4 COGS, HULKS AND GREAT GALLEYS: 1250-1400

In Italy the city-states became involved in protracted wars among themselves. Some few states expanded and consolidated their positions. The fighting was not only at sea but for the maritime republics it was there that the decisive battles took place. One town eclipsed another, Venice finally defeating Genoa, though that did not destroy the trade or the authority of the loser. By 1400 Italy had an emerging system of sizeable political units which formed alliances among themselves. The Latin Empire, set up by crusaders at Constantinople in 1204, fell in 1261 to the remnants of the old Greek Empire. The Byzantine Empire was re-established only with the help of Genoese ships and Genoese troops, who were there to topple Venice from its privileged position in the Empire. Genoa, of course, received trade concessions for its efforts. The Greek Empire expended its limited resources in trying to retake provinces in Greece. Much of the equipment and manpower had to come from allies in Italy. By the end of the fourteenth century the Turks had unquestionably replaced Byzantium as the pre-eminent power in the eastern Mediterranean. After overrunning the Crusader States they moved into Asia Minor and the Balkans where they slowly expanded their empire at the expense of Byzantium. The Turks found that they

Illustration above: The great cog seal, Stralsund, 1329.

had to take to the sea and so introduced a new source of potential naval conflict for the Italian maritime states.

In Iberia the kingdoms which started in the Pyrenees in the ninth century had taken all but a small portion of the peninsula from the Moors. By 1400 the kingdoms were constitutionally and politically much like those in northern Europe. In their attitude and policy towards shipping, though, the kingdoms were much more like the Italian city-states. Catalan merchants and sailors, especially those from Barcelona, followed their Italian counterparts in shipping and trading throughout the Mediterranean and beyond – under the watchful eye of the governments which were increasingly looking for ways to improve domestic merchant marines and navies. Monarchs in northern Europe expanded their activities across a broader range within their own lands. They also tried to expand those lands, thus bringing themselves into dynastic conflict with other rulers. The extensive fighting, most notably the Hundred Years' War between England and France, disrupted trade and, moreover opened the field for pirates who were guaranteed support and safe harbour from at least one combatant. The failure of the Holy Roman Empire by 1250 made it possible for many princes and lesser nobles in Germany to pursue their own dynastic goals. The results for trade were similar to those in western Europe. The Free Imperial cities, the towns inside the Empire which had been able to keep from falling under the authority of a regional lord, banned together in leagues to promote their mutual interests. The best-known of the leagues, the Hanse, was made up of trading towns in northern Germany and along the North and Baltic Seas. Led by Lübeck, the Hanseatic League organised trading relationships outside the Empire, gained trading concessions for member towns and, when necessary, mobilised forces to protect mutual interests. By the late fourteenth century the League was strong enough to impose a crushing defeat on the king of Denmark and forced him to accept a peace which gave German merchants virtual control of trade inside his kingdom.

The greatest disturbance to the European economy came not from political but from demographic change. The Black Death, a pandemic of massive proportions, spread across Europe from 1346 to 1350. Population growth had already slowed and perhaps even stopped by about 1300. Europe was apparently facing a crisis where food production, given contemporary techniques, was only just able to sustain the population. Because of poor weather there was a major famine in the second decade of the fourteenth century. The general deterioration of the climate cut into food output and increased the likelihood of disease.

The bubonic plague in the middle of the century took the lives of about one-third of Europeans. After 1350 outbreaks recurred, preventing recovery. Population continued to fall, reaching the lowest point at some time in the first two decades of the fifteenth century. There can be no question but that this fall in population meant a fall in total output since labour was a large component of input in all productive processes. Whether output per person fell as well is a moot point. There is evidence that the volume of trade fell by more than the population. The demographic disaster was so great that it had a pervasive effect on the economy. The effects continued throughout the fifteenth century. The changes in the economy generated pressures on shipbuilders. They responded with new designs in the fourteenth century and established the basis for the major inventions of the fifteenth.

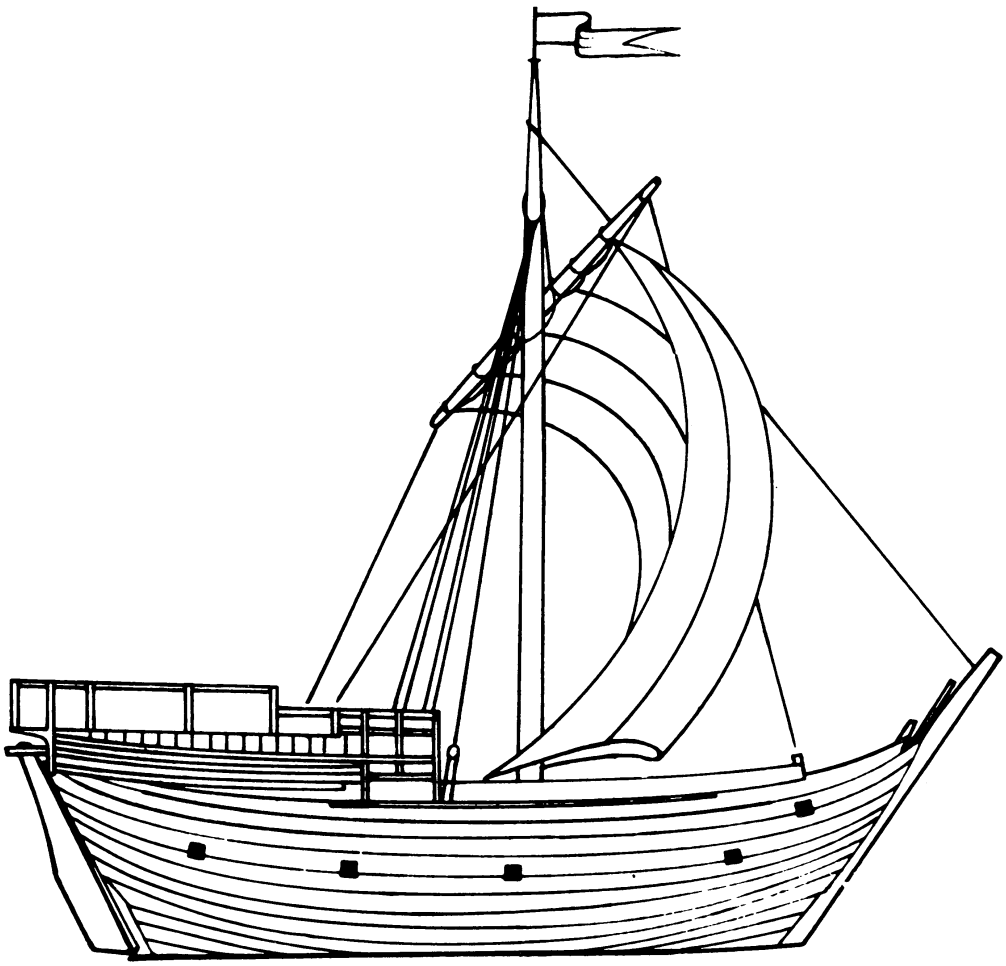
Builders continued to explore the possibilities of the cog design. The type became even bigger. The castles grew and became more a part of the fabric of the ship rather than simple additions. While in the mid-thirteenth century cogs of 100 tons were rare, by the first decade of the fourteenth century in the Anglo-Gascon wine trade 81 per cent of ships were of less than 150 tons but 16 per cent were from 150 to 200 tons and 3 per cent were over 200 tons, the largest reaching 300 tons. By 1400 average size was probably still around 100 tons but it was technically possible to build much larger long-distance carriers. The sheer volume of the wine trade between Bordeaux and England drew vessels which tested the technically feasible limits of size. At the height of the trade, in 1308 to 1309, more than 102,000 tons of wine, about 850,000 hectolitres, left the Gironde for northern points in one twelve-month period. The English market from the late twelfth century was dominated by these Gascon wines since they could be delivered in a volume and at a price to satisfy that market. Though the total volume of exports fell after 1350, concentration on the English market meant that the largest sailing ships were still used.[1] For protection, these larger ships had fenders, relatively short perpendicular pieces of wood running down from the gunwale. They were especially important to parts of the ship which were built up higher, that is at the ends where castles were sitting on top of the planking. Shrouds on the sides helped to support the heavier mast and they had ratlines. The shrouds often ran from fenders so the latter served a double purpose. The aftercastle became longer and lower to accommodate the cabin for the captain and important passengers. One cog had an oven for baking bread.[2] An example of a late fourteenth-century cog was recently discovered at Bremen.[a] In general the form of the ship confirms the accuracy of contemporary

illustrations of cogs on town seals. As toll records indicate, the Bremen find had a through deck – and a deck in the aftercastle. There was a sternpost rudder. The ship was 23.5 metres long, the maximum width was 7 metres and the capacity has been estimated at 130 tons. There were two windlasses on board. The smaller one with a horizontal axis was used for hauling the anchor. The function of the larger one set on the aftercastle is unclear. The first three hull planks, those closest to the keel, were placed edge to edge. The remaining planks overlapped. There were only twelve planks on each side, consistent with the small number shown on seals. The keel was in three parts and not one. The pieces were scarfed together and those at the ends were at a slight angle to the central piece.[3] That form of construction appears on coins from ninth-century Dorestad. It made getting off sandbars easier and with larger ships it also saved having to find a piece of wood big enough for a full keel. Obviously, shipbuilders did not easily abandon the design features of earlier vessels. Still, enough changes had been made that, by the fourteenth century, cogs for long-distance bulk carriage like that found at Bremen were testing the ability of contemporary harbours to accommodate them.

The control system on the cog was improved by the addition of the whipstaff. The rudder, instead of just passing over the sternpost, went through an opening in the stern. There was a bar attached to the tiller at a 90° angle. The helmsman handling the bar could stand higher and see the action of the ship. For larger ships a fulcrum had to be added above the point where the tiller met the bar so that the helmsman could move the heavy rudder. The bar or whipstaff was in the same plane as the rudder. Moving it in one direction made the rudder move in the other. The helmsman could stay in much the same place while moving the rudder. He was usually under the aftercastle so there was the added advantage that he and the steering gear were protected in battle. Through a window he could keep an eye on the sails while steering. Builders added the fulcrum which made the mechanism effective some time in the fourteenth century.[4] The problem with the whipstaff was that it could only move the rudder through a small angle. In bad weather or when a major change in direction was needed, the heavy tiller itself had to be moved. Manpower, perhaps with the aid of ropes and tackles, did that job.

The propulsion system of the cog saw little change. The yard was held to the mast now by a parrel, a rope going around the mast through small wooden spheres, which turned as the yard was hoisted so that friction was sharply decreased. The rope, meanwhile, held the yard fast

15: The Bremen Hanse Cog, 1380, Reconstruction of 1979



to the mast. There were no lifts, no ropes with tackles running from the top of the mast to points along the yard. Roman builders had used lifts and they were common on southern ships throughout the middle ages.[5] Perhaps because the northern yard was always one piece and not two spars as in the South, lifts were not needed.[b]

The cog had early proved itself an effective warship and by the late fourteenth century it was the only warship of consequence in northern Europe. Governments built and used other types but they were generally to supplement cog fleets. Kings requisitioned cogs from their ports when they embarked on a naval campaign. They also kept small fleets of their own cogs at strategic ports. During the earlier part of the Hundred Years' War massive fleets of cogs were sent out by the kings of England and France, meeting in battles involving thousands of men.[c] But use as a warship was secondary to the principal use of the cog as a deep-sea commercial vessel.

