The Evolution of the Nautical Chart

13th to 19th Century

Assignment 3
CART3024 Seminars in the History of Cartography

by

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Introduction

As with most of man's early activities, the early beginnings of the nautical chart is lost to antiquity. There is much speculation and disagreement about its exact origins. Some believe that there is sufficient evidence to conclude that, like so many other things, it arose out of a long, slow journey of discovery. On the other hand, some believe that the transition was sudden. Regardless, what occurred was the evolution of a new and better means of conveying information and, in the process, changing man's perception of the world. A process that continues today.

A Time Before Charts

Although the use of a graphical language to communicate a "picture" of the world had been known and used by man for many centuries, the focus seems to have been primarily on its landmasses, and the purposes and methods as were not well suited to the mariner. For example, the Greek representations of their theories on the composition of the world, which culminated in the works of Ptolemy, resulting in a world-view that, outside the Mediterranean, bore little resemblance to reality. This resulted in the fantastic misrepresentation of the size of the globe and the shape, number and location of the continents. The Romans, on the other hand, were more interested in the practical application of cartography. Their cartographic legacy lay in the use of maps for conquest, settlement and, to a more limited degree, exploration. They left us cadastral and route maps. Other cartographic styles were of even less value to the mariner, particularly those based in theology. During the medieval period, the Roman Catholic Church vigorously promoted its view of the world, resulting in the T-O map and the mappaemundi (Jourdin 8-11).

This drove mariners to devise their own maps, suited to their purposes, that of moving about the Earth on the surface of the seas and oceans. This was a more practical "view" of the world. Early solutions to this problem appeared in narrative form in what is known as a *portolano*, or what we would call today, Sailing Directions. The first extant printed copy of a *portolan* was published in Venice in 1490 (Robinson 16). These were narrative descriptions of routes to the various ports of call around the known world, primarily around the Mediterranean and Black Seas. Point-to-point descriptions were provided that included direction, time and land features. A great deal of judgement and skill, combined with local knowledge, must have been necessary, for the course to steer, in particular, was based on a very crude system of wind direction, which changed from place to place. This early directional system evolved slowly and was based on purely practical reasoning. In a time prior to the modern concept of north and south, east and west, direction was based on natural phenomenon, such as the direction of the source of light, i.e. the sun, or the direction of prevailing winds. Hence, direction was describe in terms of "The Darkness" (north), "The Light" (south), "Morning" (east), and "Evening" (west). These primary directions were sub-divided into a further four directions, based on seasonal sunrise and sunset.

However, for the mariner, wind direction can be as, if not more important, than the direction of the sun. Thus arose the concept of the wind rose. Like other places on the Earth, the Mediterranean has seasonal, prevailing winds. For the ancient mariner, it was natural to describe a route from one place to another in relative terms to the prevailing wind, assigning names to each of the winds. This system was refined over time, with the four primary, or cardinal, points being defined as north, south, east and west. At various times throughout history, the total number of points has varied, at times being eight or twelve, eventually settling and increasing to thirty-two. However, for the early mariner, there were only eight or twelve directions to follow, and with distance measured in terms of days of sailing, navigating around the ancient world must have been tricky at best (Brown 122-126.

The lot of the ancient mariner began to change for the better with the introduction of the magnetic compass. Although the properties of lodestone were known to the ancient Greeks, its usefulness as an aid to navigation was not introduced into the region of the Mediterranean until the in the latter part of the thirteenth century. Although there is some controversy about the exact means by which the compass arrived in Europe, it is certain that it was in large part due to the efforts of a French military engineer by the name of Petrus Peregrinus. In 1269 Peregrinus undertook a detailed study of the properties of lodestone, later describing his finding, including how to determine the north and south poles, and setting out his design for a box compass, in a 3500 word exposition to a friend. Not long afterward, the wind rose was combined with Peregrinus' compass to give us the compass rose we are familiar with today (Brown 126-131). All this, the existence of the portolano and development of the compass, set the scene for the development of the *portolan* chart, a sea chart based on the portolano.

The Evolution of the Sea Chart

The earliest know example of a portolan chart is the Carte Pisan or Pisane, generally accepted as dating from the year 1290. Although there is some disagreement regarding its origins and method of construction, it is evident that, when compared to maps of the same period, it is a practical effort to portray the world. Its intended purpose was the solution of the real-world problem faced by mariners, that of navigating around the world's oceans and seas, through the practical application of geographic knowledge. The accuracy of the depiction of the Mediterranean and Black Seas was such that contemporary maps paled by comparison. An outline that would remain unchanged until c. 1529, when Diogo Ribeiro corrected the east-west axis of the Mediterranean, correctly aligning Gibraltar and Cyprus on the 36^{th} parallel.

