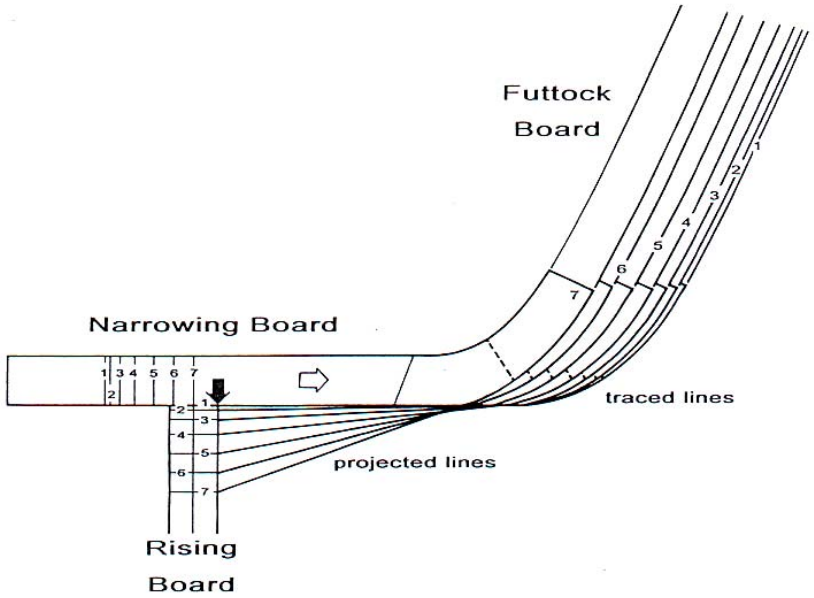

FIGURE 8-9. Wooden patterns used to mould the frames of *Santa Clara* (After Carrell and Keith 1992:285)

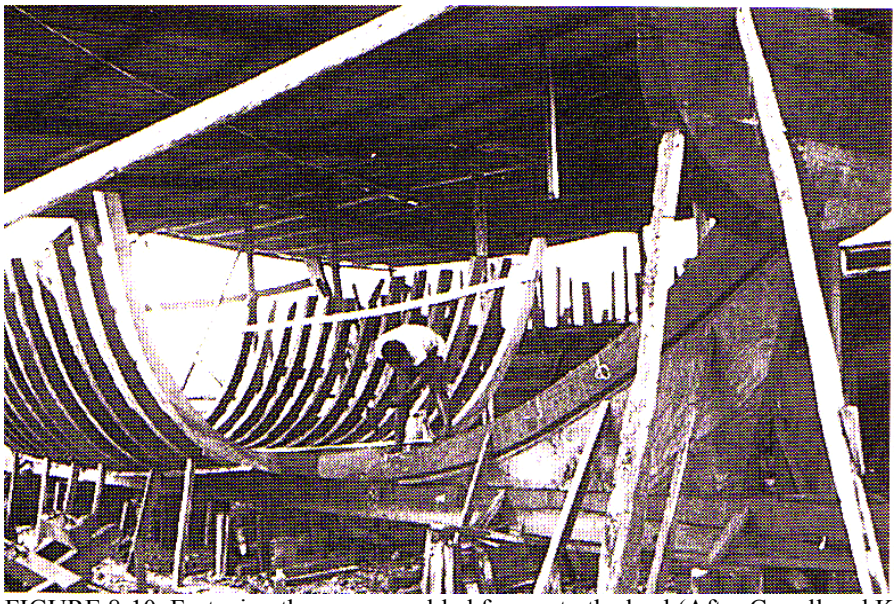

FIGURE 8-10. Fastening the pre-assembled frames to the keel (After Carrell and Keith 1992:288)

in archaeological examples such as the Molasses Reef and Highborn Cay shipwrecks, a technique that was well-received by the Brazilian boat makers. The frames were reinforced by the keelson, bilge stringers, and clamps (Sarsfield 1985b:66-69; Carrel and Keith 1992:288).

Other features of the replica were also designed in accordance with archaeological evidence and were, again, unknown by the Bahians. An example is the notching of the keelson at the main mast-step to accept three pairs of buttresses (Figure 8-11), a construction characteristic discovered on the Molasses Reef shipwreck (Figure 8-12; Carrel and Keith 1992:290).

Sarsfield's *Santa Clara* provides a rare opportunity to study the construction techniques revealed in shipbuilding manuscripts and archaeological remains. The project gives scholars of Iberian seafaring the chance to put the theory found in ancient manuscripts to the test and evaluate its soundness. For example, one scholar remarked that the use of the *graminho* method to fair successive frames based on a master frame was only theoretical and that, in practice, it was unrealistic. Sarsfield shows clear evidence that from the Bahian use of the *graminho*, it was indeed very practical (Bonino 1978; Sarsfield 1985b:69). Writing about hull ratios, Sarsfield mentioned that "some proportions, which just seem to spring out of the *mestre*'s head, fit very close to Barata's formulas" (Barker 1993:162). This seems to suggest that, although there were guidelines from which to work, ancient shipwrights ultimately employed practical experience in the shipyard to dictate the proportions of the vessel, which could be altered to suit particular

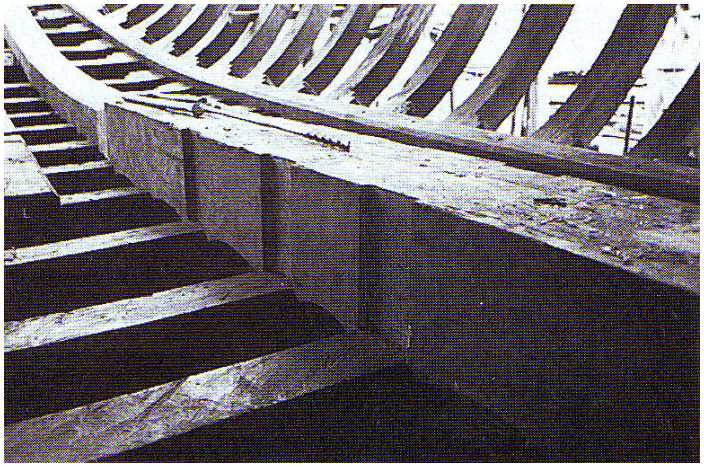

FIGURE 8-11. Notching of the keelson to accept buttresses (After Carrell and Keith 1992:290)

FIGURE 8-12. Buttressing of keelson as seen in archaeological remains of the Molasses Reef wreck (After Bass 1996:58)

hull shapes.

After Sarsfield's death, the construction and outfitting of *Santa Clara* continued. Although no plans for caravel design are known to exist for Columbus's *Niña*, Eugene Lyon discovered a sizable archival document, entitled *Libro de Armadas*, which includes

an inventory of equipment onboard *Niña*. This document includes rigging details for the ship, and was used by Jonathan Nance, in addition to Sarsfield's request for a counter-

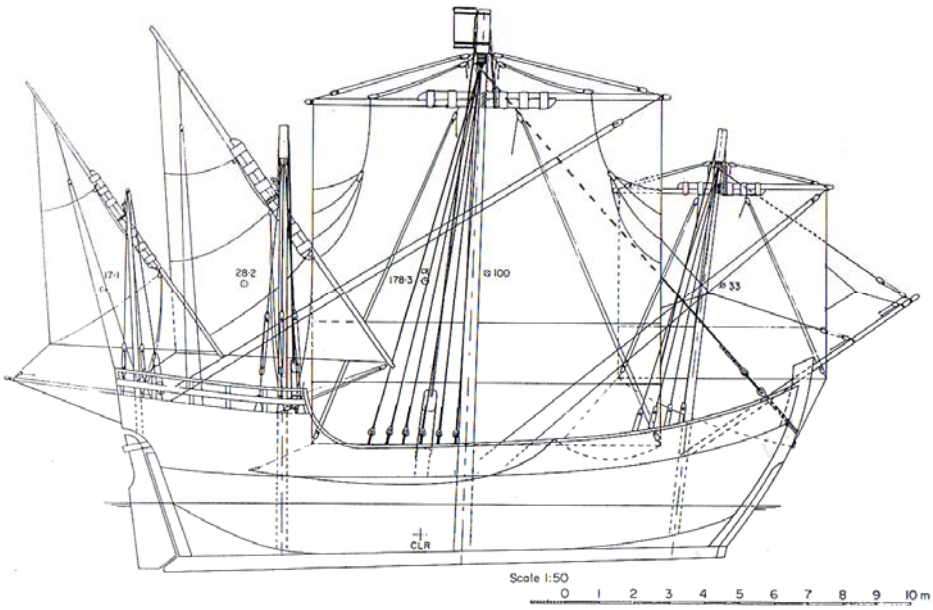

FIGURE 8-13. Nance's sail configuration for *Santa Clara* (After Nance 1992:298)

mizzenmast, in his sail design for Sarsfield's *Santa Clara*. The vessel stepped four masts, with square sails on the fore and main and lateens on the mizzen and counter-mizzen (Figure 8-13; Nance 1992:296).