The cog was the major carrier in the great trades of the towns of the German Hanse. Their continued prosperity, even in the face of the economic problems of the fourteenth century, depended on the relatively low cost of transport by cog. German merchants handled the export of surplus grain from Poland through ports on the Baltic. The wheat, and even more important the rye, were destined for the urban centres of western Europe, especially in Flanders. The cogs also carried timber and other sylvan products from Poland and Russia. Hanse merchants, most notably from Lübeck, exported the herring caught and packed along the coast of the province of Scania in modern southern Sweden. The cogs going west required a back cargo. The most important good carried back to northeastern Europe in terms of value was Flemish cloth but it did little to fill the holds. Hanse shippers found a solution to the imbalance in the volume of trade when, in the course of the thirteenth century, their cogs began to load salt produced along the shores of the Bay of Bourgneuf in southern Brittany. Grain was the primary good shipped from the Baltic ports and Hansards measured the capacity of ships in terms of the quantity of rye they could carry. The trading network of the Hanse merchants, based on these bulk goods, by 1400 stretched from Novgorod in Russia to Lisbon in Portugal.[6] The growth in the herring fishery increased demand for salt to treat the fish and so the two complementary trades combined further to increase the use of the cog.

The growth of the Scania fishery after the Hanseatic League defeated the king of Denmark in 1370 brought competitors for the German merchants from England and from Holland. German efforts to exclude

these other shippers led the competitors to sail their own cogs directly to the Baltic and to compete in the lucrative grain trade. Towns in the Baltic, members of the Hanse such as Gdansk, Riga and Revel, had the largest cogs since they carried the bulk goods over the longest distances. There was a number of smaller ships carrying salt from Brittany to England and to the Low Countries. But Hansards found that they could compete on those routes with their large ships as well – that is, if they could find another cargo to take back to the Baltic after offloading the salt. In the Scania herring fishery as many as 40,000 small boats with a crew of seven or eight men in each were used to catch the fish. As many as 500 big and medium-size ships carried the casks packed with herring to ports throughout northern Europe. Annual production at the end of the fourteenth century was about 100,000 casks. An average cargo was 200 casks, small for a deep-sea cog but large for the many coastal traders that carried the product to Lübeck and other nearby ports.[7] The growth of these interdependent trades meant more employment for German cogs and created a demand for ever more economic bulk carriers.

Other types competed with the cog for a share of the northern carrying trade. In general the success of these other designs was greater the shorter the haul. The keel appears in fourteenth-century illustrations. As always, builders were reluctant to abandon a design, especially when some use could still be found for it. Keels typically still carried a side rudder. The Scandinavian buss continued to hold some of the bulk trade of the North throughout the thirteenth and fourteenth centuries. It was modified by the addition of sharp posts and a sternpost rudder, presumably in imitation of the cog. The buss in the older form survived as well.[d] The modified type was much like a cog except for some difference in the arrangement of the ribs and the lowest planking and except for a higher length-to-beam ratio.[8]

Slavic types were still widely used. Presumably these were first developed in the seventh and eighth centuries when Slavs reached the shores of the Baltic, found Germans there using boats of originally Celtic design and probably modelled their own craft after them. Planks on Slavic boats were clinkered but, instead of being riveted, the overlapping planks were attached to each other with treenails. These boats existed side by side with typical German and Scandinavian designs. The eastward migration of German merchants and shippers and the establishment of German commercial settlements along the south coast of the Baltic led to the widespread use of cogs. The Slavic design, the pram, remained popular, however, for coasters and lighters and appar-

ently for catching herring off Scania. They did not have strong steps for the masts but did have a large number of heavy ribs. The bottom was typically flat. One distinguishing feature of some Slavic types was an L-shaped plank to join the bottom and sides. The angle there was a sharp one and Slavic builders formed a single piece to serve as the last plank of the bottom and the first of one side.[e] This was exactly the same as the method used on one of the riverboats of the Roman period found at Zwammerdam. For warships Slavs used Scandinavian types.[9] For inland vessels, however, they, like German shippers, relied on the simple pram with its Celtic origins for lightering in harbours and for transport on rivers throughout the remainder of the middle ages.

In addition to the pram there was a wide variety of types built in northern Europe for the fishery and coastal trade. Most are not identifiable. The vessels were often of earlier design, modified to handle certain waters, harbours and cargoes. For example, Frisian trade not only continued but experienced some growth in relative volume and scope. Traders from Stavoren and other towns along the Frisian coast carried beer from Hamburg to the Low Countries, local agricultural products to England, and fish and grain from the eastern shores of the Baltic to the West. They carried goods for other producers, often acting as intermediaries. Many of the trips were short, such as that from Friesland to Hoorn across the Zuider Zee carrying beef cattle. The coasters and small seagoing ships of the Frisian traders were not the kind to appear in contemporary illustrations or records. Frisians probably used small cogs for most of their trade but they were not limited to that design. Records from the Low Countries and Germany mention many types, sometimes associated with special duties, and often the names are repetitions of names that appeared earlier.[10] None of these types posed a threat to the cog in deep-sea carriage but they did offer an ever greater variety of options to shippers. The growth of long-distance carriage made possible a growth in intraregional short-distance trade for the distribution of bulk goods from the deep-water ports. Builders thus had more chances to experiment with specialised designs, and more features to choose from in designing all ships.

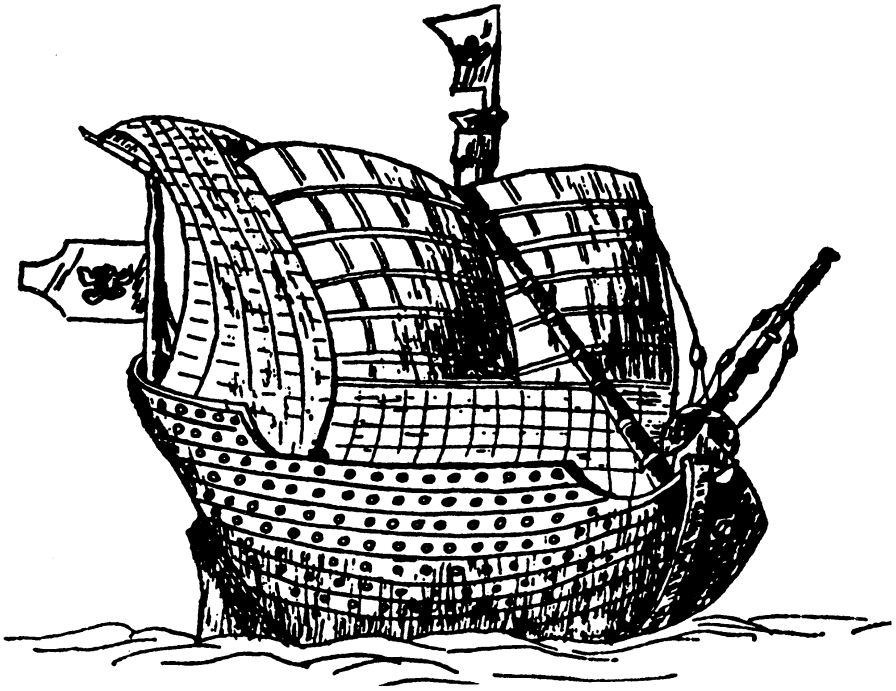
The cog did face competition in long-distance bulk carriage from one type: the hulk, the carrying capacity of which always compared favourably with the cog because of the shape of the hull. While the cog had grown much faster than the hulk in the twelfth and early thirteenth centuries, the gap was gradually closed during the fourteenth, and the hulk became more of a threat to the cog. With a clinker-built hull and wood instead of ropes to hold the bow, the hulk went from about half

the carrying capacity of the cog in 1250 to the size of the largest cog by the 1380s.[f] Shipbuilders then merged the cog and the hulk into one composite design. After 1400 the same ship might alternately be called a cog or a hulk; this was not illogical since the new type had features of both.[11] The merger was a logical result of the presence in each type of certain advantageous features. Though they had existed side by side for some centuries, builders had not combined them. The economic situation of the late fourteenth century gave shipwrights more reason to examine the possibilities. Relative to other prices, grain prices fell in western Europe after the Black Death. The growth in grain exports from the Baltic had been based on the pressure on land in the West, the demand for more food and the resulting high grain prices there. Because of the fall in population in 1346 to 1350 farmers in western Europe could concentrate their efforts on the most productive ground and thus output for each agricultural worker rose. Moreover, the plague had a massive deflationary effect on demand.

Around 1400 the cost of transport was almost half the price of Baltic grain delivered in Bruges. For other bulk goods the percentage could be even higher, for example 85 per cent for Portugese salt carried to Bruges. With more expensive goods moved over shorter distances the cost of shipment was inconsequential. Shipping wool from London to Calais added only two per cent to the price. For the trades of the Hanse, bulk goods going through often dangerous waters, the share of transport costs in the delivered price was crucial.[12] With grain prices falling, German merchants had to find a way to lower their costs just to retain their share of the shrunken market. The half of the price attributable to transport costs was a logical place to look for savings. Shipbuilders were thus under pressure to lower shipping costs, and did so by producing the new merged type. There was a time lag from the Black Death to the development of the combined design, on account of the replacement rate of ships. They were expensive capital goods and represented a sizeable investment, so they were rarely scrapped. It took some time to introduce a new type and even longer for it to show up in the surviving documents. Moreover, the decline in the total volume of trade after 1350 meant surplus capacity, so that the replacement rate was even lower than normal.

The new type was still clinker-built and of shell construction. The rounded form of the hulk was retained but added to it were a broad flat bottom, a strong keel and stem and sternposts like the cog. The flat section of the bottom was, if anything, increased relative to fourteenth-century cogs. For better manoeuvrability a second external stempost

16: A Two-masted Venetian Cog with Square Mainsail and Lateen Mizzen, 1366 (top) and a Hulk with Features of the Cog, Seal of Gdansk, 1400 (bottom)



was added as deadwood, though that had already been used on cogs. The ship presumably also had a heavy internal framework of ribs. The bow was still brought up something like earlier hulks while the stern looked much like that of earlier cogs. Forecastles continued to be triangular. The castles were built into the hull as integral parts, a trend already clear on all cogs.[g] There was no change in the rig nor in the length-to-beam ratio. No more wood was needed to build the modified type. Crew size was proportionally the same. With the changed hull shape and the flat bottom the new type could carry as much or more for each metre of length than the earlier cog. The retention of a gentle curve to the hull made the new type better at riding in tides and estuaries than the older cog. Draught was the same or less than a cog of the same carrying capacity. The keel and posts made the new type a better open-sea sailer than the earlier hulk. It was faster too.[13] The new hulk required no increase in investment, produced the same or greater carrying capacity for that investment, had the same or lower unit labour costs and had the potential for greater size without giving up the ability to visit all the harbours used by cogs. Throughout the fifteenth century builders took advantage of the shallower draught of the new type and built much bigger ships. The final result was lower unit shipping costs, exactly what Hanse merchants wanted.

