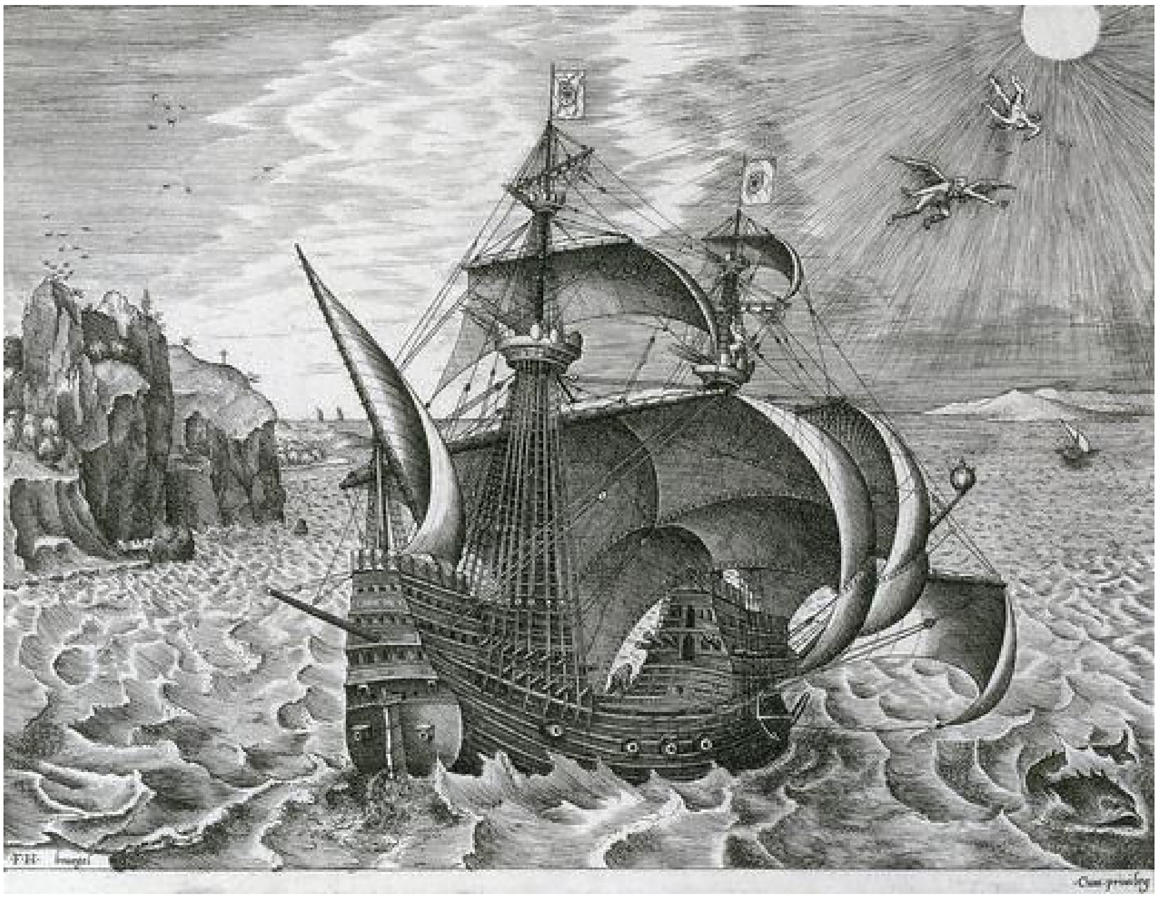

Ships and Navigation of the SCA Period

The Classification and History of Ships of Western Europe, in the SCA Period, and a discussion of the Basics of Navigation as practiced within that period

Capt. Elias Gedney
Patron, East Kingdom Guild of St Erasmus

Prefatory Note and Apology:

The history of Ships is ages old. Ships as tools of locomotion and commerce have existed since the first time early man pushed a log into a river to get across.

As numerous studies of the ships of Ancient and Classical Antiquity may be easily found by anyone with a local library and an access card, I shall attempt therefore to limit this class to the era commonly considered to be covered by the Society for Creative Anachronism, which is generally taken to be from about the year 600 AD, to the end of the 16th century. I shall further limit the scope of this discussion to cover only the ships of Europe and especially Western Europe. While I realize that the SCA actually allows for a much greater area of coverage and time period, the history of ships is so very great that any sufficiently comprehensive study as to take in all the regions and eras which are expressed within the SCA is vastly beyond the capacities of this discussion or indeed any single course of classes. Therefore I offer the reader my apologies in advance, if they feel that anything I do not discuss here has left their interests out.

I hope nevertheless to make this discussion informative and interesting, in any case.

I am deeply indebted to the exhaustive scholarship of John Isley, of the Centre for Maritime Archaeology, University of South Hampton for his informative work, “the History and Archaeology of the Ship” (http://cma.soton.ac.uk/HistShip/index.htm), and to Ian Friel’s work, The Good Ship, on which I found myself relying time and time again.

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Classifications of Ships: some Broad Categories

European ships in period may be generally classified in two basic categories: the "Round Ship" and the "Long Ship".

The Round Ship:

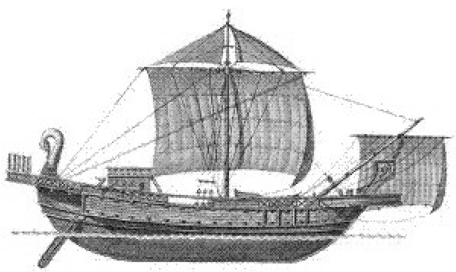


Figure 1: A Roman Merchant Ship

Round ships are those that are less than three times as long as they are wide. These are the cargo carrying workhorses of trade. This category covers such ships as the Danish Cögge, the Roman "Corn" Ship, and the Spanish Não or Caravel, all principally built for trade and carriage purposes.

The Long Ship

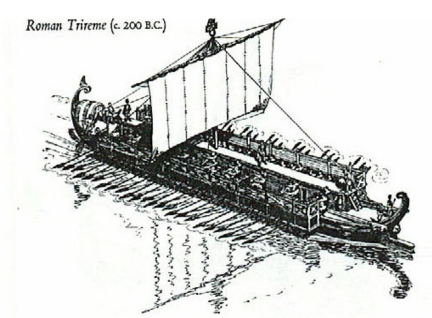


Figure 2: A Roman Galley

A Long ship, on the other hand, is three times as long as it is wide. This is the principle profile of Ships of War. Ships that follow this construction principle are the Greek and Roman Triremes and Biremes, the Dragon-ships of the Danes and Norsemen, the Great Oared Galleys of the Holy League that defeated Ali Pasha at Lepanto, and the "Race-built" Galleons that the English used to such advantage in defeating the "Invincible Armada" of Philip II, in 1588.

This is not to say that Long Ships did not carry cargo, or that Round Ships were never used in war. Indeed the exceptions to the above "rule" are frequent and remarkable, and server to point out the ingenuity and adaptability of our forefathers in the face of often-harsh necessity, long ago.

There are also ships that are found to bridge the categories, such as the Genoese Carrack or the Spanish Galleon. This is unsurprising as many books and instructions governing the construction of ships (such as the 15th century "Fabrica de Galere") give the "Ideal Proportions" of a ship to be exactly three times as long as it is wide.

Other categories:

There are other broad categories into which ships may be divided, and are all references to construction or design. Some of these are as follows:

Hull Construction:

"Clinker" or "Clench" built – a construction method where the hull planks overlap and are directly joined to each other by means of a rivet or nail through the overlap and hammered over a washer or bent backward to clamp the planks (called "strakes") together. This is frequently referred to as "lap-strake" construction. In a clench built hull the shape and strength of the hull is derived from the hull planks, and the reinforcing frames are fitted later to the shape formed by the hull. This is also often called "hull first" construction for this reason.

"Carvel" built – a construction method where the planks of the hull are laid next each other and fastened to frames (often by means of wooden pegs called "tree nails" or "trunnls"). In this construction the seams lay flat and may then be overlapped by other planks called battens. The shape and strength of this construction comes from the frame, which must therefore be built first. Therefore this is often called "Skeleton First" construction, as the framework looks rather a lot like an exposed ribcage. Since a nail or rivet does not have to be driven through two thick nesses of planking material, the planks can be made of much thicker stock, with concomitant increases in strength and size possible. Nearly all large, ocean going ships were of this construction.

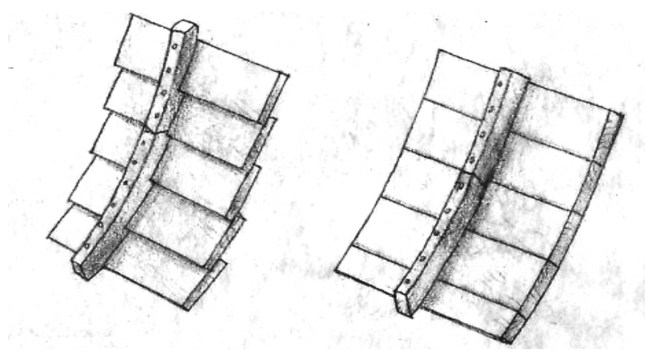


Figure 3: Hulls; Lapstrake (left) and Carvel (Right)

Rudder Construction:

Sternpost Rudder – this is a method of rudder construction where the rudder is directly attached to the Sternpost, with a tiller arm that is carried into the boat and which is

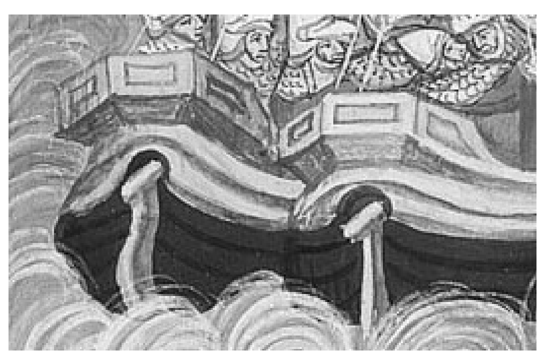


Figure 4: Sternpost Rudders

used for controlling the rudder. This can be a simple steering oar fastened to the sternpost or may be a "Pintle and Gudgeon" rudder which refers to a rudder attached to a straight, more or less vertical sternpost, by means of a dismountable hinge. This hinge consists of the “Pintle”, which is usually attached to the rudderstock and has a kind of hinge pin protruding downward, and a “Gudgeon”, which is usually attached to the sternpost, and possesses a socket into which the pintle fits to make a hinge.

Side or “Quarter” Rudder – this is the most common method of Rudder attachment in the earlier period, but was quickly phased out in the North Atlantic, in favor of the Sternpost rudder. Reasons for that phase out will be discussed later. In this construction the rudder is attached to the right rear side, or (in Mediterranean ships) to both rear sides. Roman ships were equipped with steering gear of the quarter rudder design, and ships possessing two quarter-rudders were kept in the more temperate Mediterranean Sea much longer than in the stormy waters of the north. These rudders ultimately became a quite sophisticated, and were clearly hydrofoil in cross-section.

Figure 5: Single Quarter Rudder (after the “Viking”style)

Masts and Rigging:

Single-masted – this is a ship that is possessed of but a single mast, usually in the exact center of the ship.

Multi masted – More than one mast is used.

“Fore and Aft” sails – these are sails that are designed to operate primarily in parallel with the ships keel. Such sails might be Lateen or the Spritsail (Both known from antiquity, the Lateen being from North Africa/Egypt, and the Spritsail common in small fishing boats along the Italian coasts of the Roman Empire). Another type of fore and aft sail is the “Lug” Sail which is a very late period development, apparently introduced by the Dutch sometime after 1580. The more common fore and aft sails of modern sailboats, such as the Gaff, or the “Marconi” rig are developments that occurred well after period.

“Square set” sails – these are sails that are designed operate primarily at a right angle to the Keel. This is by far the most common type of sail that you see on large ships.