Because *Santa Clara* was to be used in a major motion picture and subsequent touring to help recover building expenses, a 125 hp Brazilian Mercedes engine was installed with steel fuel tanks, water tanks, and modern heads. Likewise the keel of the ship was fitted with a four ton lead shoe to comply with insurance requirements, although these additions were intended to be removed in the future to conduct experimental testing of hull and rigging characteristics (Nance 1992:303).

In December 1991 the vessel set sail from Bahía to Isla de Margarita, a voyage of 2,500 miles (4,023 km) (Figure 8-14). There was a 12 man crew, five of whom were Brazilians from Valença. The ship reportedly heeled no more than 30°, much less than expected. The crew sailed the vessel successfully, even through a series of squalls, until time constraints required them to motor toward Margarita. After arriving in sheltered waters, the crew began experimenting with sailing into the wind under full rig. She reached five knots in approximately 15 knots of wind, and handling of the counter-mizzen reduced her ardent tendency to travel windward. When it was time for tacking, a crew of seven successfully maneuvered the mizzen yards and tacked home the sheets in less than four minutes. Under the rigging arrangement designed by Nance, *Santa Clara* was able to point slightly over 60° into the wind. During filming, the crew was able to experiment with the balance of the rig, and determined that the main function of the counter-mizzen sail was to assist maneuvering (Nance 1992:304-307).

After filming, the replica began touring the East Coast of the USA and the Great Lakes and has continued to sail to new ports around the world as a touring museum. Sarsfield's project is a remarkable example of experimental archaeology and has provided an enormous amount of information regarding the construction and sailing characteristics of caravels of discovery.

Through this type of ethnographic study, scholars are able to attain a practical perspective on how ancient vessels were constructed, to combine with knowledge obtained from studying shipbuilding manuscripts and archaeological remains. Together, these sources create a more comprehensive understanding of caravels. This is a

significant advancement in the study of shipbuilding history because we are better able to identify and understand nuances and discrepancies discovered when comparing archaeological evidence to historical texts. Similar ethnographic research needs to be conducted before these ancient shipbuilding practices are extinct. Sarsfield claims that other than Brazil, Portugal and Newfoundland are the only other places in the world where similar methods of "Mediterranean moulding" are reportedly still being practiced (Sarsfield 1985b:72).

FIGURE 8-14. *Santa Clara* under sail (After The Columbus Foundation 2006)

CHAPTER IX

ICONOGRAPHIC REPRESENTATIONS OF CARAVELS

Iconography is a final consideration here for investigating the development of caravels. Unfortunately, the vast majority of representations show the ship above the waterline only and do not reveal much of the hull shape. Nevertheless, surviving depictions make it possible to determine the overall form of the vessel, its rigging, size, superstructures, and other details that can be observed from an exterior view of the ship. Iconographic sources need to be studied carefully, however, because images can be unreliable due to inaccuracy. Reasons for questioning the authenticity of a piece stem from the stylized nature of art, the simplification of an object rendered, and the lack of specification for vessel type. Probably the majority of artists replicating ships were not employed in a maritime trade. The resultant representation was, therefore, usually a product based on simple observation rather than first-hand knowledge of ships. Another consideration is accurate dating of the source. It is often difficult to ascertain the exact age of an image, either because information is missing, or because of artists' tendencies to replicate previous works while adding distortions and taking other artistic liberties in the process (Casado Soto 2001:139). Several extant images of 15th- and 16th- century caravels do reveal some hallmarks of the vessel type, however, and are worth studying in order to visualize the changing form of this type of ship through the centuries.

Although there are scores of artistic representations of caravels across time, the intent of this chapter is to briefly examine a small number of the images that demonstrate the gradual transformation of the vessel type throughout its history.

The earliest known illustration of a Portuguese caravel is from a document dated to 5 December 1488. The master of the ship, João de Lião, signed an order for provisioning his vessel with biscuits and left a monogram with a small design of a caravel (Figure 9-1; Pires 1988:48). This simple image is considered to be a reliable depiction of a caravel from the late 15th century and shows several characteristic features of this ship type. One such feature is the single mast with a large yard stepped in the middle of the vessel. Additionally, the sketch portrays a single sterncastle, low freeboard, square stern panel, and gently sloping bow rake—all of which are typical of the 15th-century caravel.

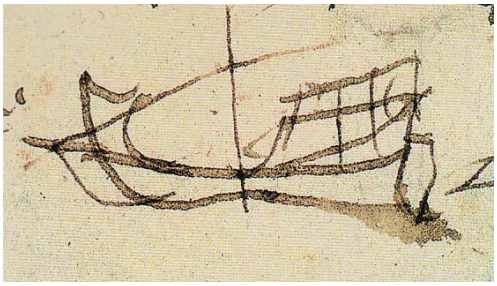

FIGURE 9-1. Sketch of a caravel by João de Lião, dated to 1488 (After Verbo 1998:74)

A similar archival discovery, dating to the beginning of the 16th century, reveals three Spanish caravels amidst the names of fisherman (Figure 9-2). These single-masted

ships appear much the same as the earlier drawing, but lateen sails are clearly shown, with yards longer than the length of the hulls.

Artistic renderings of the vessels that accompanied Vasco da Gama on his second voyage to India in 1502 can be found in *Livro de Lisuarte de Abreu*. Because this book dates to the second half of the century, it is likely that Lisuarte de Abreu never saw a caravel from the beginning of the 16th century . The ships that comprised the fleet were a combination of *caravelas de armada* and *naus* (Figure 9-3). These caravels, distinct from the fishing craft seen in the signatures, are armed with cannon, have forecastles as well as sterncastles, and step four masts with a combination of lateen and square sails.

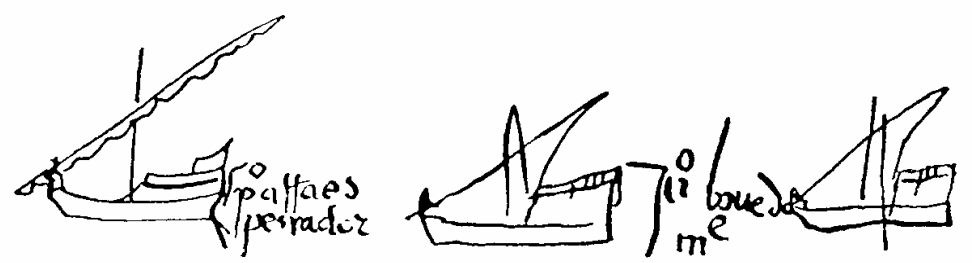

FIGURE 9-2. Drawings of caravels from an early 16th-century document found in the Archivo General de Indias (After Elbl 2000:91)

At this point in time, there was a shift toward larger, armed vessels to be sent to India, and *caravelas de armada* were utilized to protect trade goods flowing to and from the East. Despite the major modifications to the *caravelas de armada*, there are evident similarities to the fishing caravel seen in the figures above. Both images show vessels that are long, sleek, and have relatively low freeboard compared to *naus*. Additionally,

lateen sails are the main form of propulsion, and though the *caravelas de armada* have forecastles, they appear minimal in height in order to stay clear of the lateen yard. These

FIGURE 9-3. *Caravelas de armada* and a *nau* from da Gama's second voyage to India in 1502 (After Comissão Nacional 1992:19)

FIGURE 9-4. *Caravela de armada* of João Serrão in Mozambique, dated to a voyage from 1502 (After Academia das Ciências de Lisboa 1979:56)

representations conclusively demonstrate that both caravel types did, in fact, coexist during the early 16th century.