Northern Europeans also built galleys in the fourteenth century. These galleys had a typically high length-to-beam ratio. Oars were the major source of power. There was a supplementary sail. Some of these galleys were based on older northern designs, derived probably from the Scandinavian dragonships. Others were modelled on Mediterranean galleys. In either case the decision to build them did not depend on economic but on political circumstances. Kings or their advisers decided that they needed galleys or other oared ships to supplement fighting fleets. The French royal government, having the example of successful naval powers bordering its Mediterranean coast, decided to create a navy based on that southern model. The French imported Genoese ships and then Genoese shipwrights north to the Channel. Based on Spanish examples, the Italian shipwrights built and maintained galleys at royal shipyards in Normandy. Presumably these galleys were just like those of the Mediterranean. Crews had to be imported. The special shipyard at Rouen was also the site for the construction of local types of rowed barges.[14]

In England barges and balingers were a common part of war fleets in the fourteenth century. While English galleys, presumably of Mediterranean design, could have up to 140 oars, no barge ever approached

that figure. The maximum was 80 and for balingers the range was from 40 to 50 oars. Barges were apparently similar to balingers in design but heavier, usually in the range of 100 to 150 tons. These vessels were great consumers of manpower with one man per oar and a crew of sailors and marines perhaps greater than the number of rowers. Still, they were found effective doing convoy duty, privateering or carrying important individuals.[h] Barges could also be used for commercial voyages but presumably they then relied only on sail power and not on oars at all. While the Cinque Ports had supplied galleys to the English crown throughout the thirteenth century, the threat from Castilian galleys, built on the Genoese model, and then of French-built galleys at the end of that century, redoubled English interest in oared ships. Edward I ordered a galley fleet to be built in 1294. Some of the vessels were finished and the records are clear on the dimensions of the ships. If the design was consistent with that of earlier rowed vessels built in the North, it is hard to conceive how they could have sailed. But they did and in some cases proved effective fighting ships. Despite the interest in galleys, though, most ships used for naval purposes were large cargo ships needed to carry troops, horses and supplies to Continental battlegrounds. The largest of these English transport fleets, that of 1347, numbered 738 ships with 15,000 sailors needed to move about 32,000 troops to the siege of Calais.[15] The English government was less devoted to building and maintaining a war fleet of its own than to conscripting sailing ships and their crews when needed. The number of oared warships, compared to sailing ships in naval forces, was always very small. This fact, together with the serious limitations of the type, prevented edge-to-edge planked Mediterranean galleys from having much effect on shipbuilding in the North. Construction of cargo ships was largely separated from the building of the Mediterranean-style galleys. Since the latter could not operate in the strong winds, high waves, tides and currents of the open sea in the North, it is not surprising that shipwrights found no reason to adopt features of the southern types.

In the South itself the pace of design change quickened in the late thirteenth century and throughout the fourteenth, so much so that it exceeded that in the North. Up to about 1340 the possibilities for design development continued to increase. Trade remained buoyant. Moreover, the changing political situation, the loss of privileges in the Levant with the fall of the last bastion of the crusader states, and the re-establishment of the Byzantine Empire at Constantinople, created pressure on shipbuilders to meet changing needs. The penalties for

failure were softened for shipbuilders by the introduction of marine insurance. Methods of mutual protection had long been practised by shippers at sea. Sailing in convoy better to fend off pirates was common in both northern and southern Europe. The fleets of salt ships going to the Bay of Bourgneuf from Hanse towns typically sailed in large convoys.[16] More common, though, were smaller groups of four or five ships which joined together at a port. In some cases the captains agreed to share all losses with others in the group. On an informal basis, this was highly inefficient since all ships had to wait until the last had filled out its cargo. In the fourteenth century, Italian municipal governments institutionalised convoys, setting times of departure and levying charges to support convoying warships.

Meanwhile, businessmen themselves independently developed a way to spread expected losses. They introduced a third party who, for a fee, would accept the risk. The development of marine insurance, by which the shipper could pay a premium and be guaranteed payment for loss of goods and ship, took a very complex path. By no means did all shippers use marine insurance in 1400. The process of adoption was a slow one. By the late fourteenth century, however, formulas for such contracts had been worked out in a number of Italian towns so that shippers could get insurance more easily. There was an experiment in fourteenth-century Portugal in which the king established two insurance funds which accepted all losses of goods and ships. All ships in the two major Portugese ports had to pay a two per cent duty on the value of their cargoes in order to fund the insurance programme. It was a case of the government forcing the distribution of risk and establishing insurance by law. The fund required vigorous government support and when that waned so did the fund.[17] At the same time, however, the appearance of effective commercial insurance removed the pressing need for enforced sharing of risk. No matter how it was institutionalised, the result was that risk could be quantified and easily and clearly subsumed in costs. Insurance did not eradicate risk. Shipbuilders were still constrained by the potential loss. The difference was that risk was an objective fact which could be measured and weighed by buyers and builders. They could then trade off risk against other components of cost such as manpower requirements and speed. The accuracy of insurers was of no consequence. The point was that they set the cost of risk and that was the cost that shipbuilders had to consider. At the least, the development of insurance must have made more simple the choice among different types of ships for different types of voyages and cargoes.

While insurance spread risk, the improvements in navigation after

1250 decreased it. A series of improvements in tools and methods gave navigators greater ability to know where they were and how long it would take to reach their destination. By 1300 the compass had made the transition from a primitive pointer to a needle swinging freely on a dry pivot. There was a card calibrated by the principal winds in the form of a wind-rose, or even in some cases by degrees, set under the moving needle. By the end of the thirteenth century and certainly by the early fourteenth, sailors were using this improved compass in combination with the new portolan chart. Portolan really meant a set of sailing directions, just like those dating from the Roman period. In the thirteenth century, as a supplement to the text, a chart was drawn to scale describing the coast and giving the locations of ports. Writers described the use of these charts and the compass, along with dividers and an hourglass, to estimate the ship's position by plotting a course and calculating her speed. Charts are first mentioned in use on board ship in 1270. Over the following century they became more numerous, even if they may all have been derived from the same source.[i] Loxodromes emanating from the wind-rose on the chart gave a set of courses. The navigator had to decide which of the loxodromes was parallel to the course he needed to take from his point of departure to his goal; this gave him the heading he needed to steer. The newest sailing directions laid this all out for him. If he was driven off course or had to tack he had, by 1400, a set of tables which allowed him to resolve his course – that is, to break his sailing down into two perpendicular directions and then calculate his position. With such a traverse table the navigator could reduce a zigzag course to a straight line and thus he knew how to steer to get to his goal.[18]

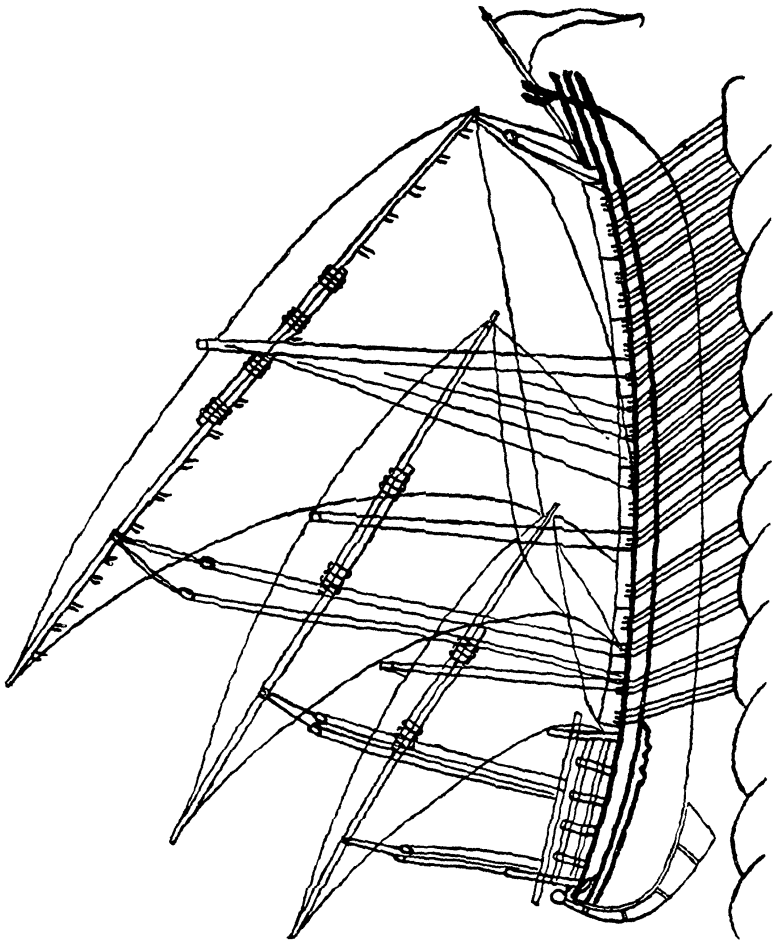
Italian and Catalan navigators could depend on their chart and compass. Celestial observations became a valuable but not indispensable supplement. In northern Europe the height of the sun and the position of the stars remained a principal source of information for navigators. But pilots along the shores of the North and Baltic Seas depended more on soundings taken with lead and line than on what they saw in the skies. In the Mediterranean, waters were clear and the bottom usually fell off sharply away from the shore. In northern Europe neither was true, and, as ships there typically stayed closer to shore depth soundings and knowing about the nature of the bottom were critical for safe navigation. Sailing instructions did not describe the use of the compass in those waters until the fifteenth century. The slowness of northern Europeans to take advantage of the new equipment was in part because they could get so much information by sounding and by

watching the shore. Hermits and the church combined over time to increase the number of lights along dangerous coasts. Tall lighthouses were still a rarity, however, even in the Mediterranean. Northern navigators also had to worry about tides. By the late fourteenth century, tides were certainly well understood and mariners were receiving tide tables to help them make their way along coasts and into harbours. The navigational methods of Mediterranean sailors increased predictability. They always had a good idea of where they were. One late fourteenth-century writer claimed that the use of Italian navigational methods explained the lower number of shipwrecks in the Mediterranean, one for every 20 in northern Europe.

Better navigation not only made ships safer but also made them more productive. It was possible to sail in the winter. Of course, pilots still had to be careful of winter storms but they were in a much better position to deal with them. They always knew how far it was to the nearest safe harbour. Sailing across open seas presented no problem at all and long reaches out of sight of land, even in the cloudiest of winter weather, were practical. The sailing season was extended. There were more voyages per year. The effects were first felt in the last years of the thirteenth century. In the fourteenth, winter sailing in the Mediterranean and regular services from there to northern Europe became common.[19] Annual production of shipping services by a vessel, and especially of large ships making long-distance voyages, rose by as much as 50 per cent. Instead of one voyage each year they now made two. Certainly, there was an over-all gain in the productivity of capital. But there was also a fall in orders for shipbuilders; the total number of ships needed for a given volume of commerce fell. Then, in the second half of the fourteenth century, the volume of commerce fell as well. There were mitigating factors which kept shipbuilders from bearing the total effect of the improved productivity of ships from better navigation. With a greater frequency of voyages the size of ships did not grow as rapidly. It was not necessary to concentrate all shipment into a single voyage. Moreover, the fall in risk which meant lower capital costs to shippers, reflected in lower insurance premiums too, would be passed on in lower shipping charges. The lower prices kept the volume of trade from falling as much as it would have done with unchanged costs. The decrease of risk and the distribution of risk opened possibilities for experiment by shipbuilders in the Mediterranean; they were under pressure to improve ships just to retain their level of activity in the face of declining total demand after 1350 and the Black Death, and declining relative demand after about 1300 and the introduction of winter sailing.