The vast majority of portolan charts were drawn on vellum for reasons of durability. The basic method began with the construction of a series of wind roses, arranged in a radial pattern around a central wind rose, effectively forming a network of rhumb-lines. This provided the mariner with a multitude of wind directions on which to base his course (Jourdin 12-13). This method of construction became known as *Plane Chart*. Although this is a very practical approach from the perspective of the sailor, it introduced an error caused by the failure to account for the curvature of the Earth. These inaccuracies were exacerbated by a tendency on the part off the chart-makers to use a non-proportional construction grid, wherein the ratio of the dimensions of the grid square or rectangle may have been set at 1:1, but was routinely set at 1:2, wherein 1° of latitude = 2° of longitude. It is speculated that the shape of the vellum drove this practice. However, the ratio was constant across the chart (Whitfield 44-6). This practice prevailed until the wide-spread adoption of the Mercator projection as a result of a treatise entitled *Certain Errors of Navigation* by the English mathematician Thomas Wright, which he published in 1599. As an accompaniment, Wright included his *Mercator World Chart*, which helped popularize the Mercator projection amongst mariners.

One of the greatest challenges for chart and map-makers during this period was that, although the mathematical theory existed from the time of the Greeks to create properly projected maps and charts, the ability to measure the physical features of the Earth did not (Whitfield 9). The fundamental method employed during marine surveys from the late seventeenth century onward was a *running traverse* (Whitfield 19) during which a series of angles to land features were measured and used to determine their geographic location using a process called *resection*. This method of survey is very quick, but highly dependent on the ability to accurately measure time, speed and direction (Robinson 15 & 53-4). Despite these limitations, its use persisted well into the eighteenth century by the likes of James Cook and George Vancouver (Whitfield 107-113).

The process begins with determining the position of the ship. For the most part, this was accomplished by a method of navigation known as *dead reckoning*. Dead reckoning involves the use of time, speed and direction, whereby the ship's progress is plotted from a know location, along a measured course, at a determined speed, for a measured time. The speed and time allow the navigator to calculate the distance travelled along the course, thus establishing the ship's current position.

The weakness of this method begins with the determination of the ship's initial location. Ideally, its was determined from a known location ashore. The next step was to determine the ship's speed. The first step in this process was to determine how much time that it took for the ship to traverse a known distance. This was accomplished with the use of a knotlog. To do so, a float was placed in the water at the bow of the ship and the time taken for the ship to sail a known distance past it was measured. At the same time, the ship's course was determined using a compass that, until the use of degrees for the measurement of direct came into vogue in the nineteenth century, was measured to the nearest point of the compass, an accuracy of 11.25°. The distance travelled could be determined from the ship's speed and time, which was then plotted along the course line from the last known position, thus yielding the ship's current position. Obviously, any errors would have a tendency to accumulate.

The next step in the process of running a traverse was the determination of relative bearings from the ship to the land feature. Again, the accuracy of the bearing was subject to the limitations of the instruments, a situation that improved considerably with the invention of the modern quadrant in 1731, followed by the sextant in 1757 (Whitfield 102).

Another, and more accurate method of determining a ship's location is the determination of its position in terms of latitude and longitude. This geographic co-ordinate system had been in use since the time of the Greeks, but was ignored by chart-makers until c. 1500 (Whitfield 7 & 40). The reason for this may have been the difficulty of using astronomical instruments at sea, their expense and a general lack of education in the science of navigation. A further hindrance was the difficulty in accurately determining longitude. A problem that remained unresolved until the development of an accurate and dependable marine chronometer by John Harrison in 1760, followed closely be the publication of a set of lunar tables by Nevil Maskelyne, Astronomer Royal, in 1765 (Whitfield 102). Harrison's chronometer permitted the determination of an accurate time differential between the ship's location and the prime meridian, thus allowing the calculation of the longitude of the ship's location.

After the determination of the ship's location and relative bearings to land features, a resection to those features could be made using bearing measured at a succession of positions, thus determining their geographic location. Without doubt, the accuracy of all these measurements greatly affected the accuracy of the position of the land features thus determined, consequently influencing the accuracy of any charts developed based on this data.

The development of the sea chart began to accelerate when the Portuguese lead a "break-out" from Europe at the beginning of the Age of Discovery. Prior to this, it was the Venicians and the Genoese, by virtue of their near monopoly in trade activities in the eastern Mediterranean and with China via the overland routes, who dominated in the production of portolan charts. However, as Portuguese and Spanish efforts to establish alternative routes to the Far East in an effort to circumvent the Muslim occupied Middle East, other schools of chart production were established in Catalan-Majorca (Whitfield 15 & Jourdin 23-4). The striking difference between the two schools was the use of embellishments and the inclusion of other geographic features, such as inland lakes, rivers and mountain ranges, by the Catalan school, which was in stark contrast to the austere style of the Italians. Although the debates over who influenced whom, and who was the first to include a certain innovation are ongoing and unresolved, it is evident that the influence and dominance of one school over the other changed several time over the course of time (Dilke 292-8).