Other 16th-century representations of caravels seen in *Memória das Armadas* exhibit similar traits to those of da Gama's vessels and seem to be fairly stylized. The *caravela de armada* attributed to João Serrão, for example, has an identical rig, low

freeboard, and a protruding beak at the bow to provide better performance when sailing before the wind (Figure 9-4). A square foresail works in conjunction with a lateen main sail. The foresail has a top gallant and what appears to be a top. The shape of the sheer differs slightly from da Gama's ships and makes a more gradual transition from the

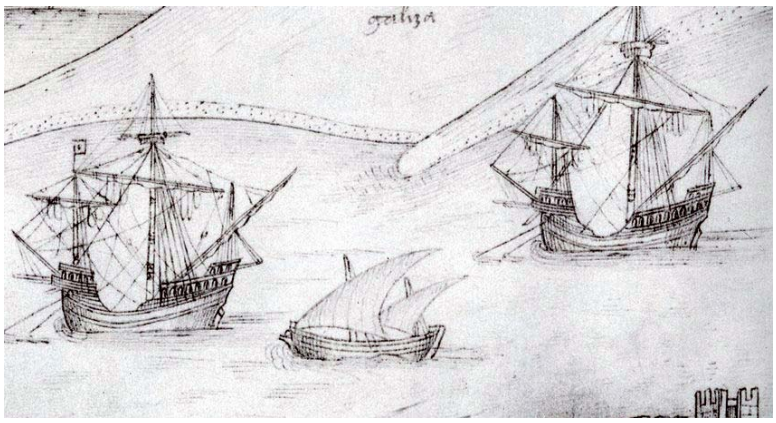

FIGURE 9-5. Possible *caravela latina* between two *naus* from *Livro das Fortalezas* (After D'Armas 1990:11)

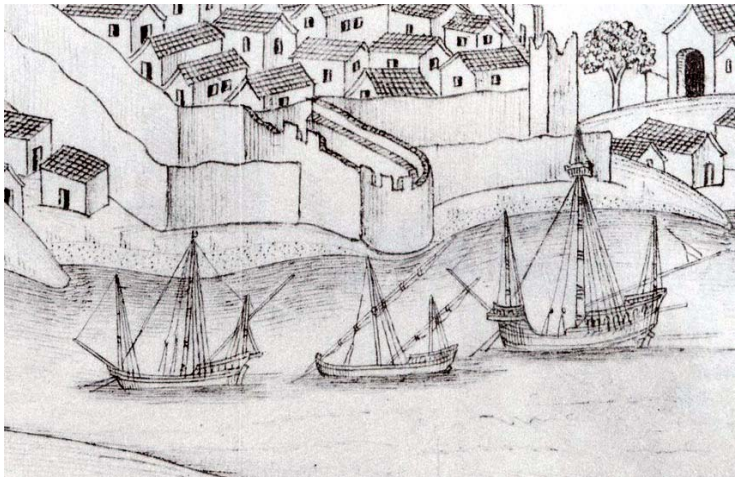

FIGURE 9-6. Probable caravels and a *nau* from *Livro das Fortalezas* (After D'Armas 1990:11)

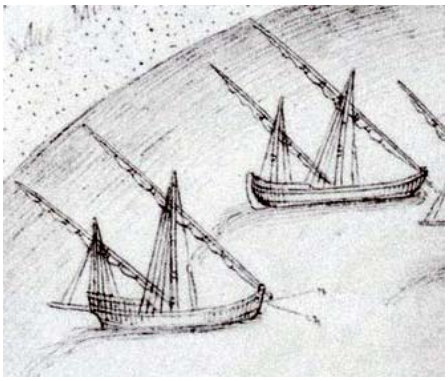

FIGURE 9-7. *Caravela latina* from *Livro das Fortalezas* (After D'Armas 1990:11)

sterncastle to the bow, where the forecastle abruptly rises. Overall, this *caravela de armada* closely resembles those of da Gama's fleet, as they were represented around 1565.

Caravelas latinas from *Livro das Fortalezas*, a work dating to ca. 1510, are more similar to earlier two-masted, lateen-rigged vessels used for inshore work and coastal exploration. Different caravel forms appear to exist in the folios of this book. Figure 9-5 shows a possible riverine caravel next to two larger *naus*, with a hull shape much different than the vessel of João Serrão, for example. This vessel exhibits a concave sheer without a prominent sterncastle and does not appear to have a square stern panel. It does, however, appear to show a stern-hung rudder. Could this be a *caravela pescareza*, or a derivative of this fishing craft, with a partially open deck? Though possible, it is difficult to say for certain due to the artistic nature of iconography in addition to the wide variety of craft in operation during this time.

Another folio from the book shows a caravel of a different type near another lateener and a *nau*, all at anchor near a fortress (Figure 9-6). The vessel on the left steps

three masts with only the mizzenmast clearly showing a lateen yard. This image is unclear, but probably represents a *caravela redonda.* The ship in the middle steps two masts, each with long yards, and may depict a *caravela latina.* Figure 9-7, also from *Livro das Fortalezas*, is a representation of two more vessels of this style at Valençó do Minho, likewise shown close to shore. These ships bear a mainmast and mizzenmast, both lateen-rigged, although the one on the right has a round stern post, and may not be a caravel. In the vessels from Figures 9-6 and 9-7, the characteristically low, gently sweeping bow is portrayed, which distinguishes it from the *naus*. The caravels are depicted as having relatively low sides, with a single castle. This sterncastle is not a dramatically rising superstructure but rather a simple deck to assist sailors with the operation of the mizzen, which is stepped at the aft quarter of the castle. All of these portrayals appear to have square stern panels as well. Clearly, these particular vessels were designed with a shallow draught and are, therefore, presented closest to the shore.

FIGURE 9-8. *Caravela latina* from the map of Piri-Reis of 1513 (After Dor-Ner 1992:56)

The traits of the caravels from *Livro das Fortalezas* are typical of those exhibited in much of the other available iconography, such as the images from the Turkish map of Admiral Piri-Reis, dated to 1513 (Figure 9-8). Piri-Reis fought the Portuguese and must have known their caravels well. This two-masted, lateen-rigged vessel has the small sterncastle, low sides, and general shape characteristic of a caravel. The most apparent difference, however, is the shape of the bow, which is not as gently sloping as many other depictions.

Figure 9-9 is adapted from an image of a caravel from the Pedro Reinel Atlas, dated to 1516. This ship has a hull form which appears similar to the depiction from Figure 9-5, but the vessel has a railing at the bow to keep water out of the vessel when sailing on the open sea, as well as an additional counter-mizzenmast.