One response was the development of the great galley, which was originally designed as a warship but was soon pressed into service as a cargo ship to compete with round ships in trades where speed was an important consideration. There were, by 1300, clear opportunities for trade between northern Europe and the Mediterranean. Exchange between Italian and Flemish merchants had for some years taken place at the fairs in the county of Champagne in east central France. All the merchants travelled then, but in the course of the thirteenth century Flemish traders more and more stayed at home and Italian merchants did their business in the Low Countries. With an active commerce in Flanders the next step was for the Italians to supply transport for the goods. The exchange was in luxury items and not the bulk goods which could be efficiently carried by northern cogs. The light galleys could not handle the goods economically. The solution was to build a bigger galley with enough capacity for a sizeable cargo, the ability to survive in northern waters and the speed to make an annual round trip to the North avoiding the worst weather. The new type was first built in the last decade of the thirteenth century not long after the first voyage of Genoese ships to Bruges and Southampton in 1277-78. To Flanders and England the great galleys carried high-quality wines, alum used as a mordant in the Flemish cloth industry, spices first shipped from the Levant to Italy and sub-tropical fruits collected along the coast of Spain. They brought back finished cloth or high-quality wool for the Italian cloth industry. Shipment added only 15 per cent to the cost of Flemish cloth delivered in Italy, a reflection of both the high value of the cloth and the efficiency of the great galley compared to its smaller counterpart. Small galleys carried 50 tons with a crew of 180 men, or .28 tons for each man. The great galley of 1320 could handle about 150 tons with an average crew of 150. At one ton for each man that meant a fall of more than 70 per cent in labour costs alone. Flemish cloth solved the problem of the North's lack of a good of high enough value per unit volume to match the spices, silks and other luxuries that came from the Mediterranean.[20] The cloth could fill the holds of these great galleys, give them a back cargo and make a critical contribution to the cost of the operation which was still high compared to the cost of transporting goods by round ship. With southern weaving shops making their own cloth, wool could be sent in place of the Flemish cloth. The cargo from the South was always more valuable than the back cargo, even more so after the change to the shipment of wool.

The great galley was also built for use in the Mediterranean. Venetians, being the first to exploit the design, were able to gain an advantage



17: Venetian Great Galley from a Treatise on Shipbuilding, 1445

in trade to the Levant, carrying spices, Eastern goods and, of course, pilgrims. Galleys were well suited to the carriage of pilgrims, with lower insurance charges and fewer delays than round ships which relied exclusively on sails. The Venetian government increased the reliability of such galleys by subjecting them to strict regulation, thus making them even more popular with pilgrims. Since the ships stopped along the way, the traveller had a chance to see more things. Comfort was at a minimum at sea, however, since the pilgrims were packed between decks while some 150 sailors worked the ship from the deck above them. Ventilation was confined to four small hatches, so the smell must have been strong. The cost of operating the cargo galley was, of course, higher than that of operating a round ship but many commodities, including pilgrims, could sustain the relatively higher freight charges. The cargo galley was thus able to regain some of the trade lost to sailing ships by galleys from the eleventh to the thirteenth century. The change to the use of the great galley was aided by a change in consumption patterns and a relative increase in the volume of luxury goods shipped. Especially in northern Europe, but also in Italy, the income gains made by survivors of the Black Death went into buying spices to diversify diets and clothes with a bit more colour and style. These goods came from the Levant and the Far East and Italian merchants willingly acted as the intermediaries for moving the goods. The logical vehicle was the great galley.

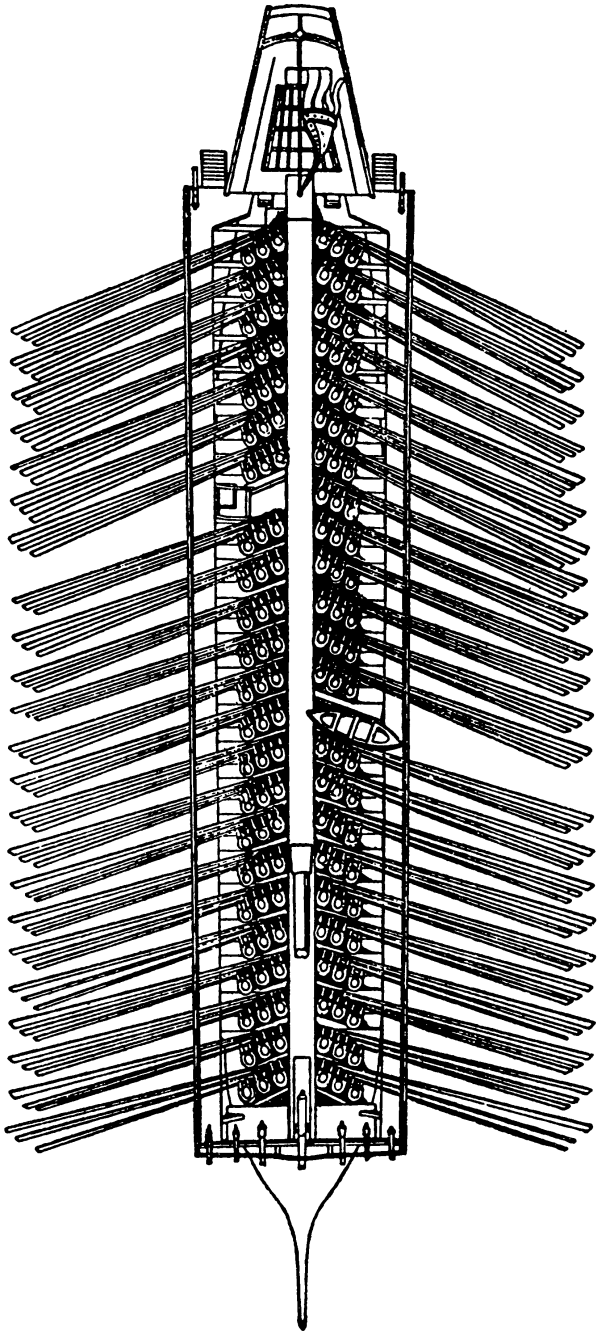
The new type was still a galley with all the attributes of that design. The aim was to gain some of the advantages of the round ship but few features were borrowed from that type. Rather, builders merely increased the size of the galley. The length-to-beam ratio was still high, about 6:1 compared to 8:1 for a light galley. The larger size meant deeper draught, markedly deeper on Venetian craft. Galleys had traditionally depended on shallow draught to give them speed but this had to be sacrificed to obtain the larger carrying capcity. The hull was more rounded, giving something of the appearance of a full sailing ship. To move the larger hull there were three masts, each with a lateen sail. The masts were progressively shorter towards the stern. The type, in fact, moved better under sail than with the oars, an exceptional characteristic for a galley. The great galley continued to grow in size throughout the fourteenth and into the fifteenth century but builders were able to maintain the quality and advantages of the design as they explored its limits. The larger galleys could carry two tons for each man, still much less than the five to eight tons per man for round ships. The galley compensated for the difference by higher speed and also greater defensibility.

With such a large crew, pirates were reluctant to attack a great galley. The absence of castles did not affect the ability of the crew to handle trouble or to escape from it. Moreover, great galleys could act together in squadrons, making them even more formidable.[21] The oars were used only in special circumstances. The size of the ship made it hard work to handle the oars and the crew preferred to avoid that unpleasant task, but the ability to use the oars to get in and out of port, to manoeuvre or to avoid a lee shore gave the great galley its advantage in speed and reliability over the round ship.

For the lighter galleys, ship designers changed the arrangement for rowing by the thirteenth century. On Byzantine dromons and their successors there were two rowers to each bench, each rower handling a single oar. In the tenth century, when designers wanted to build bigger dromons, they simply added another layer of benches, each with two men, above the first. In the thirteenth century, Italian builders chose instead to increase the number of men on each bench to three. The use of oars of different lengths and the placing of the bench at an angle ensured that rowers would not interfere with one another. The arrangement may ultimately have been the optimal one for rowing a ship. The number of rowers was increased without placing any of them higher above the water which would have raised the angle at which the oar entered the water and thus decreased efficiency. Oars did not have to be very long and so their weight was kept down, thus limiting the amount of unproductive work the oarsman had to do on the return stroke. Outriggers on each side, part of a frame which went around the entire ship, offered a fulcrum beyond the hull to give rowers more leverage. The system of rowing changed in part to obtain more total force to propel the ship without increasing the complexity of construction. The greater carrying capacities which resulted made the great galley a commercial success. These big rowed vessels could navigate more effectively against a current – a critical advantage in getting out of the Mediterranean to make the voyage to northern Europe.[22] The new type of galley was also a naval success, superseding the old Byzantine dromon. Galleys always needed large crews, even larger after the change in the number of oars per bench. At least, with great galleys, buoyant demand for the luxuries they carried kept revenue up so the wage bill could be met.

The great galley was developed in the Arsenal at Venice, the government naval shipbuilding yard and depot for armaments. Builders there continued to build great galleys to the order of the Venetian state. Government policy affected and directed demand for ships, and the

18: Reconstruction of a Mediterranean Galley with Three Rowers to Each Bench and Armed with Guns



first experiments with larger galleys began as part of the naval building programme during the second Genoese war which ended in 1299. Throughout the first half of the fourteenth century the Venetian government protected its own fleets of great galleys against all competition, thus gradually driving all galley building into the hands of the government and therefore into the Arsenal. The expansion of the communal shipyards there in 1303 and 1325 gave builders the space to handle the increase in work. The government had set out to centralise the building of warships, or at least to centralise it enough to guarantee a minimal fleet, and in time this led to expansion into, and then a monopoly of, the building of great galleys. However, Arsenal workers still only built a relatively small portion of Venetian tonnage, about ten per cent. They built vessels which were on average smaller than the large round ships produced by private yards. Throughout the fourteenth century the Venetian government increased the regulation of galley fleets and then turned to owning them, operating more and more of the ships itself or chartering them to merchants. The government wanted to keep some control over great galleys since they still could and did serve as valuable warships.