Examples of rigging types:

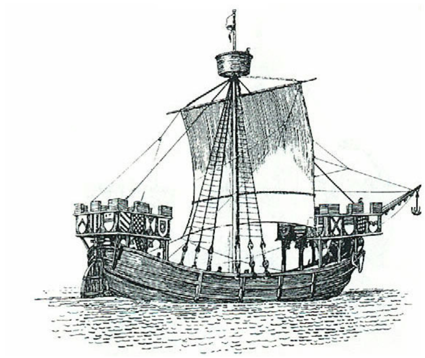


Figure 6: Square Set, Single Masted

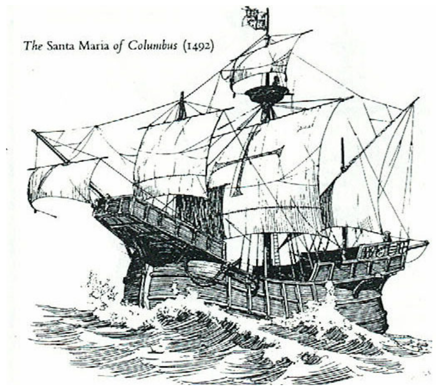


Figure 7: Square Set, Multi-Masted

Figure 8: Sprit Rig, Single Masted - "Fore and Aft"

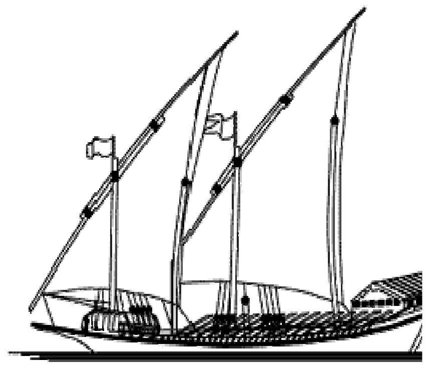


Figure 9: Lateen Rig, Multi Masted - "Fore and Aft"

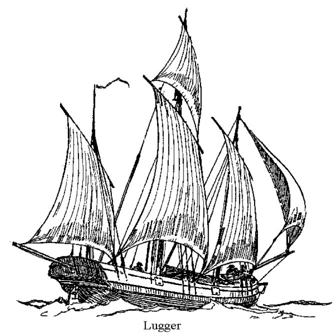


Figure 10: Lug Rig, Multi Masted -"Fore and Aft"

Timeline of ships development:

This "Timeline" is designed as a broad overview and several generalizations are mad... as with any generalizations there may be differences with respect to particular ships, especially during certain periods where there was substantial experimentation in ships design, such as the period shortly following the institution of the Portuguese School for navigation, under Prince Henry "the Navigator". It is an interesting observation to note how the development of ships followed a "punctuated equilibrium" model of evolution, where design remained conservative and in a steady state for long centuries, and change mostly occurred in brief spurts that re-wrote all the expectations and rules. Consequently, this timeline may present the image that the progress of ships development was fairly steady, when in fact it was driven by technical and market forces that were anything but constant.

600

The Mediterranean Sea:

Ship design had hardly changed from the Roman period, although much smaller in scale. The basic design was to use a round-ended ship of a carvel design (although at this stage the planks were usually laid up abutting each other with mortises free floating tenons pegged in to keep the planks aligned). Futtock[1] beams and frames are beginning to dominate the construction, as the method changes from the Roman style hull construction (where the primary structural strength of the hull came from the use of thick planks set with mortise and tenon joints, as mentioned above), to one where the planks are thinner and the skeleton of the ship is the dominant source of strength. At this time though, the roman method is used below the waterline. Two quarter-rudders are attached, and they are used alternately, lifting the one that is on the windward side. The rudders are attached in the Roman fashion, to beams that go across the ship. They are merely lashed to the beams, and are designed to displace and float most of their weight, drying out on the opposite tack. The rudders are at this point very much like roman rudders, flat boards set into a rudderstock. The Sail plans are generally Lateen, though some Square sets are to be seen. Spritsails are only seen on very small ships and fishing ships. Ships used in

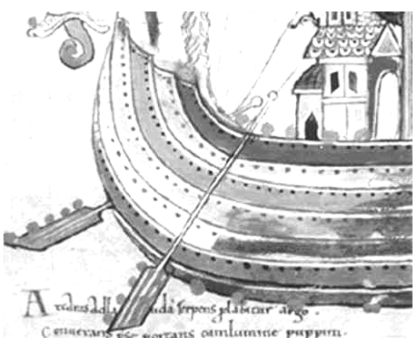


Figure 11: Early Medieval Quarter rudders

[1] Futtock beams are a one of the several "Ships Timbers" that make up the framing or "ribs" of a ship:

- Floor Timbers – beams that lay flat across the bottom of the ship and reinforced the bottom
- Futtock Beams – beams that reinforce the curve from the horizontal floor to the vertical frames (futtock comes from the Anglo Saxon "Foet-Hoke" or "foot hook"
- Frames – vertical beams that reinforce the sides

war are galleys of the Roman design, though generally possessing but a single bank of oars to a side. The galleys also possess doubled quarter-rudders. Ships of this type were the war engines of the Byzantines and often bore the classification *Galea* from which we derive the term Galley. Some of the larger versions are "double banked" (like the old Roman Bireme) with not less than 25 oars to a bank, making 100 oars in all, these were called *Dromon* (racer). At this time the *Dromon* type ships still possessed an offensive ram at the waterline, indicating that the primary method of sea warfare was the of the "ram 'em and sink 'em" variety. To this warfare was added the newly developed weapon of Greek fire, which was blown out by means of great bellows through tubes built into the stem of the galley. Greek Fire was probably a mixture of naptha, sulphur and saltpeter, and it had the disturbing tendency to float on the surface of the water and continue burning, making it a great hazard to wooden (and very flammable) ships. This was invented by a Syrian engineer named Callinias and its use enabled the Byzantines to defeat an armada of Islamic ships in 672, thoroughly spooking them with "fire raining down from heaven". By this time all the most common elements of rigging were in existence, Ships of this time used parrels, lifts, halyards, braces, sheets, brails, forestays, backstays, blocks, pulleys and most of the other items of standing and running rigging which would be expected on any sailing vessel with the exception of "rattling" on the shrouds. As there was often a rope ladder fixed to the mast, this was not a problem for the Mediterranean sailors. It took 500-600 years for this simple expedient to be adopted in the North Atlantic.

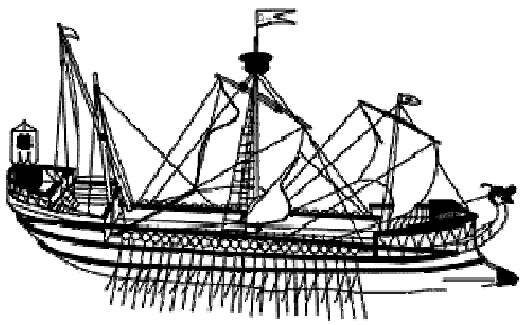


Figure 12: Dromon with waterline ram

The Masts were often composite (made up from between seven and nineteen other spars shaped and lashed together), and permanently stepped in place, usually with a coin placed at the bottom of the mast, in the step, for good luck (this tradition survives even to this day).

The Atlantic:

In the North Atlantic, the Age of the Clinker Ship was just beginning.

At this time we are beginning to see a change from the early fashion of strake-built hulls to a new method, one that is more characteristic of the "high Viking" age. Instead of the frames being made to only roughly replicate the inside contour of the hull and which are then lashed to cleats left in the inside surfaces of the planks. The new method cuts and notches the frames exactly to the shape of the hull, and the planks are then pegged (tree-nailed) directly to the frames. Not having to carve out the cleats probably made a considerable savings in wood and time, as the planks are being split from the trunks of straight oak trees, and to make the cleats the splits had to be thicker so that the area that is not the cleat can be cut away with an adze.

Even so, it is clear that the boat building community was as conservative then as it is

Figure 13: the Kvalsund ship (Reconstruction)

today, and the lashing of frame to plank cleats remained in occasional use for at least 200 more years in Round ships, and for 600 more years in the Long Ships. The reason for this is puzzling but this method was probably used because these very long narrow ships needed the flexibility inherent in the method to ride out the long ocean swells without cracking. Sometimes you will see the use of the lashed cleat method below the waterline, and treenails used above it. The Kvalslund ship is an example of this "hybrid" method. At this time, some hulls were still made by stitching the planks together with rawhide or withies, well greased or pitched, although the use of iron rivets was quite common.
The only way up to the top of the mast was to shinny up the backstay, hanging upside down. Fortunately, since the mast lacked a mast top (what is often called a "crow's nest") and the single sail could be unfurled while lowered, and the yard raised in that condition without fear of fouling any other lines, that was not a problem that needed solving. The mast steps were primitive sockets affixed to the top of the keel, and were made to take down the mast as the situation warranted.
Strakes numbered generally between 5 and 9 per side, and were often quite broad.

The topmost strake was further reinforced with heavy plank, very much like a gunwale (although that term did not come into use until the 14th century when the use of gunpowder weaponry attached to or lain on the heavy reinforcing wale became common).

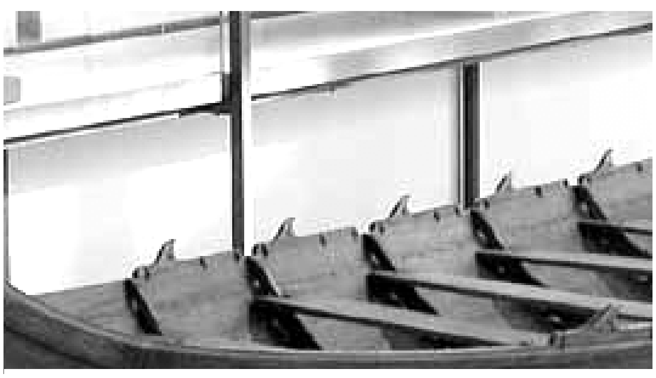


Figure 14: Detail of Kvalsund ship reconstruction… Sheer (top) strake and "crook" tholes.

They may have been laminated or scarfed together horizontally, rather than vertically[2], and the assembly pinned together with iron spikes. The Sutton Hoo Ship is assumed to have had such a gunwale. The "gunwale" supported tholes made from the crooks of tree branches generally spaced about three feet apart, although rawhide loops are not uncommon. Rowers sat on thwart benches, which rested on top of the frames, and were attached to them by

[2] Scarfing is the term used in boat building for extending a piece of wood that is too short by attaching another piece of wood to it by overlapping the pieces with matching tapered surfaces so that the overlap does not add thickness to the finished stock.
A "vertical" scarf is one in which the taper is cut so that the pieces are overlapping side by side in the final position, and a "horizontal" scarf is one where the final pieces are overlapping one atop the other. A horizontal scarf in a side plank as mentioned here is quite unusual as the plank itself is vertically oriented.

lashings. Sails were not common at this time.

Steering is accomplished in the early part of the era by means of a special steering oar lashed to the right rear quarter of the ship. By the year 800, this had evolved into a steering board very much like the one that one sees in the traditional Viking ships (See **Figure 5**, above), with a boss attached to the hull to hold the rudder in a vertical line with the top strake, and lashed at two points, to a special thole point in the gunwale, and a withy run through the boss through a hole in the center of the steering board, and fastened tightly inboard.

The frame at the rudder point is also strongly reinforced, for obvious reasons. Decks and deck beams also make their appearance, and the beams frequently project through the hull. Ornamental figureheads carved into the stem posts of war ships for psychological effect also made its debut at this time. The longest ships were called *Drakkars*, from *Drage* meaning Dragon and *Kar* meaning ship. Smaller ships were known as *Snekkars* from *Snag* meaning Serpent and *Kar* meaning ship.

800

The Mediterranean Sea:

At this time there may be seen three varieties of *Dromon*. The first is the *Ousiako*, which takes its name from an *Ousia* or a company of one hundred men. This is a two banked galley where the lower rank stays at the oars, but the upper rank can disengage and fight. Next is the *Pamphylos*, slightly larger, with a crew of between 120-160. and finally the *Dromon* proper, which had a crew of two hundred, fifty on the lower bank, and one hundred on the upper bank in two files, together with fifty marines. This was an impressive engine of warfare. *Dromons* were still fitted with rams, but the main method of naval warfare was transitioning into missile hurling with catapults, together with Greek fire. Merchant ships remained much the same as they had since Rome fell, basically single masted tubs with double quarter-rudders.

Competing with the Ossifying Byzantine Empire now are the rather lively Islamic states, and ships are increasingly traveling great distances. The basic ship of Islam is the *dhow*, which is characterized in the Mediterranean by double rudders, lateens sails and stitched together hull construction. In the dhow construction, the planks are placed edge to edge, and held together with twine, usually well greased or waxed, instead of being riveted or otherwise fastened. They are, however, fastened with iron or tree nails to the stem post and the sternpost, and to frames. This is not to say that the Mediterranean Arab states are not above adopting the Byzantine type galley for war purposes.

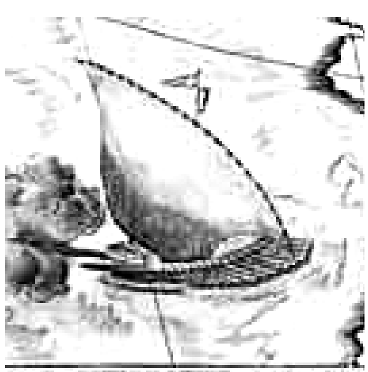


Figure 15: Dhow (16th c)

The Muslims begin their conquest of the Mediterranean with the taking of Sicily in 909.