One of the best representations of a caravel comes from the Santa Auta altarpiece, which was painted ca. 1520 (Figure 9-10). The altarpiece clearly shows a two-masted *caravela latina* with a sterncastle, square stern panel, stern-hung rudder, and

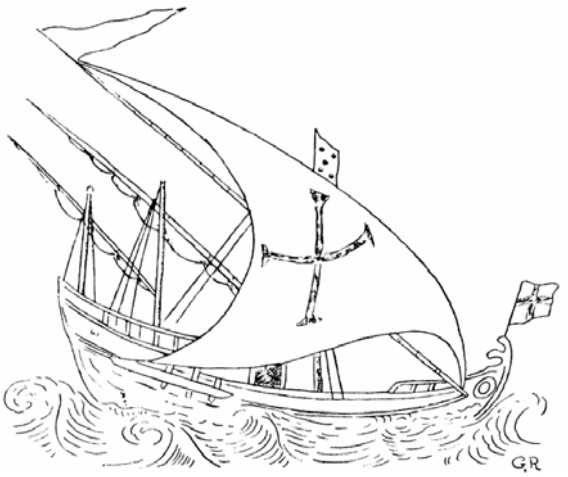

FIGURE 9-9. *Caravela latina* from the Pedro Reinel Atlas of 1516 (After Gardiner 2000:95)

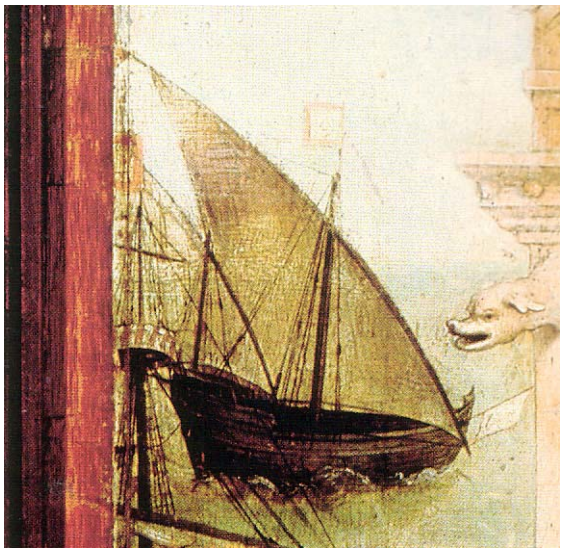

FIGURE 9-10. *Caravela latina* from the Santa Auta altarpiece of ca. 1520 (After Verbo 1998:73)

slightly-sweeping bow. Another image from the same altarpiece shows a similar ship, though the bow curvature seams slightly steeper, and it steps a mainmast and foremast

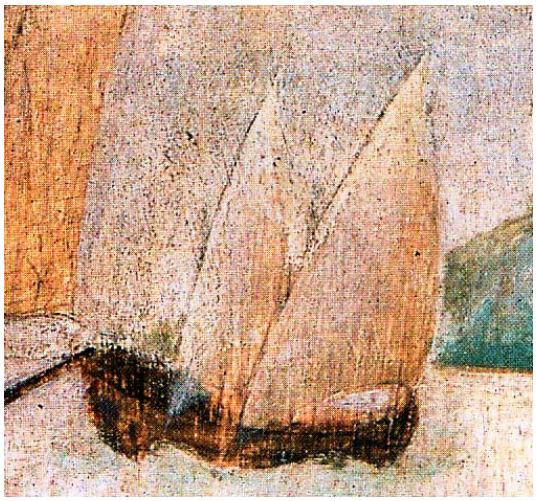

FIGURE 9-11. *Caravela latina* from the Santa Auta altarpiece of ca. 1520 (After Bellec 2002:13)

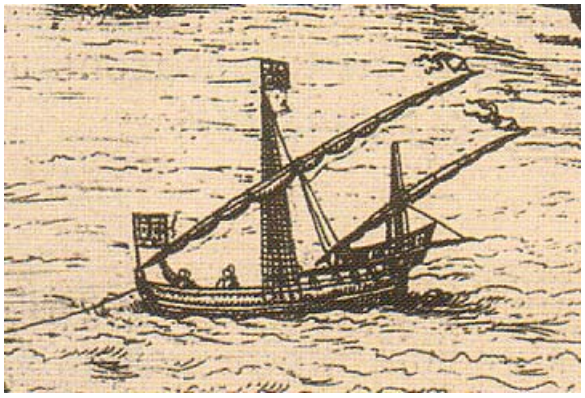

FIGURE 9-12. Engraving from 1572 of a caravel at Tangier (After Verbo 1998:168)

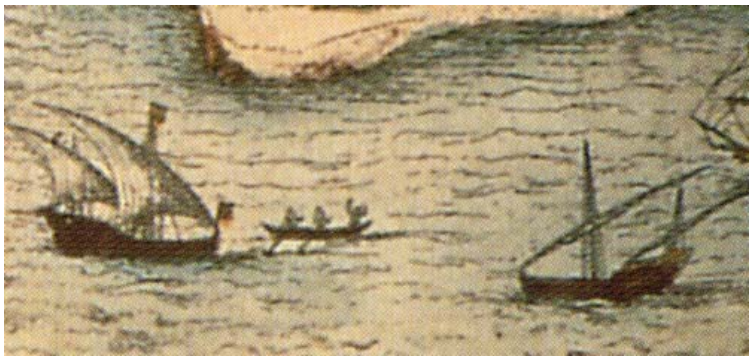

FIGURE 9-13. Caravels from an atlas showing São Jorge da Mina in the late 16th century (After Bellec 2002:51)

bearing lateen sails, with a possible mizzenmast stepped at the sterncastle (Figure 9-11). Moreover, it is portrayed lower in the water, attributing to its lower freeboard. Representations of caravels taken from late 16th-century depictions of trading forts in Tangier and São Jorge da Mina, show features closely resembling those from the images from the Santa Auta altarpiece (Figures 9-12 and 9-13). They appear as two-masted, lateen-rigged ships with a sterncastle and square stern panel. These vessels seem to be relatively small considering the human figures shown in the images. These people are not good indicators of size, however, as they are not drawn to scale. Despite this

discrepancy, these depictions provide evidence that the *caravela latina* continued to be used throughout the second half of the 16th century, at least for coastal work.

FIGURE 9-14. *Caravela de armada* from *Routiers de L'Inde* (After Universidad de Coimbra 1988:1)

The caravel from *Routiers de L'Inde*, dated to between 1500 and 1548, is another good example of the variations of this ship type during the 16th century. It is a four-masted *caravela de armada*, with three lateen sails and a single square-rigged foresail, all presently furled (Figure 9-14). Like the other caravel renditions, the mainmast lateen yard is longer than the length of the vessel's hull, a pronounced beak is apparent, and the ship has both forecastle and sterncastle. Also the stern panel is clearly square, and the bow has the characteristic caravel slope.

Toward the end of the 16th and beginning of the 17th centuries, however, caravels with three or more masts, a combination of lateen and square sails, higher freeboard, and a pronounced beak at the bow tend to appear more frequently in documental as well as iconographic sources. These caravels shifted toward the design set

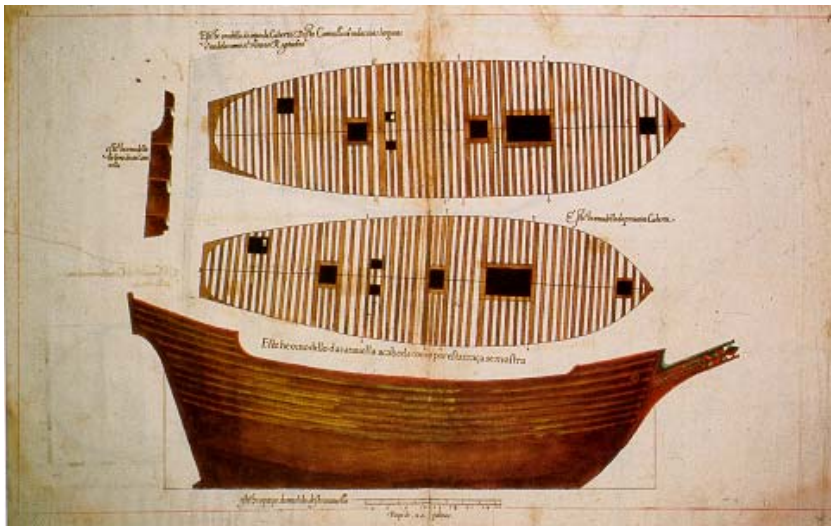

FIGURE 9-15. Caravel of 11 *rumos* (After Fernandes 1989:folio 108)

forth in Fernandes's treatise, *Livro de Traças de Carpintaria*, a beamier vessel lacking the fine lines of the *caravelas dos descobrimentos* (Figure 9-15; see Appendix B).