The largest proportion of Arsenal output was in light galleys, which typically had 25-30 benches to a side with three men for each bench. There was a single mast with a lateen sail. Control was supplied by three rudders. The two side rudders were joined by a sternpost rudder like that typical in northern Europe. By extending this design to its limits builders produced a poor sailing craft but one that was fast and highly manoeuvrable. The government in fact set limits on the size of galleys. Builders were apparently over-enthusiastic, their experiments were not highly successful and they were making the galleys into ineffective fighting ships. Galleys throughout the Mediterranean tended to become longer and lower during the thirteenth and fourteenth centuries. Over all lengths of 40 metres were not uncommon. The beam would then be under 5 metres. At the bow there was a covered platform for archers and for a manogel for firing projectiles.[j] Some defence against Greek fire was common, such as stretching hides over the hull. The ram at the bow was still a major offensive weapon.[23] The government of Venice brought the building of warships together in the Arsenal for political as well as for technical and financial reasons. The government, made up of the greater merchants, did not want to see any individual through the ownership of galleys achieve too powerful a position in the Republic. Having stumbled into a policy of a state-owned and -operated shipbuilding yard the government expanded that yard and expanded its

work to include cargo galleys. The process had certain unforeseen results. The depot developed interchangeable parts to make easier the job of fitting out warships. To do that builders also had a tendency to standardise their designs. The builders in the Arsenal were not subject to the standard economic constraints which their private counterparts faced. Or, at least, they were buffered against them by a government which had its own needs. The government created novel demands for the designers in the Arsenal, demands which could only arise under those circumstances, thus making more likely the development of different designs. At the same time, the government released Arsenal designers from other constraints, giving them greater latitude in dealing with the ships they built. The cost of building was still important but producing what the government wanted counted for more.

The Mediterranean round ship continued in use in many trades despite the appearance of the great galley. The round ship was quite logically most popular for carrying bulk goods over short distances. The type retained its position as an effective tramp, moving from port to port carrying relatively bulky cargoes. The design was little changed from that of the twelfth century except that on average the ships were larger. The rudders had tackles fitted to them so they could be adjusted at sea and lifted up when in port. On some ships the upper portion of the rudder was protected by a small gallery. In the course of the fourteenth century the sternpost rudder replaced the older method of control on some round ships. As with galleys, in some cases there were three rudders, two on the sides and one on the sternpost. Projecting beam-ends were common, as were full decks, two and sometimes three on medium-size and larger craft. Wales ran the length of the ship above the beam-ends for added protection. The hull planks were placed edge to edge but strength came from the skeleton of ribs. There was a small forecastle around the stempost and one or two raised decks in the aftercastle at the stern. There were as many as three masts with the tallest forward and raked forward. Shrouds held the masts and they were set up in tackles to give better control. They could not take ratlines so there was a ladder to the top. Since the yard had to be carried over the masthead with the lateen sail, any platform at the top of the mast had to be at the side and had to be movable. A parrel held the two-piece yards to the masts. Lifts were probably used to hoist and to control the long yards.[k] The increase in the average size of these ships over those of the thirteenth and fourteenth centuries can be attributed to the rise in the number of very large ships.[24] Shippers typically found lateen-rigged round ships useful for a specific type of service and so these vessels

remained much the same to retain that part of the carrying trade. Growth in bulk carriage tended to go to another and new type, or at least new for Mediterranean shipbuilders.

The traditional date for the introduction of the cog into the Mediterranean is 1304 but this is certainly too late. Builders in the South knew about the cog long before then. The story that it was brought into the Mediterranean then by Basque pirates suggests that it was not until the years around 1300 that Mediterranean builders became impressed with the potential of the type. The Iberians may have shown that the cog could be used on a regular basis and that it could be acclimatised to Mediterranean conditions, a possibility which sporadic visits by crusaders from the shores of the North Sea could not demonstrate.[25] The result was a major change in shipbuilding in the Mediterranean. The rapid adoption of the cog by Italian shippers can be explained by its relatively low operating costs. Costs were low because of the design of the cog, because of the changes in the technology of navigation and because of the nature of the market for shipping services in the early fourteenth century. The use of compass and chart made possible direct regular service across open water. Sailors had travelled out of sight of land for centuries but now they could do so with much greater security, and they could predict their movements. Something more like liner service, the regular movement between two distant ports, could be instituted in place of tramping along the coasts. There had been a service like that for pilgrims going to the Holy Land from Italy for some time and by 1300 certain bulk goods had become susceptible to similar treatment. Since with bulk goods, as opposed to people, it was unnecessary to stop at night, the galley did not enjoy the same advantage in carrying such goods. Agricultural goods such as grain and wine had to be moved greater distances than before as population had increased, prices had risen and marginal producing areas had found it possible to compete in distant markets. Wine from Crete found a ready market in Genoa. Grain too was shipped to Italian towns from further away, from the Crimea for example, and in larger quantities. As important was the transport of mining products and especially alum. Genoese merchants gained the right to carry alum from the islands of Phocea and Chios in the Aegean to the western Mediterranean. It was the ideal good for a bulk carrier. Alum went directly to Genoa, where it was distributed to buyers along the coast of the western Mediterranean and in northern Europe, in other types of vessels. All of these trades began before the introduction of the cog. However, for the direct shipment of such goods the cog was the ideal vehicle. Genoese shippers by the

mid-fourteenth century found the cog could be used for moving alum to northern Europe as well, and for this trade they established themselves at Southampton in England, thus putting themselves close to the centres of the English cloth industry, and giving themselves a harbour deep enough to accommodate their cogs. The vessel was slow and turnaround time was high. In some cases Genoese cogs went straight from Chios to the North to avoid the delay of unloading and loading again at their home port. Lower labour requirements on board – the square rig was easier to handle than the lateen – kept costs down. Shipment by cog added only 16 per cent to the price of alum and 10-25 per cent to the price of grain, depending on the length of the voyage. Genoese merchants, by specialising in the transport of heavy goods and in the use of the cog, gained a strong commercial position, not to mention sizeable personal profits. Because of specialisation the Genoese measured the size of their ships in units of weight rather than in units of volume which was common practice almost everywhere else. Catalan merchants, like the Genoese, concentrated their efforts on building and operating cogs. They may, in fact, have preceded their Italian competitors. But Genoese cogs were the largest, normally 600 tons by about 1400, for shipping from the eastern Mediterranean to the English Channel. They were three times the size of large Hanse bulk carriers and as large or larger than the biggest lateen-rigged round ships ever used in the Mediterranean.[26]

The climatic change and the Black Death both promoted the use of the cog in the Mediterranean and in all intra-European trades. Specialisation in agricultural production tended to promote the movement of goods, more obvious in the North where a small change in average temperature could make it possible or impossible to grow certain crops. There was a rise in the relative demand for industrial goods after the mid-fourteenth-century plague. The industries required raw materials which had to be brought over greater distances since their production was usually dictated by geography. The use of the cog allowed industry to settle near markets rather than migrate to sources of raw material supply. The cog had a much smaller crew than a Mediterranean round ship of the same size. Cogs could also be built larger than round ships and with much less than a proportional increase in the size of the crew. Since, with fewer workers, there was pressure to raise wages after the Black Death, the use of the cog made it possible to pay seamen more. The simple single mast and single square sail were much easier to handle than two or three lateen sails, and required less manpower and less skill, thus keeping labour costs under control. There was a loss of

manoeuvrability. The improved navigation techniques helped keep cogs out of situations where those poor handling qualities might be a liability. The saving in manpower could be in excess of 50 per cent and wages did not double, so there was a lower wage bill for each ton shipped by cog.

The cog was tubbier than the contemporary Mediterranean cargo ship, thus creating a saving in wood needed to build the hull. In general, an increase in length relative to breadth increased the surface area of the hull, and thus the quantity of wood needed 2.3 times as much as it increased hold space. The calculation is a rough one but the co-efficient was near that for most designs. The saving in hull planking on shorter vessels had already been discovered in the twelfth century in northern Europe when shipwrights changed from building keels and knarrs to building cogs. For shipbuilders in the Mediterranean in the fourteenth century the saving may have been more important. There were already some signs of problems with supplies of shipbuilding timber. Not incidentally, Genoa, which specialised in the building and use of cogs, had much more trouble in keeping local shipyards supplied with wood than had its great competitor, Venice.[27]

Ribs had to be larger, heavier but less numerous for cogs than for round ships so, though there was a saving in the total amount of wood needed, a premium, much greater than before, was placed on big tall oak-trees. Despite savings in wood, the cog still represented a massive capital investment. As the ships got bigger, the investment rose as well. With winter sailing possible, the capital was productive throughout the year and the outlay for the new type made more sense. Apparently, shipowners expected to cover all capital costs as well as operating costs quickly. For example, Catalan shipowners with prevailing freight rates under good conditions could expect to get their investment back within five to six months, the equivalent of four or five round-trip voyages to North Africa from Barcelona. If the cog was big enough then piracy was no longer a problem. The legally required crew size fell with the introduction of the cog since the type was more defensible. It was possible to use bowmen effectively from cogs with their high sides which offered the men protection and allowed them time to aim and fire their improved crossbows. Indeed, in the fourteenth century, while the number of sailors on average went down, the number of bowmen went up. The change in ship design led to a change in the weapons used on board, which in the long run led to an increase in the importance of men with technical skills, crossbowmen, and a decline in the importance of sailors.[28] Riding high in the water equipped with castles, few

pirates or even hostile states could deploy the kind of force needed to overcome vessels of the size of the Genoese cogs of the late fourteenth century.

Shipbuilders in the Mediterranean changed the design of the cog to suit local conditions and local building skills. The hull was of skeleton construction common to Mediterranean ships. Two or three full decks were added. The keel became curved, as was common practice with Mediterranean ships. There were no tides to lift the ship off if it ran aground. With a curved keel goods were shifted, the vessel tilted and it it rode free. Whether this ever occurred with a large cog is doubtful, but the cog still got a curved keel. Skeleton-building was more effective for a large ship, and its execution also required less skilled labour – a particularly advantageous characteristic after 1350 when skilled workers became especially scarce, not because they were more susceptible to the plague but because it took some time to train craftsmen to replace those who had died. There was little question, then, of trying to build clinker-built cogs in the Mediterranean. Control was with a sternport rudder. With a curved keel, the space between rudder and keel was filled with deadwood. The other major change that came with the cog was the reintroduction of the square sail to the Mediterranean. It may well have been used there in special circumstances through the middle ages but the success of the cog made it the typical sail for large cargo ships. Southern builders improved the simple northern square rig. Reef-points were abandoned in favour of bonnets which were used exclusively. Lifts were added, as was a more complex parrel;[l] both made hoisting the sail easier. A more complex system of ropes allowed better control of the sail. Captains could then let the sail bag and billow, which was thought at the time to be more effective. All these additions still left the cog relatively difficult to handle. Compared to lateen-rigged round ships these cogs were poor sailers. In the second half of the fourteenth century, shipwrights attacked precisely this problem by adding a second or mizzenmast steeped near the stern and rising above the now low-slung aftercastle. It carried a lateen sail.[29] Since Mediterranean builders were accustomed to multiple masts, the addition did not mark a major invention.[m] The goal clearly was to increase the manoeuvrability of the tubby vessel and perhaps to decrease turnaround time, since the lateen sail would help in getting in and out of harbours. The lateen was rarely handled at the same time as the mainsail, so there was no increase in the crew. The innovation was an effort to meet the greatest disadvantages of the cog, and with it southern shipbuilders took the first step towards the invention of the full-rigged

sailing ship.