The Atlantic:

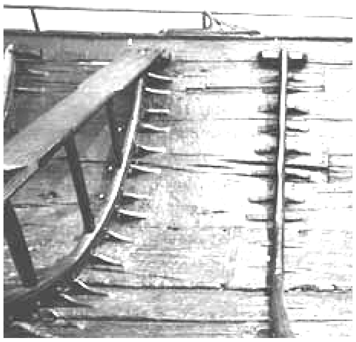


Figure 16: Nydam boat, Framing and thwart bench

We are beginning to see the evolution of the classic Viking ship. Now the sides are higher, and thole ports are cut into the top strake, though which the oars are passed while rowing. There are more framing elements than before including several innovations to the keel, allowing the use of stronger, straighter timbers. There is also now a primitive keelson, which is a reinforced socket for the mast, attached to the keel, and extending for at least 4 ribs, which spreads the downward stress of the mast and rigging over a wider area of the keel, reducing the likelihood of keel failure. For the first time we see racks placed along the gunwale to hang shields. The deck actually rests on thwart timbers which themselves partly rest on a reinforced composite strake, the *Meginhufr*, which is often made out of several pieces of heavy planking pinned together with iron pegs, sometimes showing a sharp turn in planking at this point (visible on the Oseberg and Gokstad ships). In earlier ships these thwarts are themselves used as the rowing benches. This earlier arrangement is clearly visible in the 4th century Nydam ship (Figure 16). Two types of framing members are used, floating frames reinforce the hull, and a heavier, static framing which supports the thwart timbers. The deck planks could be removed at will, as they rested in rabbets cut into the timbers, giving access to the bilge. Several thwart timbers also support the mast partner, although they frequently needed repair, since the construction of the partners was still not strong enough. Soon, however, the addition of a larger, usually fish-shaped, reinforcement to the partners was added, and the classic "Viking" Ship took shape. The space between each thwart constituted a single *Rum* or Room, which was space of a single rower, who usually sat on his personal chest for a bench. An innovation that was added at this time was the *Beitass*, or stretching pole, which fitted into a pocked at the lower corner of the sail to stretch and hold the edge of the sail to allow it to sail somewhat closer to the wind.

Figure 17: Oseberg ship, Deck Planking

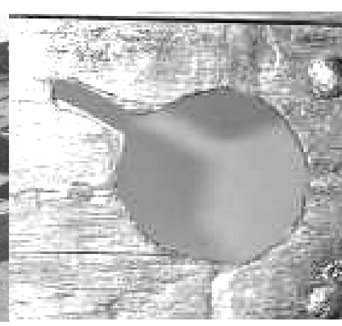


Figure 18: Oseberg ship, Thole Port

Figure 19: Tune ship, Mast Partner

At this time we also see the general adoption of small utility boats called faerings, which had may of the same design elements as the larger ships, in construction and rigging.

A new class of Round ships, which are at first simply wide long ships, begin to be seen in the distant ports. These ships are generally used for the carriage of cargo and livestock. These ships are generally 4:1 beam to length ratio, as opposed to the Long Ships, which were generally of a ratio of 6:1 to as much as 12:1. This will become known as the *Knarr*.

Of note here, as well, is an unusual ship which appeared around the end of the 8th century, and which is not seen again, in the archaeological record, though some images of its like exist. It is generally thought to be a very poorly made or primitive ship, but its unusual construction bears careful noting. The Utrecht ship was uncovered in 1930, and caused no little comment at the time, though historians have largely ignored it since then, but I believe it to be of some significance. It lacks a typical keel, instead being made on a very wide, thick hollowed oak plank, almost a shallow dugout, and which is curved upwards at both ends like a peapod, or banana. Several planks are attached to frames, which were themselves tree-nailed into the bottom board. There is no stem or sternpost, the planks are themselves led along the narrowing bottom board as it rises well clear of the water at each end. The planks all terminate simultaneously, well above the water. This is one of the earliest examples known of "Hulc" type construction, and it was this type of construction that would come to be the dominant craft type in France and England in the 11-13th centuries.

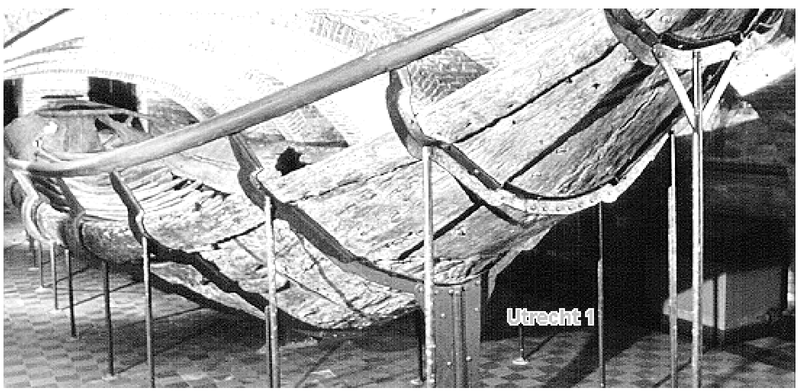


Figure 20: Utrecht 1, Early Hulc 8-9th century

1000

The Mediterranean Sea:

In the Mediterranean not much has changed, except that the Byzantine and Venetian galleys have begun to adopt the Lateen sail. That change will become characteristic of the type for another 600 years. The Mediterranean Arab states now predominantly use the galley for war, and the larger round ships for bulk cargo, though they still use *dhows* for short-range trips and to ply the coastal trade.

The Atlantic:

As the Vikings turn from raiding and increasingly relied on commerce (coincident with the ascendancy of Christianity among the Norsemen), the class of round ships that had been developing in the outer ports becomes predominant, and is generally called the *Knarr* or *Hafskip*. These ships have higher sides, shorter wider bodies, and which are more heavily reinforced across the beam, and heavier framing to which the planks are fastened with treenails, making them much stiffer than the long ships and thus more suitable for sailing journeys across the oceans. A typical example is the Haithabu 3 wreck (reconstructed in Figure 21). These ships have now come to be chiefly relied upon to ferry cargo, and now figures strongly in the classic sagas as the principle craft for long distance exploration. This makes sense, since the Long Ships were hardly good for sailing, being built primarily for rowing with the purpose of river and coastal raiding, whose narrow shape left little room for the kind of supplies needed for long trips. It was in the *Knarrs* and their relatives that Leif Ericsson and Bjarni Herjolfson traveled to find the new world, despite hundreds of years of poorly informed artwork showing such men bravely stepping forth onto Newfoundland from shield-adorned *Drakkars* with oars dipping in the lapping surf. A long *Drakkar* of twenty or more *rums* carrying a crew of 50 – 100 men could hardly have carried enough water and food to allow them to sail about for more than a few days. While references to the *Knarr* and *Hafskip* abound in the Icelandic Sagas, there are vanishingly few of them represented in contemporary iconography. This is hardly surprising, since *knarrs* were the instruments of that most mundane activity, business. This is the same reason that, even though most Roman and Greek shipping took place aboard round ships, nearly every classical depiction of a ship shows a Roman or Greek war galley. This is doubtless due to the same factors that populate modern history courses with battles and dates of momentous happenings. They are simply more attention getting. Anyone looking at a modern history book might well conclude that human history consists solely of battles each following one after another in a tragic procession, and only great men in extraordinary times of duress or travail. Yet it is no more than common sense to realize that battles are transitory phenomena, and by and large most people live their lives in the common ordinary process of garnering a living.

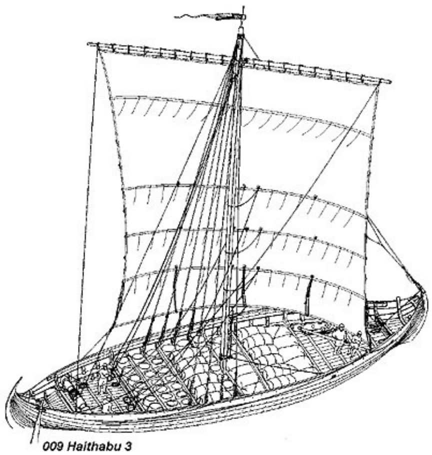


Figure 21: Haithabu 3 - Reconstruction

In an area of the French coast that was settled by Norse raiders and therefore called Normandy, a warlord named William is getting ready to press his claims to the English throne. He has assembled and constructed a large fleet of ships, long and wide, very similar to Viking long ships, though wider and flatter in cross section, and well able to carry livestock. Another difference is that the oar ports cut into the sheer strake for rowing are omitted amidships. These are the ships that

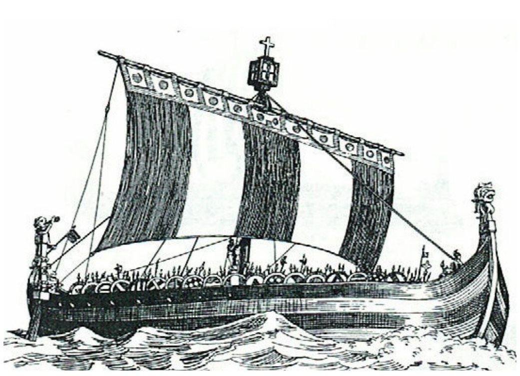


Figure 22: The "Mora" -William the Conqueror's ship, 1066

will carry his cavalry and army in what is undoubtedly the last great invasion of the Viking era. King Harold, who has been awaiting the invasion by drawing the traditional Saxon levy of commoners and nobles, the Fyrd, has been forced to send home most of his peasant army to bring in the harvest. The exiled English count Tostig and Harald Hardrauda, having compacted with William, invade Northumbria with another huge armada, this time of long ships. Harold was forced to march north to repel the invasion. Arriving at Pevensey in Sussex, William orders some ships symbolically burnt, the rest are dismantled and used to make fortifications for the landing site. William begins laying waste to the countryside around Pevensey and Hastings to draw Harold down from the north. After he manages to turn aside Hardraada's forces and kill the Viking king at the battle of Stamford Bridge, Harold was forced to leave a large part of his army in the north to deal with the remnants of the Vikings. Unfortunately, Harold is overwhelmed by the use of mounted cavalry, and taking an arrow in the eye, is killed at the Battle of Hastings. The Norman conquest of England has begun, and it began in ships.

1100

The Mediterranean Sea:

Sometime in between the 10th and 12th centuries the great galleys of the Eastern Mediterranean states have ceased to carry waterline rams. After experimenting with a variety of barbed and hooked rams above the waterline, ships of war now generally carry gangplanks instead. This reflects an important change in naval tactics, one which now prefers to use boarding and overwhelming as the primary method of warfare. Taking a ship becomes a prize. It is generally easier and cheaper to take and repair a ship and impress its crew that someone else built and manned, than it is to make one from scratch, and provision it with crew and victuals. This is, of course, not a new concept. Piracy is, after all, as old as shipping itself. However it marks a major turning point in that organized, state sponsored piracy has now become an important weapon in the shipping arsenal. For this reason, while at this time "Greek Fire" is still widely used in terrestrial siege warfare, its use on the seas begins to wane. There is no sense in risking setting your prize alight, or worse yet, risking becoming entangled with another vessel that is already burning like a torch. This last consideration, along with the effect that the shock of ramming has on standing rigging and spars are very likely the reasons that, for the last 1600 years, warships carried only very simple rigs, which could be taken down or cut away very easily, and it was not uncommon to see galleys with only rudimentary sails, if they carried sails at all.

Ships in the east are now being built in true skeleton fashion, with the prime strength of the hull deriving from the framing, as opposed to the older tradition of partial framing using thick planks joined with mortises and tenons.

The Atlantic:

After the turmoil from the Norman Conquest has settled down, the borders and political climate of Europe see a kind of steady state, and the resultant general peace brings with it a rise in the fortunes of the towns, and with that a renewal of trade. The principle ship of trade remains the *knarr*, now sometimes called the *buss*, though the design can only be scaled up so far. This limitation centers on two variables, the hull construction is thin and the frames are too small to carry the spreading load of really heavy cargoes, and the Viking style side mounted rudder can only become so large before the forces applied by leverage forces it to snap. The central mounting hole in the middle of the rudder, where the withy passes though to the rudder boss mounted on the hole, creates a weak spot, and snapping was common here under high seas. It is already common practice to carry multiple rudders, 2 or 3 of them, on any voyage, as the loss of at least one rudder can be counted on. There is more than one incident where a ships owner sues to be recompensed for a rudder leant out to aid a ship, which has not carried sufficient spare rudders.

This is not to say however that all is peaceful and quiet on the waters around England. Edward I orders a large fleet of galleys built for his invasion of Wales, showing that for war, especially in the narrow inlets and rocky bays of Wales and Cornwall, the galley is by far the preferred weapon.

Figure 23: Seal of the city of Lubeck

About 1143 -1153 the town of Lübeck is founded and the German migration east into the Baltic states begins in earnest, setting the stage for the founding of what would become known as the Hanseatic league. With the founding of Lübeck, a way station was established on the doorstep of the Baltic Sea. Soon thriving trade in bulk goods was established, with Lübeck as its linchpin. Products from the German and Baltic States, such as grain, fur, timber and timber products such as pitch and tar, were soon traveling to England, France and Belgium. English and Belgian woolens, salt, salt fish, and wines began to show up in the Baltic, and even as far as the Russian court.