A caravel depiction from a Dutch view of Lisbon in the17th century supports this evolutionary shift, exhibiting features that indicate a ship close to the Fernandes caravel (Figure 9-16). This ship steps four masts, three of which hoist lateen sails. The forecastle is of small dimensions to prevent interference of the long lateen mainmast yard. The stern panel is square and rises high out of the water, suggesting an elevated overall freeboard for this craft. The caravel has a bowsprit but does not appear to have a beak at the bow. The shadows portrayed on the port side of the vessel, the width of the transom, and the curves of the planks suggest a moderately wide beam. According to archival documents and the extant shipbuilding treatises of the early 17th century, this caravel seems to be exactly what is expected in the Tagus River during this period.

FIGURE 9-16. Caravel from a 17th-century Dutch representation of Lisbon (Photo by author, 2005)

Although the archaeological record cannot currently furnish detailed lines of a 15th- or 16th-century caravel, a shadowy but often consistent description of the vessel's appearances can be gleaned by scouring the iconographic sources. Representations give descriptive details such as how caravels appeared, how they sat in the water, what kind of superstructures they had, what type of rigging they employed, and other useful information. They also corroborate historical indications that several forms of these ships coexisted. The *caravelas de armada,* for instance, were in use in India at the same time *caravelas pescarezas* and other varieties were employed in the rivers and coastlines of the Iberian Peninsula and Africa. Iconography is a powerful tool for learning more about the appearance of ancient ships, and, in the case of the caravel, provides visual clues to the transitional phases and changing forms that occurred throughout its gradual development.

CHAPTER X

CONCLUSIONS

This thesis has given insight to the complexities of studying a type of ship for which little, if any, archaeological evidence exists. Due to its immense importance, however, the caravel has been the subject of intense research for well over 150 years. Despite this, detailed descriptions of the ship continue to evade maritime scholars. As evidenced in this study, there are, nevertheless, many surviving sources which provide bits of information here and there, enabling researchers to develop an understanding of one of the most intriguing and popular vessel types of its time.

The history surrounding European overseas expansion in the late medieval and early post-medieval eras helps explain the importance of the slowly emerging shipbuilding technology that was gradually advancing in sophistication during this period. Although the full story is more complex, an overview of social development in the Iberian Peninsula sheds some light on the question of why Portugal and Spain were the first to utilize this advanced technology to realize their overseas ambitions. A close connection with fishing and maritime trade led the 14th-century rising middle class in Portugal to expand their commercial network overseas. In turn, this prompted maritime ventures and exploration for the establishment of further trading opportunities. This eventually tied into the political conflicts that were pervading Europe and exploration ultimately evolved into to a territorial contest with Spain over the world's oceans.

The desire for Iberian expansion encouraged progression in shipbuilding technology. This advanced skill in ship design, combined with a long history of Iberian seafaring tradition found in Iberian coastal maritime life, brought about the eventual transformation of the caravel from a ship tender into an able fishing craft and later to a vessel of exploration. Due to its advantageous features, this ship was responsible for permitting the navigation of coastal and inland waterways along the African seaboard, and even transatlantic voyages to the New World.

Early inquiries into the term "caravel" have, in many cases, led to ambiguous notions of what type of craft the word represented, creating confusion instead of providing relevant details about the vessel. Such can be witnessed in definitions of "caravela" in Portuguese and other European dictionaries and glossaries from the 17th through the 20th centuries. Despite the contradictions in these descriptions, more in-depth studies by 19th and 20th century scholars have concluded that the caravel was a ship type of many evolving forms and spanning several centuries. This is of key significance for this study. One cannot discover a shipwrecked caravel from the 13th century and another from the 17th century, and expect to uncover vessels of similar appearance, proportion, function, rig, or dimension. The gradual transformation and variety of evolved forms spans too many centuries and is too large to typify the caravel beyond a handful of characteristics. Furthermore, as the lines of evidence show, caravel forms often overlapped and coexisted during certain periods. Archival research over the past 160 or so years has provided a general framework for this branching evolution of the ship type.

The 12th-century *caravellum coopertum* was almost certainly under 20 *tonéis*, but by the first quarter of the next century those caravels that had been making the voyage to the Bay of Biscay were between 20 and 30 *tonéis* and stepped one or two masts with lateen sails. These narrow ships were probably fully decked by the middle of the 13th century. So far, scant evidence is available for the development of this ship type throughout the 14th century, but in the early 15th century the caravel reappears as a commonly used Iberian fishing vessel of somewhat larger tonnage. It was a fine-lined vessel of shallow draught and able to sail closer to the wind than its square-rigged contemporaries. Its overall characteristics qualified it as a superior sailor over earlier ships used for exploration, and by the 1440s the Infante was ordering caravels to be fitted out for reconnaissance voyages along the African coast.

The *caravelas dos descobrimentos*, used extensively throughout the second half of the 15th century, were between 50 and 60 *tonéis*, perhaps 20 to 30 m long, and between 6 and 8 m in beam. In this era, square sails were sometimes used in transatlantic voyages, creating what was referred to as *caravelas redondas*. In the last quarter of the century guns were placed on board the vessels, eventually calling for a change in hull form to accommodate stability issues. These caravels increased in tonnage and perhaps also in beam, acquired a small forecastle and beak, and were dubbed *caravelas de armada*, to be used throughout the 16th century in India and the Americas.

As time progressed and trade routes were firmly established, caravels became more capacious to facilitate trade, in general keeping their superior sailing qualities. This is shown in iconographic representations by their elegant profile, which depicts them as

long hulled and bearing large sails. Even if their length to beam ratios finally fell below 3:1—a fact that has yet to be proven—and thus became hybrids between earlier caravels and *naus*, sometimes reaching 180 *tonéis* and more, the elongated profiles of *caravelas de armada* suggest they were built for speed. Other forms of the vessel existed throughout the 16th and 17th centuries, including the dispatch ships known as *caravelas mexiriquieras*, as well as *caravelões*, the defenders of the Brazilian coast and sugar transporters.

In addition to historical accounts, 16th- and 17th-century shipbuilding manuscripts add another dimension to the understanding of caravels. By studying the manner in which Iberian ships were constructed during this era, scholars obtain knowledge about structural characteristics and necessary elements to be included in an ocean-going vessel. These books provide particulars not only about ship design and manufacture, but also details concerning the lives of shipwrights during this age. A wide array of other information can be found as well, including navigational techniques, methods for arming a vessel, and descriptions about the duties of officers, to name a few.

A look at the archaeological material for Iberian vessels reveals that there is no real conclusive evidence that a caravel has yet been discovered. There are examples of shipwrecks, however, which indicate their possible use as a ship of exploration or other function that the caravel occupied. The Molasses Reef and Highborn Cay shipwrecks demonstrate plausible examples of caravels of discovery, and fall within the proper ranges of size and proportion. Evidence from another example, discovered at the Ria de Aveiro in Portugal, suggests a possible caravel used for light cabotage in the inland

waterways of the Peninsula, as well as occasional Atlantic voyaging. The problem inherent in all of the current finds is the lack of surviving hull timbers and other diagnostic features purely indicative of a caravel. The examples that we have now, however, do provide excellent parallels to compare with shipbuilding treatises and other similar wrecks in order to establish a shipbuilding trend that we would expect to uncover on a caravel of discovery.