By 1400 the variety of ship types in the Mediterranean had sharply increased compared to those that existed in 1250. In sailing ships the different sizes of lateen-rigged round ships had been joined by the northern cog, modified and improved to suit the needs of the South. Among longships there were two types of galleys. The change to three rowers per bench made the light galley a more effective warship. The great galley brought a new form of transport and gave galleys a much broader function in the movement of goods. The great galley could still be an effective warship. There was an over-all tendency to increase specialisation of design. Ships became suited more for certain tasks. The great galley took over some of the luxury traffic from galleys but also some of the traffic in less valuable items per unit volume from round ships. For most bulky goods there was the cog, while the round ship served a market half-way between that of the cog and the great galley. The greater diversification in design continued throughout the period of declining demand for shipping from the mid-fourteenth century. The variety of designs was perhaps a response on the part of shipbuilders to the shrinking of their market.

Information about ships increases sharply for the thirteenth and fourteenth centuries compared to earlier years. The material comes not only from illustrations but also from government records and from the private records of businessmen. The increased documentary evidence generates an impression of a faster pace of change and improvement in ship design, of major and distinct developments compared to, for example, the 250 years before 1250. The impression, however, is not simply or entirely the product of the greater quantity of data. In the Mediterranean, after the development of the larger galley in the tenth century, there was little change throughout the thirteenth century, while in the North, after the improvement in the cog early in the eleventh century, the same was true up to the mid-thirteenth century. From that point the pattern changed, however. Pressures from the economy, perhaps mounting for some time, became more direct and immediate. Pressures from governments became more commonplace and more overt. The precise demands of governments might not be the same as in the past but they increasingly turned to shipbuilders to solve problems and they increasingly placed constraints on builders in one form or another, often institutionalising those constraints. Government purchases were still a small portion of total shipbuilding sales but the character and form of government demand could and did have an effect on the design of ships.

By 1400 European shipbuilders had developed a bulk carrier capable of moving many goods economically and through all European waters. Continuing improvement in the type expanded the scope of its use and also the volume of goods carried. The process of lowering the cost of bulk carriage by innovation in ship design was, however, by no means complete. The unique economic circumstances created by the Black Death increased the pace of development and the use of bulk carriers. The success of builders in supplying profitable cogs and hulks to shippers affected the organisation of business and income distribution within Europe. The rise in the volume of bulk carriage, absolute at least to 1350 and relative both before and after that date, implied the concentration or potential concentration of transportation in the hands of a few people. The larger amounts of capital needed and the limited number of voyages along any given route in a year meant that few merchants could operate successfully. Trading in wine or alum was not like trading in spices, silks or specie. In luxury trades capital was certainly an important prerequisite but the higher unit profits made entry much easier. The ships and the organisation of luxury trades created opportunities for a number of traders. The limited points of supply and the limited trade routes for bulk goods acted to close the door on men wanting to make a start in that kind of trade. The greater capital requirements of bulk trades and lower returns per ton exchanged, inherent in the nature of the goods, made it a business for rich merchants. As those men gathered more capital into their hands, the merchant community changed. Though the total income of merchants went up, not all merchant incomes went up proportionally. In the North, where bulk trades were well established, so too was the tendency towards the concentration of business. The economy there was, in general, poorer than that in the Mediterranean so, instead of a shift in favour of a few traders, rather the long-term trend dating from the tenth century continued. The larger ships of the bulk trades also led to a concentration of investment in shipping. The pattern was the same throughout Europe. A larger proportion of the total investment of the commercial sector was tied up in a relatively small number of vessels. Rather than spreading the investment in those seagoing cogs across a larger number of passive investors, the sheer size of the amount involved and the changing character of business combined to lead to a decrease in the distribution of capital among owners and a decrease in the number of owners.[30] Passive investment still went on in smaller ships. But in the fourteenth century the long-term trend towards the spreading of the base of financial involvement in shipping was reversed. Those

merchants successful in bulk trades were able to take an increasing share of the total investment in shipping. As the owners of a larger share of the profitable bulk carriers, those men were able to enjoy higher returns and so the process became self-reinforcing.

The rising relative portion of trade in bulk carriage meant that the effect of commerce on agriculture was more direct and more pervasive. Trade always had an indirect effect on agriculture. Trade and exchange always implied an increase in potential total output for agriculture. From the tenth to the thirteenth century, trade also made possible the sale of surplus production from farms and estates large enough and well enough organised to have a surplus ready for sale. Commercial agriculture, growing exclusively for sale and specialising in production for the market, existed by the eleventh century and was certainly common in twelfth-century Italy, where urbanisation had created a dependent population that had to import food from the countryside. Owners of land close to the towns organised their production to suit urban consumption; but that was entirely on a local basis. By the fourteenth century, agriculture of the same type – that is, where more effort was devoted to growing crops for a cash market – could expand among farms distant from concentrations of population; this was possible because of the falling cost of shipping the crops. The obvious example was the production of grain in Poland for markets in Flanders, but over time the examples increased and so too did the land turned over to production for the market. English wool could be exported to Italy and Spanish wool to that market and to the North. The growing of grapes for making wine forced producers to sell their output to get other foods. Wine had been exported from the Rhine Valley in the eighth century. In the thirteenth and fourteenth centuries the market for that and other wines expanded. Growers in southern France established a firm market in England and producers in Crete and the eastern Mediterranean were able to market some of their output in northern Europe. Consumers benefited from the greater selection of goods. Producers benefited from the wider market which created the potential for greater returns. The lower delivered cost of bulk goods promoted regional specialisation in agriculture and by no means just within small areas.

The Black Death left only a few pockets of Europe unaffected. With so much empty space there seems to have been surprisingly little migration, with the exception of migration from the countryside to nearby cities. The lack of interregional migration was in part due to the increased use of economic bulk carriers. As the total population of Europe grew throughout the twelfth and thirteenth centuries, there had

been a major migration out of the region from the Alps to the North Sea and between the valleys of the Loire and Rhine. The Low Countries, especially, showed a surplus of births over deaths and people from that region joined people from throughout Germany in a trek eastward in search of agricultural land. As land was cleared of forests or reclaimed in the centre of Europe, opportunities there for farmers declined. The increasing number of agricultural workers had to go further afield to find land to work. The pandemic in the mid-fourteenth century led to a sharp drop in population in the central region of northern Europe, a larger absolute drop since the density was higher there; but there was no rush of population back into that area to fill the vacuum. Such a rush would not necessarily be expected. But weighing the factors which acted to push and pull migrants, the push to drive people out of newer settlements in eastern Europe had to be below a certain threshold to keep survivors there. The ability of farmers in Poland to continue to sell their surplus production in western Europe meant that it was not necessary for them to move back closer to the market. The lower cost of moving grain made it possible for them to stay in the East without giving up the ability to acquire goods like those available in the West and South. As population recovered in the fifteenth century, the distribution of population across Europe remained much the same.

The use of bulk carriers acted to block the diffusion of the superior business methods of Italian merchants. Those techniques were not as efficient when the problem was the movement of bulk goods. Italian businessmen had, over the tenth, eleventh and twelfth centuries, developed methods of generating capital, distributing risks and handling a diverse mass of cargoes going through a number of ports. That kind of multilateral trade, which at the simplest level was tramping from port to port, was common in the Mediterranean. It was not unknown in northern Europe but there trade typically meant moving a certain known cargo, a bulky cargo, from one port to another, the ports fixed by geography, and always at the same time of the year every year. These trades survived and prospered because of their very predictability. Back cargoes were established. Shipping dates were fixed. For example, in the North, ships wintered in certain ports and not just because of the difficulties of navigating but also because they were required to do so by laws which recognised the fixed nature of the seasonal bulk trades.[31] With such bulk trades, the existence of correspondents or agents at foreign ports was of little help in doing business. Merchants on board ship, who travelled with the cargo to look after the interests of merchants, needed only limited powers. In general, the

methods of the Italians offered little saving. Since ships were best suited to bulk trade and since bulk trade dominated commerce in northern Europe, the adoption of the new business methods was a slow process.

The trend towards government involvement in shipping and shipbuilding continued, especially in southern Europe. By the fourteenth century, governments had added much more to the scope of their activities. In Portugal, for example, not only was there a project for mutual insurance of all shippers but the king also granted privileges to shipbuilders to promote construction. The efforts were especially directed at building ships of over 100 tons, presumably so that Portuguese shippers could compete in bulk trades. The French government imported the building of Mediterranean-style light galleys to the North. The failure to go beyond that isolated government-sponsored imposition showed that it was impossible to declare a body of knowledge and techniques viable, except within a narrow framework and with continued support from the state. The introduction of the new technology seems to have had no noticeable effect in the North, with the possible exception of forcing the English government to follow the same practice in the short run. In Venice, by 1400, the government was not only building but also operating great galleys. The Venetian government in its shipbuilding policy was able to generate a demonstration effect on private builders, both in Venice and in the long run throughout much of Europe. The Arsenal at Venice was only the most famous of such institutions. It was the model for other government-operated wharves for building warships in Iberia and in France. The Arsenal at Venice offered an example of how to organise the business of shipbuilding not just for governments but also for private builders. Since men who worked in private shipbuilding also worked at the Arsenal and since the Arsenal performed a number of services for private shipbuilding yards, supplying them with cables and other parts when needed, local shipwrights had full access to knowledge of how to operate a big shipbuilding business. For such a complex operation methods of accountability were required. Book-keeping practice had to be borrowed from merchants. The Arsenal had to develop ways of recruiting necessary labour, at the right times. It was able to function with a kind of informality despite the great claims made on the institution in times of war; this continued into the sixteenth century despite major expansion in output and personnel.[32]

The Arsenal also brought together men with a high degree of technical skill. The task set by the government invited these men to exploit those skills, with a minimum of government interference in the execu-

tion of the technical side of their work. Since the institution, like its task, was a continuing one, shipbuilders at the Arsenal also had the problem of transmitting their knowledge and skill to each other and to their successors. Under such conditions, the first efforts were made to communicate about shipbuilding methods in something other than a verbal or personal way. Shipbuilders were forced to reconsider their approach to building and try to explain it both by word of mouth and in writing, at least in terms of the major proportions of the ships they built. Over the years the Arsenal increased the pressure on builders to organise their approach, resulting in the fifteenth century in written treatises on the art of shipbuilding. Over all, the example of the organisation and operation of the Venetian Arsenal and, to a lesser degree, similar institutions in other parts of Europe offered a guide for all shipbuilders and also for all departments of governments.

The change in the number of oarsmen in galleys presented new problems for the governments of Italian maritime republics and their competitors in the Mediterranean. The shift to three men to each bench meant an immediate 50 per cent increase in the manning requirement. The change in ship design dictated a change in the character of demand for seamen. Both the great galley and the cog needed fewer skilled seamen. The galley, though, needed more unskilled men, rowers. The status of oarsmen declined in the fourteenth century as their work became more specialised and menial. They were no longer expected to fight and trade and handle the sails or tiller. In fact, being an oarsman was taken more and more as a sign of inferiority. At the same time as the job was losing status, governments were faced with the task of finding more men for the navy. While in the thirteenth century the finding of crews to handle the oars was not a problem, after the Black Death and the fall in population labour was harder to find, especially for what was becoming a demeaning task. The rowers rowed less and crews were not kept up to the full complement. These could be only temporary stop gaps, however. By 1400 governments were still struggling with the problem of manning the galleys. It was well established that the manning of galleys, the fitting out and deploying of a fighting fleet, was inextricably interwoven with state power and with the general prosperity of the people in the Italian maritime states. That idea had been adopted in Iberia and to a certain degree in France as well, thus making it unquestionably the task of the government to find the men for the galleys.