The Hulc is increasingly seen in manuscript iconography. Known for centuries in the western France and the Low Countries, this is a ship built up from a rockered sort of dugout, to which strakes are fastened, all of which lead to common points at stem and stern instead of being rabbetted into the stempost and sternpost. In fact, this ship type is characterized by three departures from any other form of ship that we have examined so far. First, the hull is utterly without keel, stem or sternposts, looking instead nothing so much like a floating banana. Second, although the hull is lapstrake construction like the Nordic type boats, the planks are laid up in “reverse lap”, which is to say that instead of each plank being fastened outside the one below it, it is instead fastened inside it. This will be seen in iconography as showing the line of rivets fastening the planks together at the upper edge of each plank instead of the lower. Thirdly, the lack of stempost and sternpost at which the planks terminate require all planks to be brought up together at a single boxlike or collar terminus. Originally a craft designed and

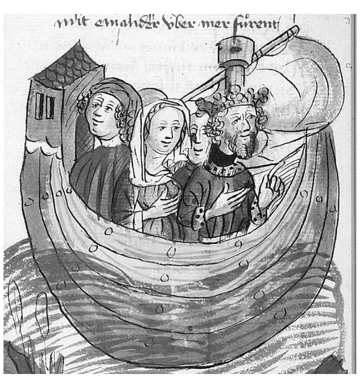


Figure 24: Manuscript depiction of a Hulc

used in the shallow waters and rivers around Belgium and western France, it probably owes its name to the Greek word *holkas*, which means towed boat, and demonstrates its probable origin as a towed river barge. At first Hulcs carried quarter rudders, often hung in the Mediterranean tradition, on each stern quarter, and attached to a crossbeam, but hulcs may have been the first ship to carry the stern mounted rudder. The earliest depiction of a stern rudder is on the Tournai font in the Winchester Cathedral (Figure 25). Owing to the addition of frames, futtocks (these are reinforcing timbers that support the lowest part of the hull as it curves upward), and floor timbers (which lay across the dugout plank or keel and support that area) as reinforcement for the hull shape, the hulk grew past its humbler origins to become a major mode of transport in the Low Countries.

Figure 25: Hulc on the Tournai font at Winchester cathedral

Figure 26: Hulc, showing planking terminus "collars"

In the Germanic countries, bordering the Baltic Sea, and around which the Hanseatic League was to form, the local boat building tradition has generated a hybrid form of *knarr*, the *nef* or *kogge*, which has certain features in common with the Knarr, but has certain features not present in the Viking tradition and probably are indigenous to the region. The name is probably derived from the Flemish word *Kogel* or *Kugel*, meaning “round”. The differences probably result from a hybridization between the Nordic boat building tradition, exemplified in the *knarr*, and the type of flat bottom fishing boat, which had been known from Roman times in the Germany and the Netherlands. Among these differences is flat-bottomed construction with grown crook knees serving as ribs to attach the sides and stem and sternposts as well as reinforcing futtocks, and particularly, cross beams, which pierce the sides and support a deck and hold the sides to shape at and above the waterline. At first this design appears with the Viking style side rudder complete with withy mounting, but soon this ship as well was to carry the stern mounted rudder.

Figure 27: Bremen Cog Replica

Figure 28: Cog on the City Seal of Strasslund (c1329)

Both the cog and the hulc were more capacious and had higher freeboard than the *knarr*, which they came to replace. Although these ships were probably much poorer sailers than the *knarr*, less handy and much less maneuverable, the additional carrying capacity was obviously a greater consideration. Considering the growing importance of trade to the affairs of towns, this is hardly surprising.

The *knarr* style construction also evolved into a particular variety of ship, becoming in the process a more or less coastal and river carrier of bulk goods. Small to medium sized ships of this type were frequently the intermediaries between the ports and the inland towns. These were generally known as "keels". This term term, was also used as a measure of trade carried in such ships. Keels were simple double ended, clinker build craft, and ships of this type were towed, rowed, poled and sailed up and down the rivers all along the English coast. This form of river transport was not to change much for the duration of the rest of period.

Figure 29: Keel on the city seal of Winchelsea

Figure 30: Keel on the city seal of Dover

I shall now offer a brief word about the stern-mounted rudder, which as mentioned above, makes its first appearance about this time in the North Atlantic. The use of the stern rudder allowed ships to grow much larger than was possible in the *knarr*, as the Viking

style rudder cannot be scaled up much larger than the single deck. The sideways force necessarily applied to a rudder to effect a turn is increased at the fulcrum as the distance to the attachment point (the fulcrum) of the rudder increased, and the rudder will snap if the length is increased too far, regardless of the material used. Add a rough sea and the sideways impact of waves This inherent limitation of scale necessitated the development of a new technology. The stern rudder was the solution.
It is not a coincidence that the stern rudder developed in the rough waters of the North Atlantic. Mediterranean style rudders can be lifted from the water in a rough sea, and the ship can then run with the storm, or shelter in one of the many protected inlets along the coast if a storm is anticipated. Viking style rudders cannot be easily dismounted at sea, as they are attached through the hull, and this made them much more vulnerable to damage as the scale of construction increased. Scalar differences notwithstanding, the older Northern European "Viking" style of quarter rudder are still inherently flawed. The attachment used to connect the northern side rudder inherently weakens the rudder itself, as the "withy hole" pierces rudder right where it should be at its strongest.

The origin of the stern rudder probably owes much to the development of the metal hinged door. The technology to make the hinge pin and its receptacle, in constructing a forged hinge, are not very different from that needed to make the “Pintle and Gudgeon” rudder hinge. The earliest variants appear on hulks and other round-bottomed ships, and the normally curved sterns of such ships are problematic when you are trying to attach a hinge to it. In that situation you can only attach the rudder at two positions. Add any more and the pins will not lie in a single line, and thus will prevent movement of the rudder plane altogether. This makes each of the two hinge points critical. Any failure and the rudder will simply fall off.

Another disadvantage to the early adoption of the stern rudder is observed in as the water flows past the round bottom of the hull and causes a considerable amount of turbulence, which drastically reduces the efficiency of the rudder. This requires the use of a broad, large and therefore very heavy rudder blade. Adding the heavy broad rudder, which is very susceptible to wave action from the side, to the use of only two attachment points, and you have a recipe for frequent and devastating failure. This explains the fact that the side rudder remained in regular service for another two hundred years, and even longer in the Mediterranean, where rounded stern boats remained in the boat building tradition right up until the end of period.

1200

The Mediterranean:

In the Mediterranean, along the southern French coast and around the coasts of Italy and into the Adriatic, the use of the double rudder has begun to achieve a level of sophistication that dances on the borderline between art and science. The typical rudder is now more of a foil shape, and achieves it purpose not just by diverting the water stream and thereby being made to cut over to the side by the water pressure, but actually acts to pull the rudder by means of what is now the same Bernoulli effect that makes airplanes fly. In addition new experiments with mountings are seen, collared and box mounts that the actual rudderstock passes though, and even some cases where the rudder passes out through a hole in the side. Earlier ships have the quarter rudders mounted by rope lashing to cross beams in the Roman fashion. Often the rudders carry a ring of metal or leather at the point there they pass though their mountings, as a protection against wear. The overall shape of the quarter rudder has now bifurcated in its evolution from the old roman style of a bladed paddle on a stick, to two basic shapes, one that resembles an oar, where the blade is long and protrudes deeply into the water, and a wider, crescent shape often with a shoe-like forward projection below the waterline. It is this latter kind of rudder that some iconography of St Phocas depicts (It is not unusual that a martyred gardener should come to be adopted as a saint for sailors, considering that he was purported to be a shipbuilder before he joined the clergy).

War galleys tend to use the crescent shaped rudders, and the larger round ships use the oar type. Sometimes forward steering oars are also used, so that sometimes it looks like there are four steering oars altogether, but generally they are seen only in port scenes, and were likely used for "backing out" of dock in tight ports. The single sail, the double ended round ship design, and the use of quarter rudders made rigging it "backward" feasible, and this would have been a logical approach and makes sense with the use of front rudders in such a design. It made it possible to sail out away from or to a position, instead of turning her around in tight spaces, until you are clear of other traffic and can come about, for better sailing, using the permanently mounted rudders. Despite these changes in design, in operation the rudders are still raised on the windward side of the ship. They are now also generally encased in protective cages or other framing, especially in war galleys, which suggests that a common tactic prior to boarding was to attempt to disable or carry away the opponent's rudder.

The Atlantic

The cog is now beginning to replace the knarr for trade purposes for reasons mentioned above, and increasingly the knarr is seen as the ship of small time operators and fishermen. In that capacity it survived a very long time. Adding to the utility of the cog is the adoption of a false keel to reinforce the flat bottom, as well as the addition of straight sternposts to which the sternpost rudder is now securely mounted. Unfortunately, the rounded stern of the ship has not been addressed and the rudder remains in a heavy wash of turbulence, so rudders still have to be made large and heavy, making them vulnerable to wave action. A false straight sternpost is also added to the hulk, allowing it to use a proper PG ("Pintle and Gudgeon") rudder as well. Both the hulk and the cog are becoming larger.

Figure 31: Hybrid Cog/Hulc on the city seal of Danzig, c1350

The Hanse traders are now active in England, France, the Baltic countries, Russia, Scandinavia (where they have effectively evicted the Swedes from Gotland to make a trading base there), the Netherlands, Belgium, and even, according to some reports, as far away as Genoa in Italy. They have effectively eclipsed the Vikings as the pre-eminent traders of Europe. There is one fly in the ointment of the Hanseatic League, however. The Low Countries around Flanders are rapidly becoming the preeminent textile manufacturing center in all of Western Europe, importing huge quantities of raw wool from England and Spain, and making them into finished cloth. Despite numerous trade agreements giving the Hansë monopolies of carriage on such goods (which the Hansë jealously guarded and maintained as late as the 17th century), hulks filled with raw and unfinished wool are beginning to show up in England and all along the Channel coasts of Spain and France.

The boundaries between the cog and the hulk design are not firmly delineated, however, and several hybrid ships are seen, with the fronts ends of the strake running like a hulk to a common point above the waterline, and the back ends more like a cog in construction with the planks being let into a true sternpost with a rabbet.

At this time reefing points, which had been experimented with in Viking ships (and which reefed the loose foot of the sail, unlike modern reefing points which reef to a spar) are no longer in general usage in large ships (though they remain fairly common in small boats), and the chief method of shortening sail is achieved through the use of "bonnets", which are removable strips of fabric, used to enlarge sail area in lighter winds, and removed to shorten sail. One bonnet is usual, though in latter years it is not unusual to see three on a sail. Why reefing points are lost remains something of a mystery, but perhaps it is more due to the fact that the there was no easy way to get aloft to where you could tie up the points (the loose footed sail used by the northern ships meant that they could not be effectively tied off from below). In order to go up, you had to shinny up the backstay (the Jacobs ladder had not yet been imported from the Mediterranean ships, and the ratline was centuries away). Therefore a way of shortening sail the meant only lowering the yard part way and simply removing the bonnet was an advantage under sail, in the changeable conditions of the North Atlantic weather.

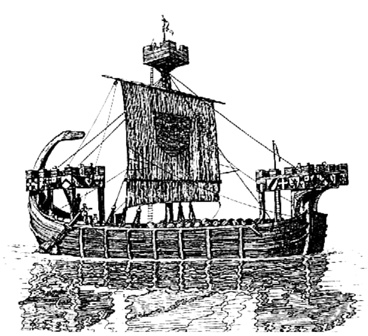


Figure 32: English ship of the 13th Century with "fighting top" and "castles"

It is at this time that we see a bit of a change in naval tactics, and a new element is added to the galley for war. The increasing size of the cogs and hulks of the period have made them attractive vessels for troop transport, and for the first time we see the adoption of Castles on board these vessels. Originally these are merely temporary structures, hastily fortified firing platforms raised at the stern and forward ends and also at the masttop, but soon the Castle became as much a part of a ships construction as the deck. This reflected the adoption of a kind of ocean going siege warfare, where the castellated ships are maneuvered together and soldiers are massed on deck to invade the castles, exactly as they would do on land. This will be the primary naval combat strategy until almost 1600 when advances in gun foundry at last allowed the use of naval cannon to be used for anything beyond a diffident shore bombardment, and as a deck clearing tactic immediately before boarding.