An excellent way for researchers to grasp the complexities of ancient shipbuilding traditions is through the application of known design methods through experimental archaeology. This is exactly what John Patrick Sarsfield did with his reconstruction of *Santa Clara*, and the results of his project have immensely enhanced our knowledge of how caravels and other Iberian vessels were built. His work brought the methods described in the shipbuilding treatises to life, and in combination with traditional boatbuilding methods still used in Brazil, has revealed many of the secrets of shipwrightry employed during the Age of Expansion.

Finally, no study of an ancient ship type would be complete without examining representations of the ship through time. Iconographic sources, beginning with the late 15th-century monogram of João de Lião and ending with 17th-century Dutch renderings of Lisbon, show the extensive variation in form of the caravel. Again, this is evidence of its gradual development through the ages. Period images also demonstrate that multiple forms of the caravel coexisted, further substantiating these conclusions reached through archival evidence. Despite the diversity of forms revealed in the depictions of these ships, certain characteristics are still present, which distinguish caravels from other

vessels. Some of these features include the sweeping bow, single sterncastle and—in later versions—low forecastle, multiple lateen sails later combined with square sails, and low freeboard.

FIGURE 10-1. Modern depiction of a *caravela redonda* (After Brás de Oliveira 1940:12-13)

As stated several times throughout this work, a pure archetypal caravel cannot be defined. An in-depth look at several lines of evidence shows a gradual and branching developmental history which defies any uniform evolution. Historical records have thus far provided the most descriptive definition of the various caravel forms throughout the centuries of its existence, but do not come close to telling the whole story. Archaeological evidence, shipbuilding manuscripts, iconographic representations, and ethnographic studies applied to ship design all contribute a wealth of knowledge about the enigmatic caravel. Through an examination of all the data, we have uncovered a

long, though somewhat still obscured, developmental history of this significant ship type. What we do know, however, is that the caravel represents a remarkable type of craft that obtained and subsequently clung to certain advantageous characteristics that perpetuated its survival for five centuries and remains to this day the national icon of Portugal (Figure 10-1). Once the conclusive remains of a caravel are discovered and studied by nautical archaeologists and maritime historians, a new set of data will be added to this preliminary study and advance our knowledge of Iberian maritime culture for the better understanding of our seafaring past.

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APPENDIX A

SOME UNITS OF MEASUREMENT APPLIED BY 16TH- AND 17TH-CENTURY IBERIAN SHIPBUILDERS

Measurements	**Equivalence**	**Metric Value**
Braça	8 *palmos de goa*	2.048 m
Codo de ribera		0.565 m
Dedo	½ *polegada de goa*	0.183 m
Goa	3 *palmos de goa=1/2 rumo*	0.768 m
Palmo de goa	1/3 *goa*=1/6 *rumo*	0.256 m
Pipa	½ *tonel*	0.805 m³
Rumo	2 *goas*=6 *palmos de goa*=3 ¾ *braça*	1.540 m
Tonel (pl. *Tonéis*)*/Tonelada*	2 *pipas*	1.610 m³

(Compiled from Fonseca 1934[1]:316; Phillips 1987:294; Castro 2005:191)

Tonnage during this age referred to a tun of wine, which was equivalent in volume to two *pipas* (pipes), the large tapered hogsheads in which wine was stored on vessels and sold after transportation (Morison 1942:114).

APPENDIX B

RECONSTRUCTION OF A CARAVEL BASED ON A 17TH-CENTURY SHIPBUILDING TREATISE BY MANUEL FERNANDES

Manuel Fernandes's work, *Livro das Traças de Carpinteria*, from 1616, gives detailed instructions on how to build several types of Portuguese and Spanish vessels, including galleons of varying tonnage, carracks, warships, brigantines, and caravels. I drafted construction drawings of a caravel under the guidance on folio 16 of the manuscript, entitled "Calculation and dimensions for a caravel with a length between perpendiculars of 11 *rumos*" (Fernandes 1989:folio 16).

Although the vast majority of my instructions came from Fernandes's manuscript, I had to use other contemporary sources and shipwreck examples to fill the gaps that Fernandes left in his guide to the design of this caravel. In addition, I studied characteristics of a few Iberian wrecks from the 15th through the 17th centuries, in order to keep with the Iberian tradition of shipbuilding. These include the Ria de Aveiro A shipwreck, the Pepper wreck (*Nossa Senhora dos Mártires*), and the remains of *San Juan*. These wrecks facilitated a better understanding of certain elements in shipbuilding that are absent from Fernandes's manuscript.

Most of the measurements in the following description of the vessel are given in *palmos de goa*, *rumos*, or *dedos*: the standards of measurement for 17th-century Portuguese shipbuilding (see Appendix A). For easy comparisons of the Iberian shipwrecks, metric measurements are given as well. Most of the measurements for the

caravel are given in whole units—or fractions of whole units—of *palmos*, *rumos*, and *dedos*. A number of measurements are given solely in metric, however, when there is no whole or fractional equivalent to the Portuguese standards. Following is a description of the principal parts and scantlings of a 17th-century Portuguese caravel designed under the guidelines put forth in Manuel Fernandes's *Livro das Traças de Carpinteria*.

Keel

The manuscript states that the keel of the caravel is to have a length of 11 *rumos* (16.94 m). I made the molded dimension 1 *palmo* (25.67 cm) and the sided dimension 4 *dedos* (17.42cm), which seem reasonable for a cargo carrier of this length. Oliveira defines the keel as a "thick beam that runs along the length of the ship in the middle of its bottom, like a spine or the lumbar line of any long insensitive animal thrown on its back" (Oliveira 1991:168). This member of the ship would be made of cork oak (*Quercus suber*), which was considered the premium wood for the job (Castro 2005:155).

Since the keel was such an important part of the ship's structural integrity, I designed it much thicker than the keel of the smaller Ria de Alveira A shipwreck, which has an 8 *rumos* (12.32 m) long keel that measures roughly 12 cm molded and sided. The keel from the Fernandes caravel was designed to resist the mechanical stresses resulting from navigation on the high seas. The Ria de Aveiro A shipwreck, although exhibiting signs of possible Atlantic voyaging, was conclusively a riverine vessel as well, therefore possessing some smaller proportions and timber dimensions.

The Pepper wreck, with a tentative keel length of 27 m, has a sided dimension of 25 cm. The molded dimension is probably between 29 and 46 cm (Castro 2005:153). This larger molded dimension is attributed to its larger size, for the keel of the Fernandes caravel is only approximately 17 m in length. For this reason, I kept the molded dimension of the keel around 26 cm.

Stem

Fernandes gives a height of 25 *palmos* (6.42 m) for the vessel's stem. The length of the stem is 34 *palmos* (8.73 m), which is derived from Fernandes's indication that the overhang of the stem is 17 palmos (4.36 m). The sweep of the stem, from the keel to a height of 25 *palmos* (6.42 m), is made to the visual specifications of a caravel from the 17th century. The method of creating an arc to determine the shape of the bow, as described by Oliveira (Chapter VI of this thesis), produced a shape that was too circular for a caravel. Since his instructions for this method was designed for *naus*, I used only part of the arc and created the rest based on the shape of the Fernandes vessel and other iconography that depict caravels of this century. The molded and sided dimensions measure 1 *palmo* (25.67 cm) each, keeping with the logic of the keel dimensions.

Sternpost

Fernandes states that the stern post shall be 22 *palmos* (5.65 m) high, with an aft rake of 7 ½ *palmos* (1.93 m). This gives the stern post a length of 25 *palmos* (6.42m). The molded and sided dimensions are the same as the stem: 1 *palmo* (25.67 cm).