The economic results of the Black Death, and especially the effects of the sharp drop in population on income per person and the distribution of income, continue to be the subject of debate. The development

of ship design in the fourteenth century appears to have contributed to the greater concentration of wealth, with certain merchants better off because of their ability to trade successfully in bulk goods. Improvements in bulk carriers, by promoting production for distant markets, concentrated incomes in the hands of those in the best position to produce goods for those markets. Those economic results are at best difficult to measure but they were probably insignificant compared to the direct demographic effect of the plague and the loss of one-third or more of the population. Ship-design improvements, on the other hand, did allow for the repopulation of towns. Given the nature of the pandemic, the death rate in towns was probably higher than that in the countryside. Towns did shrink as a result but by no means did urban life cease. Rather there was, as before, migration from the countryside into towns. Shipping contributed to that trend towards urbanisation in exactly the same way as it had from the ninth century. If anything, the process was accelerated in the fourteenth and fifteenth centuries, giving Europe a more urban character. Improvements in ship design also contributed to the changing relative income of the regions of Europe. Northwestern Europe ran a trade deficit with southern Europe, that is with Italy, and with the Baltic. In both cases England, northern France and the Low Countries bought more by value from those regions than they sold there. They did not have enough goods to cover the cost of furs and grains imported from the Baltic nor did they have goods to pay for the luxuries brought north by the great galleys. Cogs from Gdansk and galleys from Venice found back cargoes so that their operation was economically viable. Trade was possible and the goods had access to markets in northwest Europe. But since the ships were not suited to handle the type and bulk of goods which that region had to offer, the deficit had to be covered by an outflow of gold and silver.

The Black Death, both through its primary effect on population and its secondary effects on the economy, enhanced the position of monarchs. The kings and princes of western Europe found themselves able to consolidate their position and, from the mid-fourteenth century, economic circumstances worked to their advantage.[33] In order to carry out their programmes kings needed money, and ready cash was the best asset. Merchants and shippers had just the ready cash which governments needed. Italian city-states had long relied on the easily taxable income of such men for their own political strength. Rulers in western Europe in the fourteenth century increasingly copied Italian procedures, exploiting the possibilities created by trade. The most convenient situation was to have resident merchants, preferably prosperous and prefer-

ably native, who could be persuaded to support the crown through tax payments on their business and through loans. Native merchants were in a weaker position when it came to granting loans and the king could often simply force them to concede. If he repudiated the loans there was little the merchants could do. The easiest way to get the money, however, was to levy regular charges on a continuing flow of trade. If it went through a fixed point and was in fixed goods, supervision was simple and taxation could go ahead with a minimum of administrative cost and a minimum of loss from corruption. Moreover, the promotion and manipulation of such trade was easier for the clumsy governments of northern Europe which were only beginning to generate reliable systems of administration. The best situation for a king, then, was to be able to tax and control trade in some bulk good or goods. Indeed, something of a colonial economy based on the export, in large quantities, of a domestically produced good was the simplest, and therefore preferred, form of trade. It had the disadvantage of being less lucrative both for merchants and for tax collectors than trade in luxuries where the value was likely to be higher, but then luxury trade increased the possibility of avoidance. The changes in ship design worked to decrease that avoidance and at the same time to promote just the kind of trade that was easiest for governments to tax. By the end of the fourteenth century, trade in established commodities between certain ports was commonplace. Even in the Mediterranean that type of commerce increased. Certain ports there fared well under these circumstances. Monarchs who could and did tap the income from those trades were in general the ones most successful in the political contests, both internal and external, of the fourteenth and following centuries. These monarchs realised that the next step was, through legislation, to make sure that they got within their borders and preferably in the hands of domestic merchants as much of the available trade as possible. They achieved this through direct subsidy or more commonly through limitation on or exclusion of foreigners. Moreover, if kings could assert their legal authority over those merchants and the ships that carried the goods, then royal courts would enjoy an increase in power and income, both critical for European monarchs.[34] All this had the effect of generating greater government involvement in shipping and trade and therefore, directly and indirectly, in ship design. Further, the changes in ship design fed the economic strength of the monarchs and allowed them to devote themselves even more to that involvement. If nothing else, merchants, shippers and shipbuilders became more important to the political authorities. Thus the concern with the regulation of trade,

which had appeared in Italian port towns in the eleventh and twelfth centuries, became typical of all Europe.

NOTES

1. Margery K. James, 'The Fluctuations of the Anglo-Gascon Wine Trade during the Fourteenth Century', in E. M. Carus-Wilson (ed), *Essays in Economic History*, vol. II (St. Martin's Press, New York, 1962), pp. 125-50. E. M. Carus-Wilson, 'The effects of the acquisition and of the loss of Gascony on the English wine trade', *Bulletin of the Institute of Historical Research*, XXI (1947), pp. 146-9. Yves Renouard, 'L'exportation des vins gascons', *Histoire de Bordeaux*, vol. III (Fédération historique du Sud-Ouest, Bordeaux, 1965), pp. 254-7.

2. Bernhard Hagedorn, *Die Entwicklung der wichtigsten Schiffstypen*, pp. 17-21, 41-2. L. G. C. Laughton, 'The Cog', *MM*, XLVI (1960), pp. 69-70. Colin Platt, *Medieval Southampton: the port and trading community A.D. 1000-1600* (Routledge, London, 1973), p. 71. Walther Vogel, *Geschichte der deutschen Seeschiffahrt*, pp. 493-4.

3. The reconstruction of the Bremen cog continues at the Deutsches Schiffahrtsmuseum in Bremerhaven and more features of its construction will become clear as work progresses. *HSUA*, pp. 191-2. *FHMN*, p. 295. Siegfried Fliedner, 'Der Fund einer Kogge bei Bremen im Oktober 1962', *Mededelingen van de Nederlandse Vereniging voor Zeegeschiedenis*, VII (1963), pp. 8-16. Also see Siegfried Fliedner *et al.*, *Die Bremer Hanse-Kogge Fund Konservierung Forschung* (Verlag Friedrich Röver, Bremen, 1969).

4. H. S. Vaughan, 'The Whipstaff', *MM*, III (1913), pp. 232-6, IV (1914), p. 137. The Bremen find gives no indication of this improvement in steering gear, throwing into question the scope of the use of the innovation and the speed of its adoption.

5. Paul Heinsius, *Das Schiff der Hansischen Frühzeit*, pp. 134-5. Alan Moore, 'A Barge of Edward III', *MM*, VI (1920), p. 231; this long oared ship had a parrel for the yard. R. Morton Nance, 'The Ship of the Renaissance', *MM*, XLI (1955), p. 187.

6. A. H. De Oliveira Marques, 'Navigation entre la Prusse et le Portugal au début du XV^{e} siècle', *Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte*, XLVI (1959), pp. 477-90. Arthur Agats, *Der Hansische Baienhandel* (Carl Winter's Universitätsbuchhandlung, Heidelberg, 1904), pp. 16-53. A. R. Bridbury, *England and the Salt Trade in the Later Middle Ages* (The Clarendon Press, Oxford, 1955), pp. 25, 31-3, 38-58, 84-91; in the second half of the fourteenth century the political situation was especially advantageous for Bay salt producers and the Hansards were the first to capitalise on it. Walther Vogel, *Geschichte der deutschen Seeschiffahrt*, pp. 280-95.

7. Aksel E. Christensen, 'La Foire de Scanie', *Société Jean Bodin, Recueils*, V (1953), pp. 244-55; estimates of herring production and of the number of ships involved are not consistent. G. W. Coopland, 'A Glimpse of Late Fourteenth-Century Ships and Seamen from Le Songe du Vieil Pélerin of Philippe de Mézières (1327-1405)', *MM*, XLVIII (1962), p. 190.

8. Ole Crumlin-Pedersen, 'Cog-Kogge-Kaag', p. 132. *HSUA*, p. 190. Atle Thowsen, 'En studie i nord-norsk trebåtbygging', *Sjøhistorisk Årbok* (1966), pp. 38-57. This is a report of a find of a cargo ship of Norway, about 22 metres long, which shows all the features of modification.

9. The punt, still in use on some rivers, is of essentially the same design as the

pram. Ole Crumlin-Pedersen, *Das Haithabuschiff*, pp. 24-7. *HSUA*, p. 189. *FHMN*, pp. 95-6, 109-11.

10. F. C. Berkenvelder, 'Frieslands handel in de late Middeleeuwen', *Economisch-Historisch Jaarboek*, XXIX (1963), pp. 140-67. Walther Vogel, *Geschichte der deutschen Seeschiffahrt*, pp. 498-507.

11. Siegfried Fliedner, ' "Kogge" und "Hulk" ', pp. 67-9. Bernhard Hagedorn, *Die Entwicklung der wichtigsten Schiffstypen*, pp. 43-51. Paul Heinsius, 'Dimensions et Caractéristiques des "Koggen" Hanseatiques dans le Commerce Baltique', p. 19, and *Das Schiff der Hansischen Frühzeit*, pp. 210-18. Another type, the ewer, also grew in the thirteenth and fourteenth centuries so that it could be used on the high seas. It lacked many of the features of the hulk which allowed the latter type to compete effectively with large cogs. Dagmar Waskönig, 'Bildliche Darstellung des Holks im 15. und 16. Jahrhundert', *Altonaer Museum Jahrbuch*, VII (1969), pp. 140-1.

12. G. Asaert, *Westeuropese scheepvaart in de middeleeuwen*, p. 139. Philippe Dollinger, *La Hanse* (Editions Montaigne Aubier, Paris, 1964), p. 195.

13. Paul Heinsius, *Das Schiff der Hansischen Frühzeit*, pp. 218-25. He is mistaken in claiming a novelty in the flat bottom of the merged type since this was a distinguishing feature of cogs. Dagmar Waskönig, 'Bildliche Darstellung des Holks im 15. und 16. Jahrhundert', pp. 141-5.

14. Claude Farrère, *Histoire de la Marine Française* (Flammarion, Paris, 1962), pp. 14-23. Charles De La Roncière, *Histoire de la Marine Française* (Librairie Plon, Paris, 1909-20), vol. I, pp. 403-7. Armand Le Hénaff, *Etude sur L'Organisation Administrative de la Marine sous L'Ancien Régime et la Révolution* (Librairie de la Société du Recueil Sirey, Paris, 1913), pp. 18-27. G. La Roërie and J. Vivielle, *Navires et Marins*, pp. 91-3; galley fleets were especially large and numerous at the end of the thirteenth century when the French chose to establish a naval force to contest control of the Channel; obviously, the Mediterranean galleys made an impression on the French king, Philip IV. Louis Nicolas, *Histoire de la Marine Française* (Presses Universitaires de France, Paris, 1961), pp. 7-10.