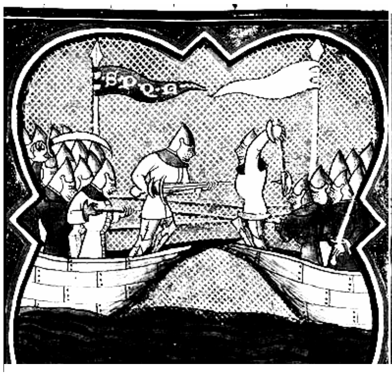


Figure 33: Warfare at sea, armored fighters

Figure 34: Warfare at sea, note the armored fighter falling into the sea

1300

The Mediterranean

We now see evidence for multi-masted ships, though this usually consists of a second mast added in front of the main mast and raked steeply forward, but a true second mast in its own mast step, carrying a full lateen sail is not unknown at this time. By the end of the 14ht century three masts are to be found in very large round ships. The increasing contact with the northern merchant ships, such as the Hanseatic cog, has resulted in some new strategies being adopted. The lateen sail has proven very difficult to scale up to the sizes needed by the larger merchant ships, so the square sail rig has been adopted for large ships. Scalar problems have also prompted the adoption of the stern rudder, though its failure rate, due to the general rounded shape preferred by the Mediterranean shipwrights, is such that the stern rudder is seen as an option, which is added to the preferred doubled quarter rudder, resulting in many ships having three total rudders. Even after the adoption of the straight sternpost and a proper attachment of hinges, the three-rudder format was retained for more than a century.

The Atlantic:

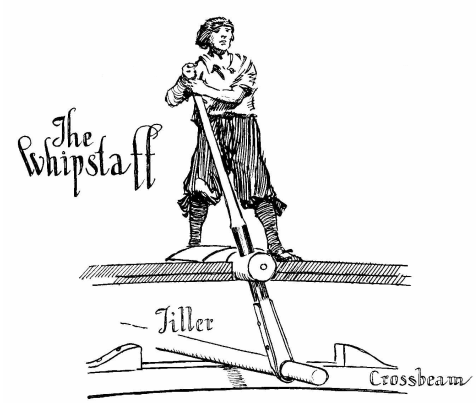


Figure 35: Whipstaff and Tiller

At the start of the 1300's the three basic ship types, the knarr (or buss), the cog and the hulk are distinct, and the differences were easy to classify.

The addition of a second full deck in the larger ships occurred in the first part of this century, and necessitated some changes to other aspects of the overall design. One was a means of steering when the tiller was itself tucked below a deck or inside the stern castle.

This was achieved by attaching a pivoted lever to the tiller arm, and running that lever up through the deck above. This was called the whipstave, or whipstaff, and it was the principle steering control used through to the end of the period. The "Ships Wheel", a kind of windlass attached by means of a rope and pulleys to the tiller, was not invented until nearly 1650.

Another change was the adoption of the vertical Capstan for the main hauling.
In a single decked or open boat, the anchor and docking lines may be attached to a simple windlass, a horizontally mounted drum around which one winds a line. Using levers attached to or inserted into the windlass one can raise heavy sails, and anchors, and “walk up on” dock lines from the low deck, usually through a hawsehole or fairlead set at deck level. The use of the horizontal windlass goes back well into antiquity.
The addition of a covering deck, and heavier ships anchors and lines, and the reduced headroom in the lower deck made a different winching mechanism necessary, the capstan served the purpose adequately. The capstan was a winch that passed through the top deck and whose body sat on a bearing surface on the lower deck. The line, or usually a messenger line (a smaller, easier to control line that is attached to the anchor line, and transfers the pull to the anchor line) is wound two or three times around the body of the winch, and as the winch is turned by the men at the capstan bars in the top deck, the line is wound up on the body, and at the same time the section that had been wound on is “tailed” off the winch. They addition of covering decks also changed the process pumping the bilges clear of water. In Viking ships, this was accomplished with wooden buckets and square wooden bailers, but the permanent decks of latter periods made that method highly impractical. A variety of pumps, including primitive chain pumps using sponges or rags, were used in the larger ships, the most common being the “spear” pump, which has a simple padded dasher that one pushes into the pump tube and pulls up again and again, lifting water past the single valve in the pump’s foot. The adoption of levers or other mechanisms for operating the spear were not to be seen for a long time. Manning he pumps must have been backbreaking tedious work. Along the same line, we see the addition of certain kinds of sanitary accommodation on ships, such as pissdales leading to the scuppers, and the first signs of garderobes mounted in the castle superstructures. With the adoption of the Bowsprit and beakhead, the natural place to go would be at the beakhead, as the wind would carry any smell away from the ship, and seats of ease were added here as well, though they are originally just keyhole shaped holes covering a boxlike affair that opens out to the sea below. Before the addition of these niceties, the most common place to eliminate was over the side, usually standing or squatting out and hanging on to the shrouds at the sides. (In the Mediterranean galleys, the place for elimination had been to go forward and squat out at the waterline ram at the bow… even after the ram had become largely obsolete, a step or seat was retained here as well for the same purpose.)

By the end of the period, some cogs had adopted the skeleton first/carvel construction of the Mediterranean tradition. The Cog was a design well suited to skeleton construction, depending as it did on heavy shaped timbers for strength and shape.

The basic design of large ships tended, in fact, to have incorporated design elements of all three ships, heavily reinforced clinker construction, square set sails, flat or shallow bottoms, stern mounted rudders, and whipstaves.

For the first time we see, on the City seal of Danzig, cut in 1350, the adoption of the Jacobs ladder, a separate rope ladder from the deck to masttop, which is also an import from the Mediterranean shipbuilding tradition. These ladders were necessary with the general adoption of the “fighting top” as a place to set bowmen in ship combat. Otherwise the only way to access the masttop was to shinny up the backstay, as you can see in the city seal of Winchelsea. "Ratlines" in the mast shrouds would not appear for another 150 years or so.

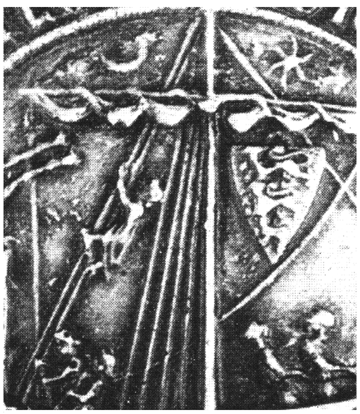


Figure 36: Ways to "Go aloft," using the backstay

Figure 37: Ways to "Go aloft," the Jacob's Ladder

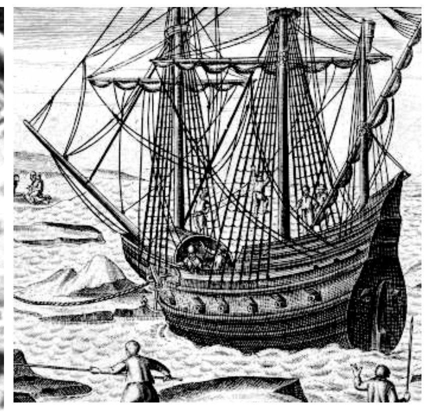


Figure 38: Ways to "Go aloft", Ratlines on the shrouds

This century is chiefly notable for the widespread adoption of the large ship as a weapon of war, as opposed to the smaller galley. This was doubtless due to the rougher waters and higher seas of the North Atlantic, for the Galley remained in general use as a Mediterranean ship of war through the end of period. Proof of this conjecture will be demonstrated when I discuss the 1588 Spanish Armada campaign, later in this document.

The Cog achieved its highest form in the mid 1300’s when the power of the Hanse was at its peak. There are accounts of Cogs being built with three decks, and boasting as much as 1500 tonnes in size. To build to that size, the cog had been adapted from its original design parameters and now boasted a combination of carvel construction above the waterline, and its original lapstrake construction below. Gone is the original flat bottom, replaced by a heavy keel, and wide garboards. Though it still lacks true skeleton framing, it nonetheless boasts heavy reinforcement with grown timbers, frames, futtocks, floor timbers, carlins, deck beams, and an assortment of wales. Adorned with castles and a fighting top for defense, and cannons for offense, the Hanseatic cog became the most powerful warship in the seas of the middle 1300’s. But this supremacy was not to last out the century. Another ship was to challenge the Hanse for supremacy.

As the center of trade shifted in the latter half of the 1300's, away from the North Sea trade of the Hanse towns of Germany like Lubeck and Danzig, and toward the Netherlands as a result of the rise of the wool towns around Flanders. As a result more and more cargo was being shipped to and from these towns, and it tended to go in the native ships of the area, the Hulks. Just as the Cogs grew large and were appointed for war so too were hulks similarly enhanced for military purposes. Building up the relatively ad hoc construction of the Hulk to the size and strength needed to serve as a mass carrier and military platform, was not a simple task. Since it has no keel, per se, and the plank ends terminate in together at a single termination point, it has no true stem and sternposts, and must be reinforced with an extraordinary assemblage of timbers, such as false keel and stem and sternposts, aprons, breasthooks, futtocks, and other similar reinforcing members. But this growth, like that of the rival cog, was limited by the physics of clinker construction. There is only so much strength you can build into a hull without a proper skeleton, before the stresses from waves and hogging rip the hull apart (Hogging is the tendency of the ends to sink around the center of buoyancy -- no doubt this tendency was greatly accelerated by the weight of the castles built up on the end). And the sailing characteristics of these enlarged single masted single sailed ships were exceedingly poor, and they could not be improved without some new ideas.

1400

At the beginning of the century, the differing northern and southern trends in boat building more or less merged, partly because of the increased trading contacts between the Mediterranean ports such as Genoa, Venice and Constantinople, and the northern centers of trade like London, Gotland, Danzig, Odense, Bruges and Antwerp, and partly because the black death had so radically altered the geopolitical landscape of Europe (The Black death lead to a "refeudalization" of Europe, and in the process the more-or-less independent city-states of the Hanseatic league were placed under remote central control of their varying kingdoms, limiting their effectiveness). This trend culminated in the development very early in the 15th century with a new class of ships, which served as a base model for all ships to come until the age of steam and steel. This new class of ships was called the carrack, kraek, or nao, and many of the techniques used in the design and construction of the carrack were still in use building the fast frigates of the American Civil War, four hundred years later. By changing the basic cog design to incorporate the true skeleton first construction, carvel planking, and three masted rigging of the Mediterranean round ship (the Nef), and merging those design elements with the cog's straight vertical sternpost, a reinforcing system of wales and futtocks, stern hung rudder, and the cogs defensive system of castles and tops, and you have the basic design for the many ships that were to conquer the world, from the days of

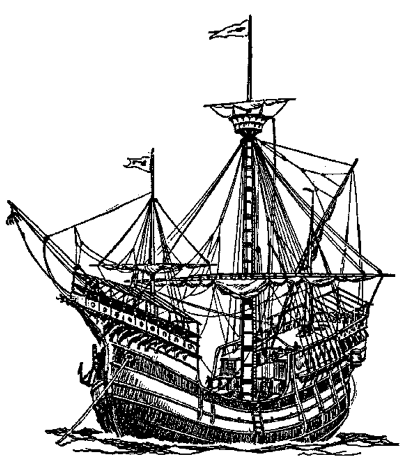


Figure 39: Carrack

Henry the Navigator through to Shackleton's attempt at the south pole. Added at this time was the a high rising stempost, used to anchor a bowsprit, and the incorporation of deadwood between the after hull and the rudder at the stern post, which change nearly eliminated the turbulence caused by the water turning around the hull at the rudder that made the rudder inefficient. This little change made the rudder as much as three or four times as efficient, and rudder size concomitantly decreased, thereby decreasing its susceptibility to damage and increasing the leverage of the tiller, without sacrificing maneuverability. It is not known when the practice of cutting a loading port in the left side of the ship became commonplace, but it certainly was used in the Carrack. The sheer height and size of the great carracks, cogs and hulks made it necessary to have some facilitation for putting a loading port in the ship, as getting heavy cargo all the way up to the weather deck on these ships would have been a logistical nightmare. With this change came a slight change on terminology. The right side of the boat has always been called "starboard", after "Steorboord", the Anglo-Saxon word for the side rudder, mounted on the right side of the ship. But the left had similarly been called "Labboard", after "Ladingboord", which was the gangplank used to access the ship over the rails (the right side was never pulled up to the dock, because of the risk of damage to the rudder). Now the left also became known as the "Port" side. The carrack often retained lapstrake planking above the waterline, as it was cheaper, and that area did not require the strength of the lower hull, as the water did not press on it, except when waves broke on the side, or when the ship heeled far over on a reach. The Ratline ladder (a system of short ropes lashed across the mast shrouds to serve as a ladder) makes a general introduction here as well, a replacement for the older "Jacobs ladder". The defensive castling goes from being merely boxed in platforms tacked on to the stem and stern, and are now fully incorporated into the design of the ship. In some cases the forecastle is significantly higher than the stern, and we see a lateen mizzen, which is used to counteract the windage caused by the high forecastle. The lateen mizzen proved to be a successful innovation as it could be steered to allow the rig to take steering stress off the rudder or augmenting its function, prolonging its lifetime, and the latten mizzen was preserved for a long time. It was possible to operate a ship in heavy weather on just the foresail and the mizzen alone.