Planking

Fernandes left no indication of the size of the inner or outer planking, but an examination of his drawings reveals the approximate sided dimensions of the outer planking and wales. The outer planking was given a sided dimension of 7 *dedos* (30 cm)—1 *palmo* (25.67 cm) between wales—and molded dimension of 3/2 *dedos* (6.42 cm). The molded dimension is a bit thicker than the planks of the Ria de Aveiro A vessel, which are 5-5.5 cm thick. The *San Juan*, a mid-16th-century Basque whaler with a total length of 22 m, which is close to the total length of this caravel (25.14 m), has 5-6 cm thick planking (Castro 2005:132). Thus, the marginally larger caravel has slightly thicker planking. The inner planking is of similar length to the outer planking, but its molded and sided dimensions are slightly less because, with regard to planking, not as much reinforcement is needed on the inside of the ship. The molded and sided dimensions of the inner planking are 1 *dedo* (4.28 cm) and 1 *palmo* (25.67 cm) respectively. The planking of this vessel would be fabricated from umbrella pines (*Pinus pinea*), which was considered the best material for this element (Vieira de Castro 2005:141).

Keelson

Since the keelson plays an important role in the structural soundness of the ship, it was drafted over one and one-half times the thickness of the keel. The molded dimensions taper from 42 cm at the forward extremity to 34 cm at the aft extremity. The sided dimension is 4 *dedos* (17.42 cm).

Mainmast and Mast Step

The mast step, an expanded and fortified part of the keelson, is placed at the middle of the keel. This location, as well as that of the mast, is given by Fernandes. The mast step has a sided dimension of 3 *palmos* (77cm), which I designated because of the diameter of the main mast (50 cm) and the necessary surrounding fortifications. Either side of the mast step was given sufficient space to account for filler pieces and wedges. The main mast measures 63 cm in diameter at the second deck, and then tapers to 56 cm at the first deck. It further tapers to 50 cm at the mast step. Wedges are driven on either side of the mast in the mast openings at the first and second deck. The cant of the mast is indicated by Fernandes, which is 4 *palmos* (1.03 m) at the height of two decks.

Mizzen Mast and Foremast

The location of the mizzen mast is found by taking the distance between the step of the main mast and the stern. Once this is found, the distance is halved and the mizzen mast is placed there in the middle (Fernandes 1989:folio 16). I quadrupled the beams on the first deck at this location in order to stabilize and secure the mizzen. The manuscript gives no indication of the size of any of the masts for this vessel, but since the mizzen is an ancillary mast used primarily for balancing the rig and adjusting propulsion , I made it less than half the size of the widest diameter of the main mast. Fernandes does not mention a foremast in his instructions. According to the iconographic sources, however, as well as modern experimental reconstructions of caravels, it is probable that this vessel would have a foremast.

Moreover, although there is no mention of the foremast in Fernandes's guidelines, there is an opening on the first and second decks in his illustrations for this caravel. Transferring the location of these openings proportionally to my drawings, I placed the foremast appropriately and secured it to the apron with blocks and wedges. Additionally, it is wedged at the first and second deck mast openings. The diameter of the foremast is 36 cm wide and uniform throughout. Since this mast has a larger role in the propulsion of the vessel (and thus receives more pressure and strain), it was given larger dimensions than the mizzen.

Frames

Fernandes gives a depth of ⅔ *palmo* (17.42 cm) for the first floor timber. This extends to the timbers on either side of the main frame as well. According to the manuscript, the main frame is to be placed 3 *palmos* (77 cm) forward of the middle of the keel. Then, one floor timber of one point is placed abaft it and another ahead (Fernandes 1989:folio 16). From here, the nine frames on either side of these frames vary according to the rising and narrowing of the floor timbers. I used the *mezza luna* to determine the rising and narrowing of these timbers, as it is described in Oliveira's manuscript (Oliveira 1991:176-177). To determine the shape of the midship frame, I followed the instructions given in *Livro das Traças de Carpintaria* (Fernades et al. 1995:147). This is one helpful detail that Fernandes did include in his instructions. The sided dimension of the frames measures 1 *palmo* (25.67 cm), which is close to the dimension of the floors from *Nossa Senhora dos Mártires* (23-25 cm) (Castro 2005:117).

Beams

The beam dimensions and placements were derived from the illustrations provided by Fernandes. Most of the beams measure ¾ *palmo* (19.25 cm) molded and ¾ *palmo* (19.25 cm) sided. Some of the beams are larger or doubled (even quadrupled) to offer support for the masts, hatches, and other through-deck elements.

Stringers and Wales

The stringers from the Ria de Aveiro A wreck are placed at the floor timber and the first futtock, and measure 6 cm molded and 24 cm sided. Since they are placed at a strategic junction, the stringers for the Fernandes caravel were positioned in the same area. I added another stringer above the turn of the bilge for supplementary support. Additionally, I strengthened the stringers by making them slightly thicker than those from the small coastal vessel. The molded dimension is 2 *dedos* (8.56 cm) and the sided dimension is 7 *dedos* (30 cm). The dimensions of the wales come from the illustrations from Fernandes, as well as advice from Oliveira, who notes that "they are two fingers or thicker than the planking, but not as wide as the planks" (Oliveira 1991:199). This caravel's wales measure 2 *dedos* (8.56 cm) molded and 3 *dedos* (12.84 cm) sided.

Other Structural Elements

The cap rail measures 7 cm molded and 50 cm sided, which provides an overhang on either side of it for the outer planking and the gunwale. The gunwale measures 33 cm molded and 12 cm sided. Although Fernandes does not mention knees for the construction of the vessel, beam shelves, which measure 7 *dedos* (30 cm) molded

and sided, were added to support the beams. Additionally, waterways were inserted at the decks to prevent the deck water from running down between the frames. These measure 24 cm molded and 19 cm (average) sided.

Fastenings and Caulking

Conforming to the Iberian method of fastening, this vessel uses double dovetail scarves to join the floors and futtocks, as well as iron spikes. The spikes are driven through pre-augured holes from the after side of the floor. The planks are attached to the framing with two spikes per frame. The fastenings are made of iron and have square shanks and square heads with rounded corners. The keel and keelson are secured with iron bolts (Castro 2005:138). The material used to caulk this vessel is lead that is twisted to make a string 6 mm thick. A scantling list of the components mentioned above follows:

Keel

Length: 11 *rumos*; 66 *palmo*s; 16.94 m
Thickness: 4/3 *palmos*; 8 *dedos*; 34.22 cm
Width: ⅔ *palmo*; 4 *dedos*; 17.42 cm

Stem

Height: 25 *palmo*s; 6.42 m
Length: 34 *palmos*; 8.73 m
Width: 1 *palmo*; 25.67 cm

Sternpost

Height: 22 *palmos*; 5.65 m
Length: 25 *palmos*; 6.42 m

Width: 11 *dedos*; 47.08 cm

Outer Planking

Width: 7 *dedos*; 30 cm / 1 *palmo*; 25.67 cm between wales
Thickness: 1.5 *dedos*; 2.14 cm
Length: 16 *palmos*; 4.1 m

Inner Planking

Width: 1 *palmo*; 25.67 cm
Thickness: 1 *dedo*; 4.28 cm
Length: 16 *palmos*; 4.1 m

Deck Planking

Width: ¾ *palmo*; 19.25 cm
Thickness: ¾ *palmo*; 19.25 cm

Beam

Width: ¾ *palmo*; 19.25
Thickness: ¾ *palmo*; 19.25 cm
Lenght: 25 *palmos*; 6.42 m