15. J. T. Tinniswood, 'English Galleys, 1272-1377', pp. 276-315. R. C. Anderson, 'English Galleys in 1295', *MM*, XIV (1928), pp. 220-41. These galleys were clinker-built and had typical northern rig. They resembled Mediterranean galleys in little more than relative length. See also R. C. Anderson, 'The Oars of Northern Long-Ships', pp. 191-5. H. J. Hewitt, *The Organization of War under Edward III, 1338-62* (Manchester University Press, Manchester, 1966), pp. 87-92, 182-6, and *The Black Prince's Expedition of 1355-1357* (Manchester University Press, Manchester, 1958), pp. 33-42. Michael Prestwich, *War, Politics and Finance under Edward I* (Faber and Faber Ltd, London, 1972), pp. 137-48. J. W. Sherborne, 'English Barges and Balingers of the Late Fourteenth Century', *MM*, LXIII (1977), pp. 109-14. The largest fourteenth-century barge he found was of 300 tons, which was greater than many contemporary round ships.

16. Arthur Agats, *Der Hansische Baienhandel*, pp. 25-6. A. R. Bridbury, *England and the Salt Trade in the Later Middle Ages*, pp. 76-7. Charles-Emmanuel Dufourcq, *La Vie Quotidienne*, p. 80. The frequency of convoys depended on the level of danger. He compares the eastern and western Mediterranean.

17. L. A. Boiteux, *La Fortune de Mer*, pp. 34-8, 40-2, 65-89. F. E. DeRoover, 'Early Examples of Marine Insurance', *Journal of Economic History*, V (1945), pp. 172-87.

18. Barbara M. Kreutz, 'Mediterranean Contributions to the Medieval Mariner's Compass', pp. 371-5. L. Denoix, 'Les Problèmes de Navigation au Début des Grandes Découvertes', *TCHM*, III, pp. 132-5. F. C. Lane, *Venice*, pp. 119-20. D. W. Waters, *The Rutters of the Sea* (Yale University Press, New Haven, 1967),

pp. 8-12. E. G. R. Taylor, *The Haven-Finding Art*, pp. 98-138.

19. G. W. Coopland, 'A Glimpse of Late Fourteenth-Century Ships and Seamen', p. 191. Patrick A. Beaver, *A History of Lighthouses* (The Citadel Press, Seacaucus, New Jersey, 1973), pp. 12-18. F.C. Lane, 'The Economic Meaning of the Invention of the Compass', pp. 607-14. W. E. May, *A History of Marine Navigation*, pp. 50-1, 176-81, 203-4, 213-15. Uwe Schnell, 'Bemerkungen Zur Navigation auf Koggen', *Jahrbuch der Wittheit zu Bremen*, XXI (1977), pp. 137-48.

20. G. Asaert, *Westeuropese scheepvaart in de middeleeuwen*, pp. 56-60, 137. F. C. Lane, *Navires et Constructeurs à Venise*, pp. 6-7, and 'Tonnages, Medieval and Modern', pp. 230-2. Archibald R. Lewis, 'Northern European Sea Power and the Straits of Gibraltar', pp. 158-60. E. B. Fryde, 'Anglo-Italian Commerce in the Fifteenth Century: some evidence about profits and the balance of trade', *Revue Belge de Philologie et d'Histoire*, L (1972), pp. 345-51.

21. Romola and R. C. Anderson, *The Sailing-Ship*, pp. 113-14. F. C. Lane, *Navires et Constructeurs à Venise*, pp. 14, 19-22, 222, 'Progrès technologiques et productivité dans les transports maritimes', pp. 293-4, and 'Venetian Naval Architecture about 1550', *MM*, XX (1934), pp. 181, 189. Michael E. Mallett, *The Florentine Galleys in the Fifteenth Century with the Diary of Luca di Maso degli Albizzi Captain of the Galleys 1429-1430* (The Clarendon Press, Oxford, 1967), pp. 24-9.

22. John Francis Guilmartin, *Gunpowder and Galleys* (Cambridge University Press, Cambridge, 1974), pp. 69-70. F. C. Lane, 'Tonnages, Medieval and Modern', pp. 230-1. The word arsenal is of Arabic origin and was used throughout the Christian Mediterranean to describe a government yard for building warships.

23. F. C. Lane, *Navires et Constructeurs à Venise*, pp. 93-7, 125-9. Up to the mid-fourteenth century the largest great galleys were built in private yards. See also F. C. Lane, 'Venetian Merchant Galleys, 1300-1334: Private and Communal Operation', *Speculum*, XXXVIII (1963), pp. 191-4, 200-3. Jacques Heers, *Gênes au XV^e Siècle* (SEVPEN, Paris, 1961), pp. 270-1. The Genoese did not use great galleys but rather built eight or twelve light galleys for the navy when war broke out. The light galleys were much the same as their Venetian counterparts.

24. G. W. Coopland, 'A Glimpse of Late Fourteenth-Century Ships and Seamen', p. 188. R. Morton Nance, 'An Italian Ship of 1339', *MM*, I (1911), pp. 334-9, and 'The Ship of the Renaissance', pp. 180-4. Marco Bonino, 'Lateen-rigged Medieval Ships', pp. 15-17, 22-5.

25. Siegfried Fliedner, ' "Kogge" und "Hulk" ', pp. 89-90. Bernhard Hagedorn, *Die Entwicklung der wichtigsten Schiffstypen*, pp. 39-40. Paul Heinsius, *Das Schiff der Hansischen Frühzeit*, pp. 78-9. Charles-Emmanuel Dufourcq, *L'Espagne Catalane et Le Maghrib*, pp. 40-5.

26. G. Asaert, *Westeuropese scheepvaart in de middeleeuwen*, p. 60. Michel Balard, 'Notes sur l'Activité Maritime des Génois de Cagga à la Fin du XIII^e Siècle', *TCHM*, VIII, pp. 379-80; in the 1290s Genoese merchants were using large and medium-size round ships for long-distance bulk carriage from the Crimea to Syria, Tunis and Genoa. Jacques Heers, *Gênes au XV^e Siècle*, pp. 274-8, 316-20, and 'Types de Navires et Spécialisation des Trafics en Méditerranée à la Fin du Moyen Age', *TCHM*, II, pp. 110-15. F. C. Lane, *Navires et Constructeurs à Venise*, pp. 43-5. Henri Bresc, 'Una flotte mercantile periferica: la marina siciliana medievale', in Henri Bresc *et al.*, *Studi di storia navale*, Centro per la storia tecnica in Italia, Pubblicazioni, IV, 7 (1975), p. 9; in 1367 a Genoese shipwright had to be brought to Messina to oversee construction of a *cocka*. F. C. Lane, *Venice*, pp. 122-4. By 1400 Genoese cogs even reached 1,000 tons. Venetians were held back from building such giants by the shallowness of their harbours. Still, by the mid-fourteenth century *cocka* was the usual term for a large

round ship in Venice.

27. Antonio de Capmany, *Memorias Historicas sobre la marina commercio y artes de la antigua ciudad de Barcelona*, vol. III, pp. 81-90. Jacques Heers, *Gênes au XV^e Siècle*, pp. 245-6, and *L'Occident aux XIV^e et XV^e Siècles* (Presses Universitaires de France, Paris, 1963), pp. 103-4. F. C. Lane, *Navires et Constructeurs à Venise*, pp. 35-7, and 'Progrès technologiques et productivité dans les transports maritimes', pp. 290-2. He suspects that crew size did not fall as much as possible because of the need to protect against pirates and that much of the saving in operating costs was lost because of longer turnaround time. Both features certainly reduced the social saving that could be gained from using the cog. This did not alter the fact that labour saving was great enough over many routes to make it worth while for shippers to change to cogs. Charles-Emmanuel Dufourcq, *L'Espagne Catalane et Le Maghrib*, pp. 531-40.

28. F. C. Lane, 'The Crossbow in the Nautical Revolution of the Middle Ages', in D. Herlihy *et al.* (eds), *Economy, Society and Government in Medieval Italy, Essays in Honor of Robert L. Reynolds* (Kent State University Press, Kent, 1969), pp. 161-72.

29. Romola and R. C. Anderson, *The Sailing-Ship*, pp. 110-12. Siegfried Fliedner, ' "Kogge" und "Hulk" ', pp. 91-2. F. C. Lane, *Navires et Constructeurs à Venise*, pp. 39-40. R. Morton Nance, 'The Ship of the Renaissance', pp. 180, 187-9.

30. Eugene H. Byrne, *Genoese Shipping in the Twelfth and Thirteenth Centuries*, pp. 12-14, 65-6. The major examples for the trend come from Genoa. Venice, by government policy, purposely prevented extreme concentration of ownership. It is hard to believe that the pattern was not similar outside Genoa. Jacques Heers, *Gênes au XV^e Siècle*, pp. 279-82, 288. F. C. Lane, 'Venetian Merchant Galleys, 1300-1334', p. 203.

31. G. Asaert, *Westeuropese scheepvaart in de middeleeuwen*, p. 120. Arthur Agats, *Der Hansische Baienhandel*, p. 25. In the fifteenth century, the Hanseatic League slowly abandoned legal prohibitions on winter sailing, largely because their competitors enjoyed greater flexibility in providing shipping services.

32. L. A. Boiteux, *La Fortune de Mer*, p. 40. W. A. Englebrecht, *Schets der Historische Betrekkingen Portugal-Nederland*, pp. 5-6. Gervasio de Artiñano Y de Galdácano, *La Arquitectura Naval Española (en Madera)* (for the author, Madrid, 1920), p. 18. F. C. Lane, *Navires et Constructeurs à Venise*, pp. 141-66. Bailey W. Diffie, *Prelude to Empire*, pp. 67-9.

33. Jacques Heers, *L'Occident aux XIV^e et XV^e Siècles*, pp. 191-5. Harry A. Miskimin, *The Economy of Early Renaissance Europe, 1300-1460* (Prentice-Hall, Inc., Englewood Cliffs, NJ, 1969).

34. Edwin M. Bacon, *Manual of Navigation Laws* (A. C. McClurg and Co., Chicago, 1912), pp. 9-14. Fredric L. Cheyette, 'The Sovereign and the Pirates, 1332', *Speculum* XLV (1970), pp. 40-68.

NOTES TO ILLUSTRATIONS

a. *AB*, no. 177. G. Asaert, *Westeuropese scheepvaart in de middeleeuwen*, pp. 89, 109. *HSUA*, pp. 202-3. *FHMN*, p. 66. Siegfried Fliedner, ' "Kogge" und "Hulk" ', nos. 107-10.

b. Romola and R. C. Anderson, *The Sailing-Ship*, pp. 87-8, 91. G. Asaert, *Westeuropese scheepvaart in de middeleeuwen*, pp. 31, 38, 94. *FHMN*, p. 65. Bernhard Hagedorn, *Die Entwicklung der wichtigsten Schiffstypen*, plates III, VI-XII. Paul Heinsius, *Das Schiff der Hansischen Frühzeit*, pp. 23, 55-7, 59-62,

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