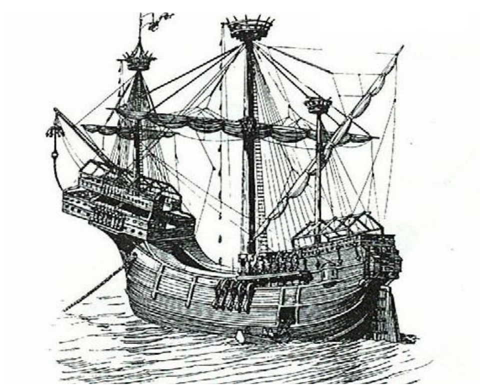


Figure 40: Carrack with open Lading port

Most notably, the cannon appears on board ships at this time, though they lack the naval trucks we are accustomed to, and are lead over the top strake, which is reinforced with a heavy "wale", which is a long timber or heavy plank used to reinforce the hull from the outside. Since this wale was necessary to reinforce the sides so that cannon can be lashed to it, and fire over the wale, it for the first time gains the appellation "gonnewale" or gunwale, which this kind of reinforcement at the sheer is still called today, though it is often pronounced "gunn'l".

The use of cannon also gave rise to the development of the purpose built warship (though these often were also leased out to merchants for their use). In 1415, Henry V had three great warships built for his war: the Jesus (1000 tonnes), the Holigost (760 tonnes), and the Trinity Royal (540 tonnes). He also built a huge ship, the GraceDieu (1400 tonnes), which did not see action, and was eventually moved to a berth at Burlesdon, where she got stuck in the mud and eventually was burnt out. Her remains are there to this day. It is even more remarkable to see the size of these early carracks when you realize that at the time the hull was clinker built. In order to use clinker construction at such a great size these ships were triple skinned, with planks laid up layer upon layer. These ships were probably large armored cogs, and represented the last gasp of the great cog as a primary ship of warfare. The age of the carrack had begun. These early ships carried a few cannon, and may have bombarded Harfleur from the sea during the famous siege of that town, though at such a distance as to be completely ineffective.
At first cannon were placed high in the castles for maximum effect, but it was found that this added too much weight above the waterline and made the ship unstable. The most common place for big cannon on these early ships was therefore on the weather deck, in the waist of the ship, pointed over the gunn'ls. Small guns remained in the castles, and were often used to enfilade the main deck, the castle serving as a keep when boarded, and the gunnery thus directed to punish boarders already on ship.

This is not to say that the old style of ships and constructions simply wink out of existence. They merely cease to be the dominant transport carrier, and they reduce in size, and by the end of the century the cog, the knarr and the nef are all relegated to mostly to fishing and small coastal sailing. This is the century of the carrack, and its smaller cousin the caravel.

In 1419 Henry, the prince of Portugal, founded a school at Sagres, at which he concentrated the best navigators, cartographers, and builders he could find. His purpose in doing this was actually to find the "lost" African Christian kingdom of Prester John. He believed that if he could unite with the storied kingdom, he could smash the Muslim presence in Africa in a pincers movement, and make the continent safe for Christian development and exploitation, and also serve as a staging point for the retaking of the Holy Land. It would have been excellent strategy, except for the fact that it was all a myth. Regardless of the original rationale, the effect of the establishment of the school for navigators at Sagres was long lasting, and earned Henry the nickname "Henry the Navigator". Seeing a need for a more able ship for exploration, as opposed to bulk cargo or army transport, Henry spearheaded the redesign of the nef, using the lessons obtained from the northern carrack, and developed a new boat, eminently suited for long-distance trade and exploration, the Caravel. The smaller caravel carried three or four masts, lateen rigged at first but by the end of the century it also carried a ship type rig, square set on the fore and main, and lateen rigged on the mizzen. This later rig gave the caravel the name "caravela redonda", and was generally considered better suited for deep ocean sailing. With a length to beam ratio of 7:1, more like a long ship, the caravel was a fast, handy sailor. It is these boats, the carrack and the caravel that were to dominate the navies of the day. The carrack served as the principle engine of war and bulk goods transport, and the caravel served as the principle tool of long distance trade and voyages of exploration.

In addition to the caravel, the Portuguese and Spanish also made good use of the Não, a small carrack, specially outfitted for exploration. Columbus' expeditionary force in 1492 consisted of a Não and two caravelas.

Figure 41: Caravel

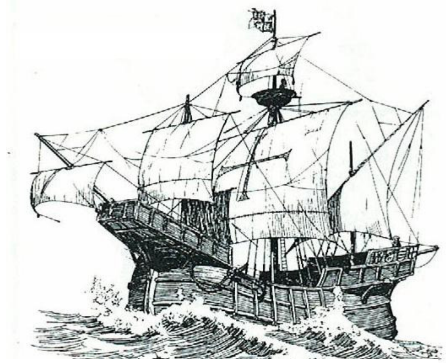


Figure 42: Caravel

1500

With the advance in gunfoundery in the last half of the 15th century, the production of relatively reliable heavy guns was now possible. The range and destructive potential of theses weapons made them extremely attractive to have as shipboard ordinance. These larger guns posed a substantial problem. Where to put them? It was obvious from some notable accidents that the higher the heavy gun is placed above the waterline, the less stable the ship becomes, and the greater the arc of motion through which the gun must travel. These factors made large guns even on the weather deck very difficult to control and use. The solution the came up with, gun ports in the hull, though obvious to us today, was not so obvious then due to several factors. One was the fact that the ship above the waterline was still clinker built, and it was very difficult to cut a port in a clinker hull, near the waterline, that would successfully keep the water out when closed. The second was that a clinker hull depended for its structural integrity on the planks being secure and uninterrupted in their run. Cutting through two or more strakes in the same point would promote failure the first time the ship faced any rough seas. The third was that the heavy framing used to reinforce the lapstrake portions of the hull were not spaced closely enough together such that the ports could depend on them for strength when pressed from outside by wave or the weight of the water outside. Making any intentional hole in the ship that was at or near the waterline was not a process lightly to be undertaken. Clearly the Clinker hull had to go, and it was quickly done away with. With the final hurdles to gunports removed, the heavy guns could be emplaced near the waterline. It was soon discovered that balancing the guns by installing then equally on both sides had a number of beneficial effects, not just militarily, but also in term of ships handling and overall stability. In addition to the ability to answer fire on either tack, and to make aiming easier due to less overall motion of the gunnery platform, such placement also had the beneficial effect of improving the roll characteristics by adding an inertial dampener near the center of roll at the waterline.
Soon entire decks could be dedicated to the application of gunnery, and this at last served to make the final irrevocable distinction between the purpose-built man of war, and the armed merchantman, in which the guns had to share space with the carriage of cargo and

were often relegated to the weather deck. It is largely through the efforts of Henry VIII of England that such an investment in guns and ships came about. Henry was well known for encouraging the manufacture of guns, and frequently imported the best craftsmen for the purpose from France, Belgium, and Germany. Henry was equally fanatic about his ships, as would be proper for any king of an island nation only a few miles by sea from three countries as likely to be at war with him as not.

Even with all the advances in gunnery, the basic strategy of naval combat had not changed much in the preceding century, and it was to remain the same throughout this century, with one notable exception, which shall be addressed later. The basic method of naval combat was still the close and board variety, but the addition of improved gunnery and high castles has changed the format slightly. One of the weaknesses of any boarding tactic is getting within range to grapple and board in the first place. One boat may be a devastating military platform, but if it can't get close to a more maneuverable enemy, that military advantage is nullified. The addition of improved gunnery allowed the long range disabling of an enemy, and no boat can outrun a cannonball. The target of choice was the rigging. Disabling the rigging might stop a boat, but it won't sink it. That way it can be boarded and conquered by marine soldiers as always. The other new factor was the combination of high castles, which served as defensive redoubts, from which a variety of small guns and antipersonnel weapons like murderers, fire-lances, and wildfire, and fused bags of gunpowder could be employed on troops which have successfully boarded. Henry VIII's fleet of great warships consisted of great Carracks, with the High Castles characteristic of the class. The Mary Rose was of this class as well, and her loss in 1545 was due to an inexperienced boat builder overseeing her refit for action against anticipated French war. A mere apprentice, who was put in charge due to the sudden death of the master architect, he succumbed to pressure by the admiralty to put more guns on her, and she was overloaded at the top, when she heeled in a sudden gust of wind. Water poured in the open gun ports, and she went down in the Solent with all hands.

Of course all this acceleration in military technology spread by contact to other countries, as well. Genoese carracks and English carracks of the differed very little, except in the types of guns carried, and the strength of construction (a difference important only when Mediterranean ships ventured into the Atlantic). These ships came to be called "high charged" ships, after the towering castles that adorned such ships.

Merchant ships, however were not spurred on by the same need to mount great ordinance, and so were not impelled to make the same changes to the structure of the ships as the military ships. Most merchant ships, therefore, remained smallish carracks, between 100 to 300 tonnes, throughout the century.

The aforementioned improvements in Naval gunnery had begun to highlight the inefficiency of the carrack as a weapons platform and defensive structure. The high castles were like the proverbial barn door and drew fire easily, and the high top hamper caused a distressing tendency to roll, even with the heavy guns mounted low in the hull.

Adding to these problems, is the fact that the high castles were unfortunately likely to catch the wind and push the ship around, making it difficult to sail in a straight line and hold the ship at a steady angle, which is necessary to long range ship-based gunnery, to be able to repeat shots. The improved long-range cannon had clearly made the Carrack obsolete.

In the Mediterranean the Great galley of war had developed into swift oared barges, sometimes adorned with cannon on the bows (for they were designed to chase down and opponent, not to sail about them), usually bearing three or more masts with lateen sails. Instead of the multiply banked oars of the roman trireme, the 16th century galley was powered by large sweeps often set on outriggers, each one manned by three slaves or pressed convicts. But galleys are open boats, prone to boarding, unable to carry much ordinance, and vulnerable to arrows and gunfire. So naturally an attempt was made to combine the self-propulsive advantages of the Galley with the offensive and defensive capabilities of the large carrack. As the Byzantine Dromon already carried some defensive works in the form of a rudimentary forecastle, the precedent for such a ship was already set. This was to become known as the Galleas, or Galleass. Alas it was to prove not have the advantages of either the carrack or galley, but rather carried many of the disadvantages of both. It could not carry enough sail to sail very well, or enough oars to row very fast. It could not carry very large castles due the long narrow hull's propensity to capsize (a consideration of Boat design of which anyone who has tried to stand in a canoe has been keenly aware). Neither could the Galleass carry a great deal of heavy ordinance, due to the low freeboard, and lack of room on deck because of the rowers. Nonetheless, in the early 1500's the Galleass was the "next wave", and nearly every Navy has at least a few, because until distance gunnery was made reliable, the only thing that could effectively fight a galleass was a galleass. The galleass and the galley proved themselves in the Battles of Lepanto with such stunning success that the Spanish and Holy League forces relied upon them to an extent that was to prove unsound thinking in the attempted invasion of England in 1588, a mere 17 year later.

Figure 43: the Galleass

The second half of the 16th century was one of rapid evolution in ship design. One of the chief design drawbacks of the carrack was the height and complexity of the castling used for defense. Not only did they prove to be a major contributing factor to the poor handling characteristics inherent in the design, but they also were not actually constructed as a part of the ships hull, and therefore tended to hang over the sides. This appended construction also meant that the framing that reinforced the hull sides did not also reinforce the castles, making them concomitantly weaker. This was not the only drawback to the carracks upper works, for they were designed as defensive redoubts and the complicated series of decks could only be accessed from a single small, reinforced door at the weather deck. This makes sense in a castle wall where such doors rarely have to be crossed and climbed, but is a ridiculous impediment to trying to work between the weather deck and castles. This is no doubt the reason that rope bridges were often strung between the top decks of castles as a shortcut path. Another drawback to the handling characteristics of the carrack was its rather stumpy length to beam ratio, which was more suited to the carriage of bulk cargo, than to aggressive sailing maneuvers to bring cannon to bear and defeat an opponent by out sailing and disabling him. The carracks design was basically structured around the capacity to bring a lot of marines to the battle and let then slug it out, exactly as though two land forces managed to bring their castles to the battlefield. In the mid 1500's interchange with the Mediterranean states and their great galleys and galleasses, principally through the alliances of Spain, and Italy, brought about a new design that attempted to address some of the design problems of the carrack. The castles were still there, but the overall ship was lower and leaner, with a lower freeboard, and the castles faired into, and integral to the hull design itself. It was also less round, and a noticeable tumblehome (which is when the hull turns inward somewhat as it rises from the water line) helped make it a better and more stable ship of sail. This design was commonly called Galleon, which may reflect its origin in the Mediterranean as a ship constructed partly upon methods and design principles used in the Galleass.