Stringers

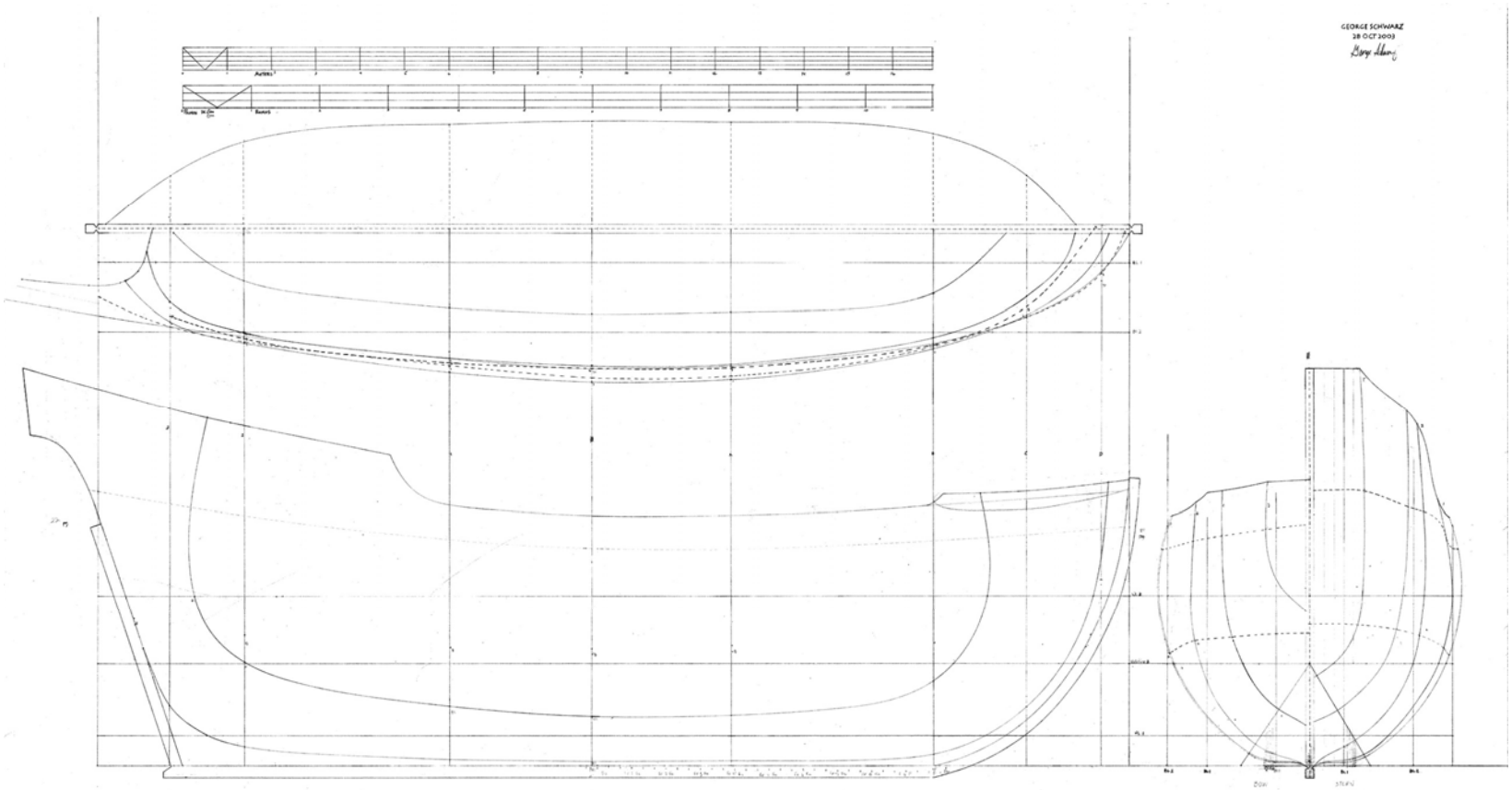
Width: 2 *palmos*; 51.34 cm
Thickness: 2 *dedos*; 8.56 cm
Length: 2 *rumos*; 3.08 m

Wales

Width: ½ *palmo*; 12.84 cm
Thickness: ⅓ *palmo*; 8.56 cm

Mast Step

Width: ½ *palmo*; 12.84 cm and tapers to 1/3 *palmo*; 8.56 cm at depth of 10 cm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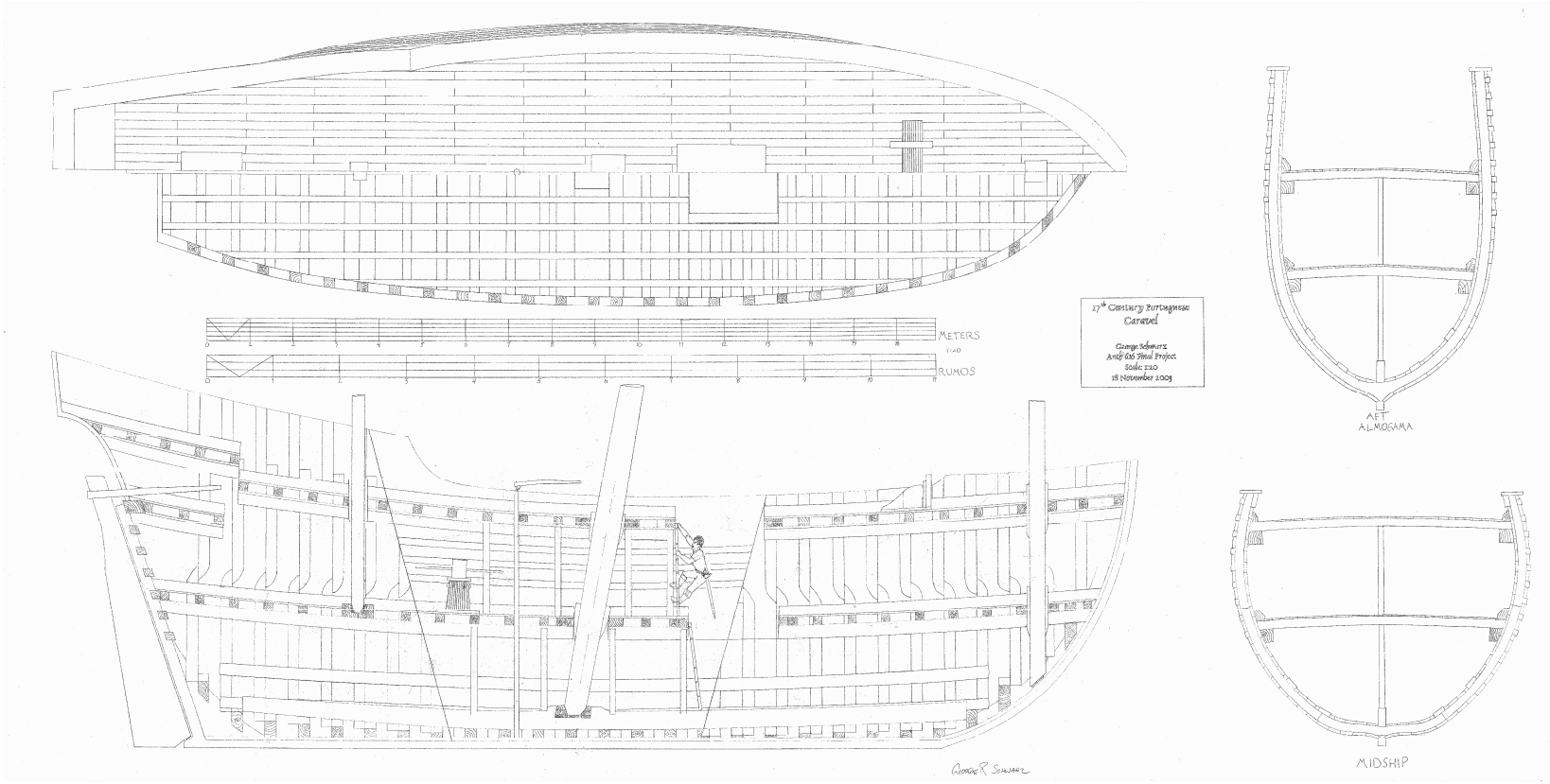
17th Century Portuguese
Caravel
George Schwartz
Anth 636 Final Project
Scale: 1:20
18 November 2005
METERS
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