During the early stages of the Age of Discovery, geographic information was considered of such great value that official policies for restricting the distribution of charts were enacted. This was particularly true of Portugal, which may explain the relative rarity of Portuguese charts prior to the sixteenth century (Jourdin 26). However, by 1750 the gap between secret and published data was so negligible that these policies were abandoned and states began to offer charts for sale to the public (Whitfiled 91).

As the balance of power shifted to the central European countries of France and Holland, so too did the production of sea charts. The French established a school of chart-makers at Dieppe in 1540 (Whitfield 54). This school proved to be exceptionally prolific, having produced more than two hundred charts between 1534 and 1587 (Jourdin 30). However, the quantity of production did not come at the expense of quality. The Dieppois closely followed the development of Portuguese chart-making, steadily surpassing the Portuguese in the accuracy and currency of the geographic content of their charts. This was particularly true of their depictions of North America, for which they drew upon the reports of Giovanni da Verrazano and Jacques Cartier.

In the meantime, the Dutch were making a concerted effort to displace the Portuguese in the Far East. In 1593, Jodocus Hondius established his cartographic workshop in Amsterdam, which was amongst the leaders in the establishment of the Dutch cartographic school. Additional workshops appeared, most notably in Edam, Warder and Enckhuysen, from which Lucas Janszoon Wagenaer published his *Spieghal der Zeevaert* (Mirror of Navigation) in 1584. This collection of forty-four coastal charts of European waters ushered in a new era for the sea chart. It spanned the coast from the eastern Baltic to the Straits of Gibraltar; offering the mariner sailing directions, profile views and, most importantly, depth soundings, measured in fathoms reduced to mean half-tide values, the first to do so. As well, it utilized a system of standardized symbols for the depiction of an anchorage, landmarks, and shoals and rocks. However, Wagenaer neglected to include either rhumb-lines and latitude or longitude, thereby rendering the charts projectionless,. Furthermore, despite having included a scale, he failed to adhere to it (Jourdin 32 & Whitfield 67-9). Despite these drawbacks, Wagenaer's work became a favourite of English sailors for almost a century, among whom it, and all others like it, became known as *waggoners* (Howse and Sanderson 11).

Wagenaer's work was quickly followed up by Willem Blaeu's *Licht der Zeevaart* (Light of Navigation) in 1608. Blaeu's portolan atlas contained forty-two charts of northern and western Europe. He made better use of scale, thereby achieving greater accuracy in the depiction of coastlines. He too included sailing directions and coastal profiles but, unlike Wagenaer, chose to included rhumb-lines and a latitude bar, but not a longitude bar.

What made the activities of the Dutch chart-makers particularly unique was the fact that very early on, Dutch companies engaged in overseas trade established and maintained hydrographic services offices. For example, the Dutch East India Company's hydrographer was responsible for the collation of all incoming information from Dutch mariners employed by the company, updating the chart record, and publishing for commercial sale the charts produced by the company (Whitfield 89-91).

The production of chart atlases continued throughout the seventeenth century, peaking with van Keulen's atlas *Zee-Fakkel* (Sea Torch), which first appeared in 1681. It grew to contain almost 400 charts, all drawn using the Mercator projection, covering all the oceans and seas of the known world (Whitfield (91).

The methods of gathering geographic data did not change significantly until the end of the seventeenth century when France established its royal academy of sciences and royal observatory. As a consequence, France was able to develop methods of measuring an arc of longitude, accurately determine longitude by observation of the moons of Jupiter, and create a triangulated network throughout the country. This allowed for the accurate determination of topographic features, including coastal features. The effect was that France, at the end of the seventeenth century, had the most accurate charts of any country in Europe (Whitfield 95-6). Subsequent to this, under King Louis XIV's minister Jean Baptiste Colbert, *Le Neptune François* was published in 1693 in Paris by Charles Pène, and, according to Peter Whitfield, contained an unprecedented level of hydrographic information (82 & 96).

Despite her early beginnings as an exploring nation and the driving factors of defence and commerce (Robinson 25), Britain did little in the way of domestic chart-making. Despite a lack of government policy, a school of manuscript chart-makers did established itself in London's dockland. This school was active from c. 1600 to the 1690's, producing few original charts, instead being content to copy the work of foreign chart-makers, particularly the Dutch (Whitfield 92).