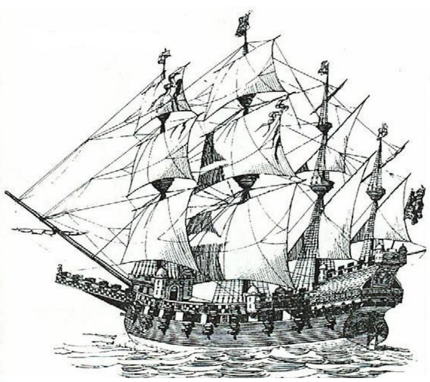


Figure 44: Galleon, English

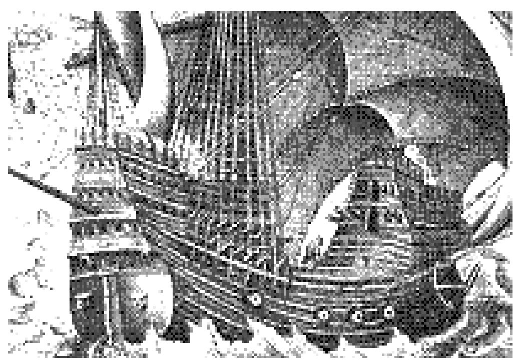


Figure 45: Galleon, Spanish

In England, Sir John Hawkins – still smarting from his defeat at San Juan de Ulua, where he was almost trapped and taken onboard a huge unwieldy carrack called the "Jesus of Lubeck", and which he was forced to abandon in favor of smaller, more maneuverable ship - had since been appointed the Treasurer of the Navy under Queen Elizabeth I, and he used the position to spearhead the improvement of the Queen's aging Navy, at the time mostly large armed merchantmen, and a few large armed carracks and one or two older galleons. Inspired by his long naval experience in carracks, he drove himself with characteristic skill and determination to produce better and abler designs, and the result was the Foresight, a ship that was long and sleek and had most of the forecastle cut away, and the stern castle reduced to long, low "poop" deck. This was not an original idea, the Dutch had got to it twenty years before Hawkins, but their experimentation was piecemeal, and hampered by the Spanish invasion of the Low Countries, which devastated the countryside and depressed the economy. The improvement in handling and operation of the new design was dramatic. The Foresight became the progenitor for the next generation of warships, the "race built" galleon (so called because the Castles were cut away or "razed"). This was the ultimate state of the art, and the design did not much change for almost three hundred years.

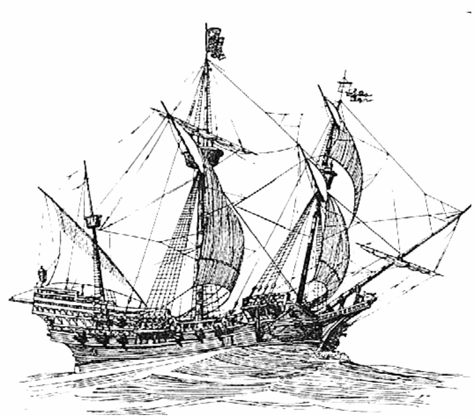


Figure 46: "Race Bult" Galleon

A few notes touching upon Navigation within the SCA period

Once a ship is out of sight of land, the primary concern of any mariner is two-fold. First he needs to know where he is. Second he needs to know how he is to get where he is going. These problems have not changed. Since the days of the ancient Greeks, mapmakers have divided the earth in a system of intersecting lines called latitude and longitude. Figuring latitude is comparatively easy. Latitude is basically the height of the celestial pole above the horizon. You can effectively measure it with a tool no more complicated than three sticks, and the Pythagorean theorem. Using Latitude is even easier. You only need a reference stick for the latitude of the place you want to get to. You simply travel north or south until the pole and the horizon line up on the stick and travel east or west until you get where you want to go. Finding Longitude is much harder, and a reliable method for determining where you are exactly proved insurmountable until a reliable ships chronometer was developed well after period.

How the process of navigation was undertaken in period is an interesting study in contradictions, a combination of astrology and astronomy, of sophisticated mathematics and simple tools, of accurate observation and unfounded assumption. A more detailed discussion, while certainly warranted, is beyond the scope of this paper. The reader shall have to be content with a brief overview.

For the most part the Vikings preferred to sail within sight of land, but long voyages of discovery were not unknown. Some of the greatest sagas describe travel to remote locations such as Ireland, Iceland, Greenland, and even America. The6y accomplished this by using very handy ships, and some clever tricks. It is clears that the Vikings were well aware of the fact that the pole star remains at a constant height as you sail east or west, so the concept of latitude was not unknown, and they often used notches cut into a stick or the mast itself to stand for the observed height of the pole star at various destinations. Although the magnetic compass was relatively unknown in Scandinavia until well after the turn of the 11^{th} century, the Vikings also may have has an interesting device that could be called a sun compass. This is a flat disk with a rod in it, which has a shadow line that delineated the arc of the rod's shadow as it was cast by the sun. It operated as a sort of reverse sundial, you lined the shadow up according to the hour and time of year, and an indicator on the dial pointed roughly north. It is known that the Vikings were competent observers of the heavens, and made latitude tables for the sun and certain stars.

Certainly the compass was well known to the Europeans in the latter period, but its appearance in Europe was not until the 12th century and its use as a navigational may not have been known for another hundred years. Prior to that the directions were determined by using the pole star at night or by seeing the position of the sun in the sky and roughly guessing form the time of day, or by using an astrolabe or other tool to get the point at which the sun reached highest in the sky, at which point it is always due south. Certainly the compass made life a lot easier, and greatly improved accuracy, both of charting and navigation by charts. By the 1500’s the variation of a compass was well documented and it was even thought by some explorers that variation was a gift from God, because it varied evenly with longitude in western Europe, and it was assumed by some that the progression would naturally continue, and thus you could easily determine longitude. Of course, the first time a compass was taken across the Atlantic, this was proven to be a false assumption.

Failing to obtain a reliable method for determining longitude, mariners were accustomed to sailing to a destination’s latitude, and then cruising east or west until they make landfall. This method of deep-water navigation was to be the basic theme of navigation throughout Period. The main task, then, was to measure latitude. This was done in several ways, both during the day and at night. The most direct was to measure the angle of the Pole star above the horizon, which affords the most direct measurement. But one could not only measure at night, for a ship could move north or south considerably during a day, because of winds and currents, even if she were to steer due east or west. So the height of the sun was often taken at noon, when it was highest in the sky, and a table consulted to give you the factor to add or subtract from that angle to obtain the latitude, according to the day of the year you took the measurement on.
There were many tools invented to make these measurements. Perhaps the earliest is the Astrolabe, invented by the ancient Greeks. This is, at its most simple, a protractor, with an indicator you line up with the object being measured, and you read the angle directly off that protractor. Geoffrey Chaucer, of Canterbury tales fame, wrote an early treatise on the use of the Astrolabe, both as a navigational aid and an astronomical tool. Because it had to be kept vertical during measurement, the Astrolabe bodies were frequently heavy, and designed to be hung like a plumb bob while the measurement is taken. This, as you can imagine is very difficult in a pitching, rolling ship. For this reason, measurements were taken on the nearest rock or bit of land. This is common practice in many texts, and many woodcuts of Astrolabe use show the measurement being taken in just such a way, usually with the ship in the background. Measuring the sun is very difficult on the eyes, so the indicator was often fashioned in such a way that the shadows of the indicator (called the alidade) would show when the alidade is lined up correctly without having to look directly at the sun.

Figure 47: Astronomical Astrolabe

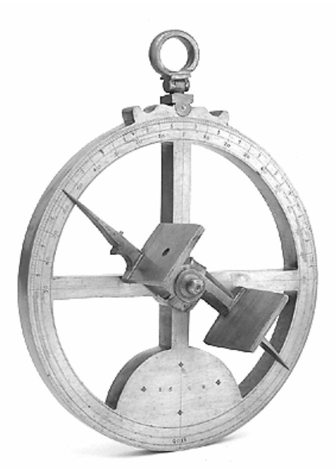


Figure 48: Mariners Astrolabe

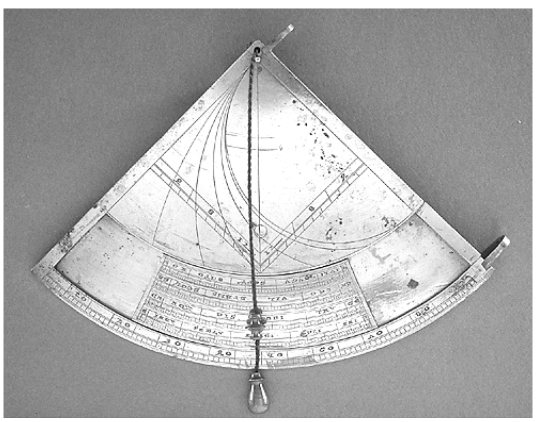


Figure 49: Quadrant

Another tool was the quadrant, which was a partial protractor, of 90 degrees, with a weighted line attached at the vertex of the quadrant. You sighted along one edge to the object being measured, and read the measurement where the weighted string falls. Sighting was often assisted by fashioning a sighting tube along the edge, which could also be used as a shadow indicator, so that, again you don't have to look at the sun. However this tool was also susceptible to both the pitching ship and to wind acting on the string. The Cross staff was developed in the 16th century to address the problem of pitch and roll and windage. Its principle was based on simple trigonometry: If you know the base of a triangle and its height you can find the angle of its vertex. It consisted of a crosspiece of known length that slid along a graduated stick. You put the stick up to your eye and moved the crosspiece until one end was lined up with the horizon and the other end lined up on the object being measured. As the instrument maker usually marked the scale on the stick with the angle measurement in the first place, reading it was simplicity itself. But this meant that there was no shadow method and some mariners got damaged retinas from looking too much into the sun (this is the reason for the ubiquitous Pirate" eye patch, btw). At the end of period, a navigator named John Davis invented the Back Staff, which allowed you to quickly take the height of the sun, but keep your back to it, and this tool with its dual protractor scales and shadow vanes sights was the forerunner of the modern sextant.

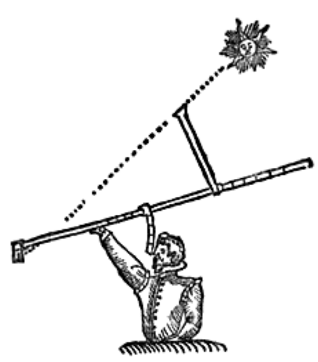


Figure 50: Cross Staff **Figure 51: Early Back Staff**

Another tool for determining the ships position was the chip log, used in "dead reckoning" for finding a ship's speed through water. ("Dead reckoning" is just a term for an educated guess of the ships position according to the ships course and speed) The chip log was a wooden block mounted on a line, which was tossed into the water off the stern and payed out until it was past the wake turbulence, and then allowed to run freely for a measured interval of time (usually 14 seconds on a special sand glass), as knots in the rope slip past the fingers of the operator and are counted. The number of knots payed out in the timed interval give a rough estimate of speed. Then the chip log is reeled back in.

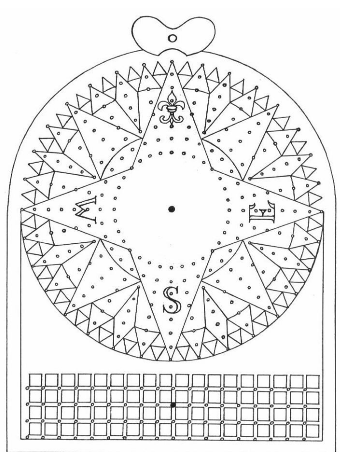


Figure 52: Traverse Board

Course and speed were measured every half hour, and indicated on a special pegboard called a traverse, which was good for the eight measurements of each "watch". Then the readings on the traverse board would be taken by the mate, and given to the navigator for dead reckoning purposes.

One last tool was the Lead and Line, which was a lead weighted rope knotted every six feet (or "fathom"), which was used to get the depth of the water under the boat and by means of a bit if wax or tallow stuck in a hollow on the bottom of the weight, to ascertain the nature of the bottom (whether it was silt, rocky, or sandy, etc.).

A mariner was also keenly aware of the tides, and understood the correlation of the tides and the phase of the moon. Tide tables were maintained and frequently referred to, though they were not the specific guides we have today, but generally gave basic tide and time information for the new moon in various ports. The Mariner was left to work out for himself the time of high tide according to the phase of the moon. Fortunately they also had simple calculators using the 29½ lunar cycle to figure this out.

A simple paper astrolabe and tide calculator follow.

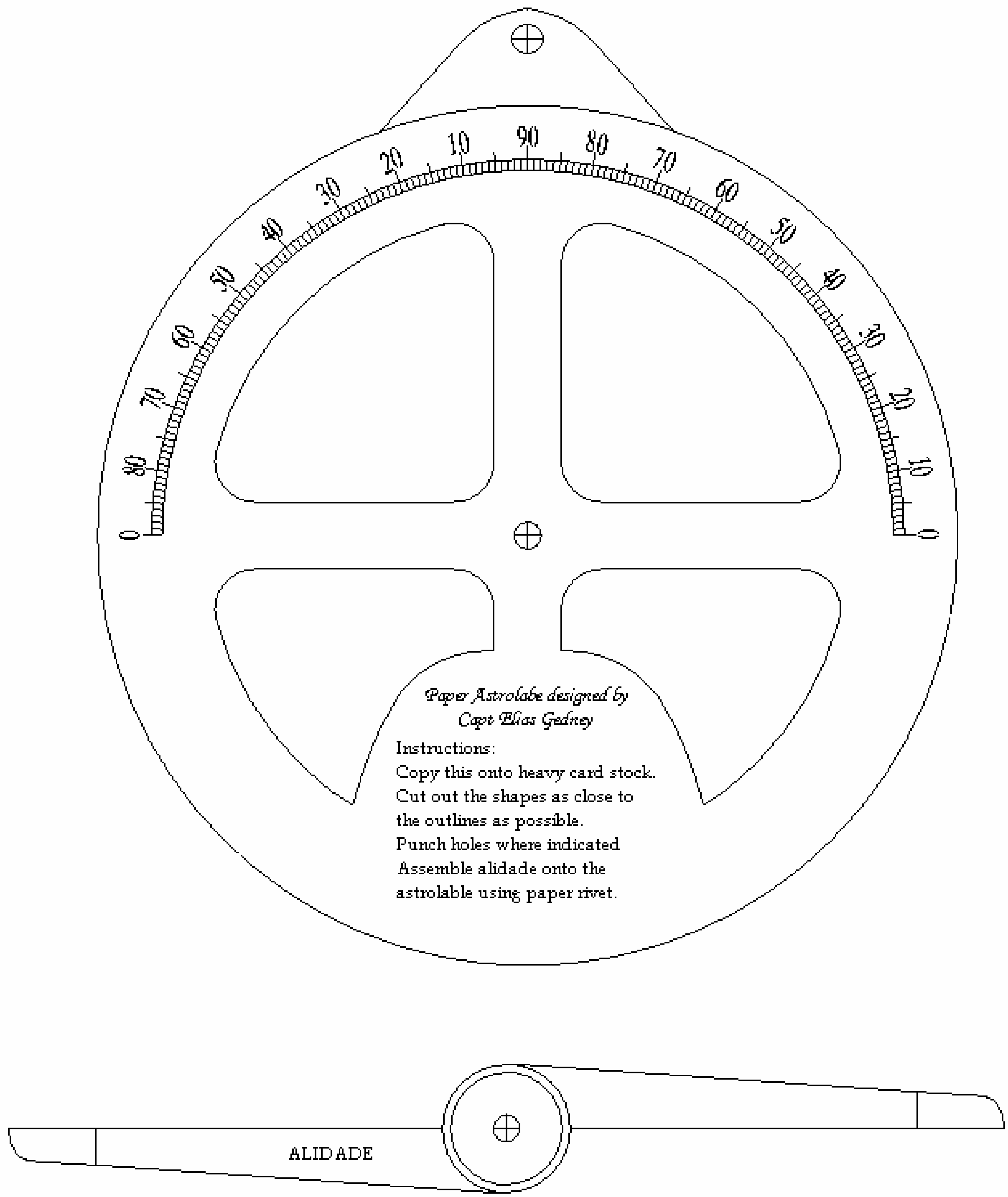
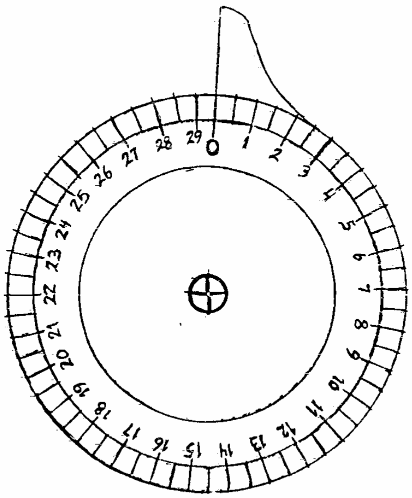
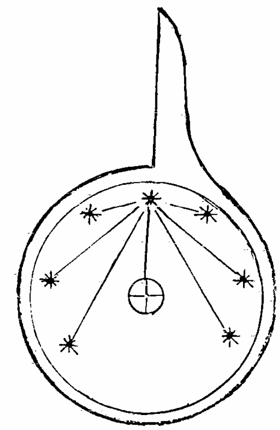


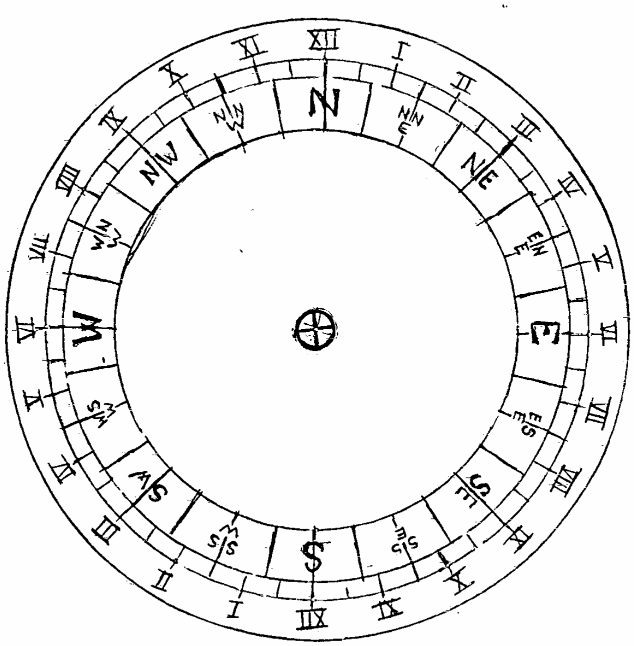
Figure 53: Basic Paper Astrolabe



Intermediate Volvelle



Inner Volvelle



Outer Volvelle

Tide Calculator

A sixteenth-century tide calculator. The outer volvelle is engraved with the hours I-XII, and the seaman's equivalent rhumbs. For example, N. = XII midnight, S = XII noon, E = VI A.M., W = VI P.M., each of the 32 points being equal to three quarters of an hour.

The intermediate volvelle is engraved clockwise from 1 to 29 1/2 for the age of the moon in days. It has a pointer by which it can be set to the "establishment" of any selected port.

The inner volvelle has a pointer which, when set to the age of the moon, indicates on the outermost volvelle the time of high water on that day at the selected port.

For example (Port with an Establishment of SE by E, and the moon is 11 days old):

Establishment of port	SE. by E (8 hr.)
Age of the moon	11 days
Time of high water	16 hr. 48 mm

(11x48min.) / 60mm = 8 hours 48 minutes

Establishment	8 hours

Time of high water = 16 hours 48 minutes (4:48 PM.)

Figure 54: Paper Tide Calculator

NOTES:

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Cover: A Man of War with the Fall of Icarus
By: Frans Huys (c. 1522-62) after Pieter Bruegel the Elder (c. 1525/30-69) (c. 1528 in Archibald) Date: 1562

Figs 1,2,6,7,10,13, 32, 35, 39, 40, 42, 44, 46:
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Figure 3: Adapted from on-line illustration, no longer published.

Figure 4: Jean Froissart, Chroniques (Vol. 1), Paris, Virgil Master (illuminator); c. 1400-1410 Image: La Rochelle besieged by Richard Fitzalan, Earl of Arundel <http://hognose.kb.nl/cgi-bin/gurl2url.pl?KB_OBJECT_ID=MIMI:72A25_343_MIN:1>

Figure 5: Picture of the "Helge Ask", replica of the Skuldelev 5 wreck.
(Photo courtesy of the Navis I Database of Ship Wrecks)

Figure 8: "De Heu van Brussel", engraved 1648 Wenzel Hollar [1607-1677]

Figure 11: Fanciful depiction of a Viking ship from a manuscript…
Attributed to a Time-Life publication here:
< http://www.wmich.edu/medieval/academic/courses/engl676f97/maldon3.html >

Figure 13, 14: Photo of a Reconstruction of the Kvalsund ship. Exhibited in Bergen Maritime Museum, Bergen Norway

Figure 15: Detail from Abraham Ortelius (1527—1598) `Presbiteri Johannis, Sive Abissinorum Imperii Descriptio.' (The land of Prester John.) (Antwerp, Abraham Ortelius, 1603.)

Figure 16: Picture of the Nydam boat, Archäologisches Landesmuseum, Gottorp Castle, Schleswig, Germany (Photo courtesy of the Navis I Database of Ship Wrecks)

Figure17, 18, 19: Various photos by Dr Gerald Nelson, Casper College, Casper, WY
< http://wind.caspercollege.edu/~gnelson/scandinavia/vikingships.htm >
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Figure 20: Picture of the Utrecht 1 wreck, Centraal Museum, Utrecht.
(Photo courtesy of the Navis I Database of Ship Wrecks)

Figure 21: Reconstruction of the Habitabu 3 wreck, rigged and loaded for exploration (picture courtesy of the Navis I Database of Ship Wrecks)

Figure 24 : "Abbess Savine, Princess Amelie and King Rainher sailing to Norway" Wilhelm von Orlens, Hagenau (Alsace), Workshop of Diebold Lauber (illuminator); c. 1450-1470, Collection of the Hague

Figure 25: Scene from the life of St Nicholas on the Tournai marble font in Winchester cathedral, Photo : Dr. John Crook < http://www.norman-world.com/angleterre/cultures/GB_FR/culture5_5.htm >
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Figure 26: "Cornelia with her company mourning Pompey and weighing anchor to flee; the body of Pompey has been thrown out of the other boat after his head had been cut off " Donato Acciuoli, Life of Scipio Africanus. Plutarchus, Life of Pompejus. Leonardo Bruni Aretino, Life of Cicero. Translation from the Latin by Symon de Bourgouyn France, Symon de Bourgouyn (scribe); c. 1500, Collection of the Hague

Figure 27: Photo of the replica of the Bremen Cog, the "Hansekogge", Förderverein Historische Hansekogge Kiel e.V. Geschäftsstelle Lorentzendamm 24
24103 Kiel < http://www.hansekogge.de >

Figure 28: The City Seal of Strasslund, ca 1329, seal imprint in the author's collection, Photo by author

Figure 29: The City Seal of Winchelsea. from "the Good Ship" by Ian Friel. (see bibliography)

Figure 30: The City Seal of Dover. from "the Good Ship" by Ian Friel. (see bibliography)

Figure 31: The City Seal of Danzig (now Gdansk), ca 1350, seal imprint in the author's collection, Photo by author

Figure 33: "Sea battle between the Romans and the Greeks under Cleonymus off Venice", Livy, Histoire Romaine, Paris; c. 1380-1390; Collection of the Hague

Figure 34: " Sea-battle between the English under Richard Fitzalan and the French ", Jean Froissart, Kroniek (Vol. III). Translated from the French by Gerrit Potter van de Loo North Holland; c. 1450-1460; Collection of the Hague

Figure 36: Detail from the City Seal of Winchelsea. from "the Good Ship" by Ian Friel. (see bibliography)

Figure 37: Detail from the City Seal of Danzig (now Gdansk), ca 1350, seal imprint in the author's collection, Photo by author

Figure 38: Picture of Dutch ship, c1597, From engravings of Willem Barentsz expidition to Nova Zembla, Picture scanned from separated page no longer in Author's collection (flood damage)

Figure 41: photo of the Nina replica, courtesy of the Nina website < http://www.thenina.com/ >

Figure 43: Picture of Galleass courtesy of the Probert Encyclopedia < http://www.probertencyclopaedia.com/R6.HTM >

Figure 45: Detail from A Man of War with the Fall of Icarus
By: Frans Huys (c. 1522-62) after Pieter Bruegel the Elder (c. 1525/30-69) (c.1528 in Archibald) Date: 1562

Figure 47: Istituto e Museo di Storia della Scienza, Firenze
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Figure 48: Istituto e Museo di Storia della Scienza, Firenze
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Figure 49: British Museum, London, Registration no. MLA 1972,1-4.1, Image courtesy of Epact < http://www.mhs.ox.ac.uk/epact/index.htm > Permission to use pending

Figure 50: "Taking a pole-star sight with a cross-staff," 1545, from Pedro de Medina's *Arte de Navegar*, Valladolid. Taken from David W. Waters, *The Art of Navigation in England in Elizabethan and Early Stuart Times* (London: Hollis and Carter, © Henry C. Taylor 1958

Figure 51: Backstaff from *'Seaman's Secrets'*, London, 1607

Figure 52: Traverse board from "The Pilgrims & Plymouth Colony:1620" *(Navigation: The Traverse Board*) < http://www.rootsweb.com/~mosmd/travbrd.htm >