The situation in Britain began to change in 1681 when Captain Greenvile Collins was commissioned to make the first official survey of the British coasts (Whitfield 95), likely employing similar method as those detailed by John Love in his book *Geodaesia* (Art of Surveying) of 1688 (Robinson 53-4). This effort resulted in the publication of *Great Britain's Coasting Pilot* in 1693, a landmark in British hydrography. The Coasting Pilot contained forty-eight charts, but unfortunately did not employ any method of topographic survey, thereby causing the charts had to be produced as plane charts: without latitude and longitude.

Not long afterward, France took the significant step of establishing its Depôt des Cartes et Plan de la Marine (Hydrographic Office) in 1720 (Whitfield 96). Under the tutelage of Jacques Nicolas Bellin as the Ingénieur Hydrographe de la Marine from 1741-1771, the Neptune François was expanded and the publication of the *Hydrographie Françoise* commenced, consisting of a series of world-wide charts (Whitfield 96 & 105). French charts of this period contained not only hydrographic information, but a significant amount of topographic information. As a result, Whitfield contends, they could be considered dual-purpose maps (96).

By the mid-eighteenth century, the theory and practice of nautical survey in Britain was being taken more seriously, as evidenced by the publication of the first English books on maritime surveying by Alexander Dalrymple and Murdock Mackenzie (Whitfield 105). Dalrymple's book was entitled *Essay on Nautical Surveying*, which was published in 1771 (Whitfield 114). Mackenzie, who spent a goodly number of years surveying the west coast of England and the coast of Ireland (Robinson 60-3), is further credited with developing the station pointer, a nautical instrument used to quickly fix a ship's position using two sextant angles (Whitfield 105). This work laid the foundation upon which James Cook would base his surveys of North America and the Pacific region.

As a young naval officer, James Cook partook in the British campaign against Quebec in 1759. His contribution to the success of the campaign cannot be understated as it was his survey and charting of the St. Lawrence River that allowed the British fleet to sail up-river to the ramparts of Quebec. Cook spent the next eight years refining his skills, charting Nova Scotia and Newfoundland. In 1768, he was dispatched to the Pacific where, over the course of the next eleven years he would undertake three voyages, making significantly additions to the body of geographic knowledge of the west coast of North American and the Pacific region (Whitfield 107-110).

During his voyages of exploration, Cook was training the next generation of explorers and cartographers; men such as George Vancouver and William Bligh. While Bligh turned out to be a better surveyor and cartographer than ship's captain, George Vancouver went on to further explore and chart the west coast of North America from 1792-1794 (Whitfield 113).

While Cook was surveying and charting the Pacific, a contemporary and colleague by the name of Joseph Des Barres was busy surveying the east coast of North America from Nova Scotia to as far south as the Gulf of Mexico. Des Barres was a British military engineer of Swiss origin who "lived to be the oldest mapmaker known to history." He spent twelve years surveying and the following ten years compiling charts his charts, eventually publishing them as the *Atlantic Neptune* commencing in 1777 (Whitfield 111-113).

In 1795, the British Admiralty followed the lead of the French and Dutch in establishing its Hydrographic Office. Its first Hydrography was Alexander Dalrymple. Under Dalrymple, chart production was slow to say the least, there being only one chart published in 1800, followed by a further ten in 1810. This was understandable to some degree, given that Dalrymple's first order of business was to inventory the charts possessed by the Admiralty.

Captain Thomas Hurd succeeded Dalrymple in 1808. Under Hurd there was a marked increase in the productivity of the Hydrographic Office. By 1825 the Admiralty catalogue of charts contained a listing of 736 charts and, by 1828, the Admiralty was compiling and publishing tide tables, list of lights, and, Sailing Directions. The Admiralty began offering charts for general sale in 1823 (Whitfield 113-114).

During the nineteenth century, British charts began to include subdivided latitude and longitude borders, a greater density of soundings, and bottom data. Parallels of latitude and meridians of longitude replaced rhumb lines. Compass roses were simplified and modified to show both true north and magnetic north. By the end of Admiral Beaufort's tenure as Hydrographer to the Navy, British charts were highly regarded for their accuracy, extensive world coverage and fine engraving. Thus, the standard was set for the production of nautical charts for a good number of years (Howse and Sanderson 13).

Conclusion

Throughout history, the story of the sea charts has been one of a practical solution to an everyday problem. The portolan chart likely arose as the result of the sea captain's need for a better guide to his trading destination. However, it had to be simple and easy to use, thus the inclusion of rhumb-lines to allow for the calculation and setting of courses. Even the material with which it was made, vellum, was born of a need to survive the harsh conditions encountered at sea. A practice that resisted change until the seventeenth century,. The nautical chart evolved in response to demands for greater accuracy and information, coming to include more topographical, bathymetric and oceanographic information. An evolution that continues to this day with moves toward international standards and methods for the inclusion of seabed imagery. A never-ending process of problem-solving.

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