THE EVOLUTION OF SYMBOLS ON NAUTICAL CHARTS PRIOR TO 1800

by

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ABSTRACT

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This study attempts to determine the way in which symbols evolved on nautical charts, the identity of originators of these symbols, the spread in their use, and the forces involved in their continuing evolution. A twofold approach is utilized to resolve these questions. First a history of nautical charts prior to 1800 is presented and second, the actual examination of over 4200 nautical charts was carried out to discover and document their symbol content. A graphic summary of the symbols used on these charts is presented along with an analysis of the data gathered in light of the history of nautical cartography. The evolution of the symbols on nautical charts was found to be closely aligned with one of the three types of symbols described by Dreyfuss (1972): arbitrary, abstract or representational. The arbitrary symbols examined in this study clearly went through an evolutionary process, whereas the abstract and representational symbols remained virtually static throughout the period. The originators of the symbols are given when identifiable and the spread and evolution of the symbols is discussed. From this study it can be concluded that this type of research is most valuable in discovering the evolution of symbols on nautical charts and that the graphic summary could be considered a standard for evaluating the evolution and use of symbols on nautical charts prior to 1800.

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Chapter 1

INTRODUCTION AND METHODOLOGY

> One of the more challenging problems in the study of the history of thematic cartography is the attempt to unravel the manner in which some of the common symbols evolved, who originated them, how their use migrated from one area to another, and what forces were involved in their origin, spread and increasing sophistication (Robinson, 1971, 49).

A literature review of the history of nautical charts substantiates that there has been no extensive systematic study of the evolution of symbols on nautical charts. Numerous authors, including Smith (1969), Mota (1962) and Osley (1969), have traced the work of early cartographers and produced fine biographical works about their lives. Koeman (1970) and others have compiled excellent cartobibliographies. However, discussion by authors of the first appearance of a particular symbol on a nautical chart has been brief and with little substantiation. Ritchie (1976) and Howse and Sanderson (1973) are among those who have made such references. This study attempts to detail the evolution of symbols on nautical charts prior to 1800 based on a systematic examination of portolan charts and the charts contained in both sailing directions and nautical atlases.

Fundamental to the framework of this study is an understanding of the terms "nautical chart" and "symbol." A definition of each of these

terms is therefore in order.

A nautical chart is "a chart intended primarily for marine navigation" (U. S. Naval Oceanographic Office, 1966, 937). A portion of a modern nautical chart is shown in Figure 1.

Charts differ from maps in that whereas maps are intended to be read or looked at, charts are intended to be used (Ristow and Skelton, 1977, 11). The safety of lives and ships are dependent on accurate charts which show correct and complete information in a clear and intelligible form (Putnam, 1908, 23). It is also important to point out that "charts have always been and still are used by sea captains, pilots, sailors and other seafarers who are experienced at sea" (Koeman, 1964, 48).

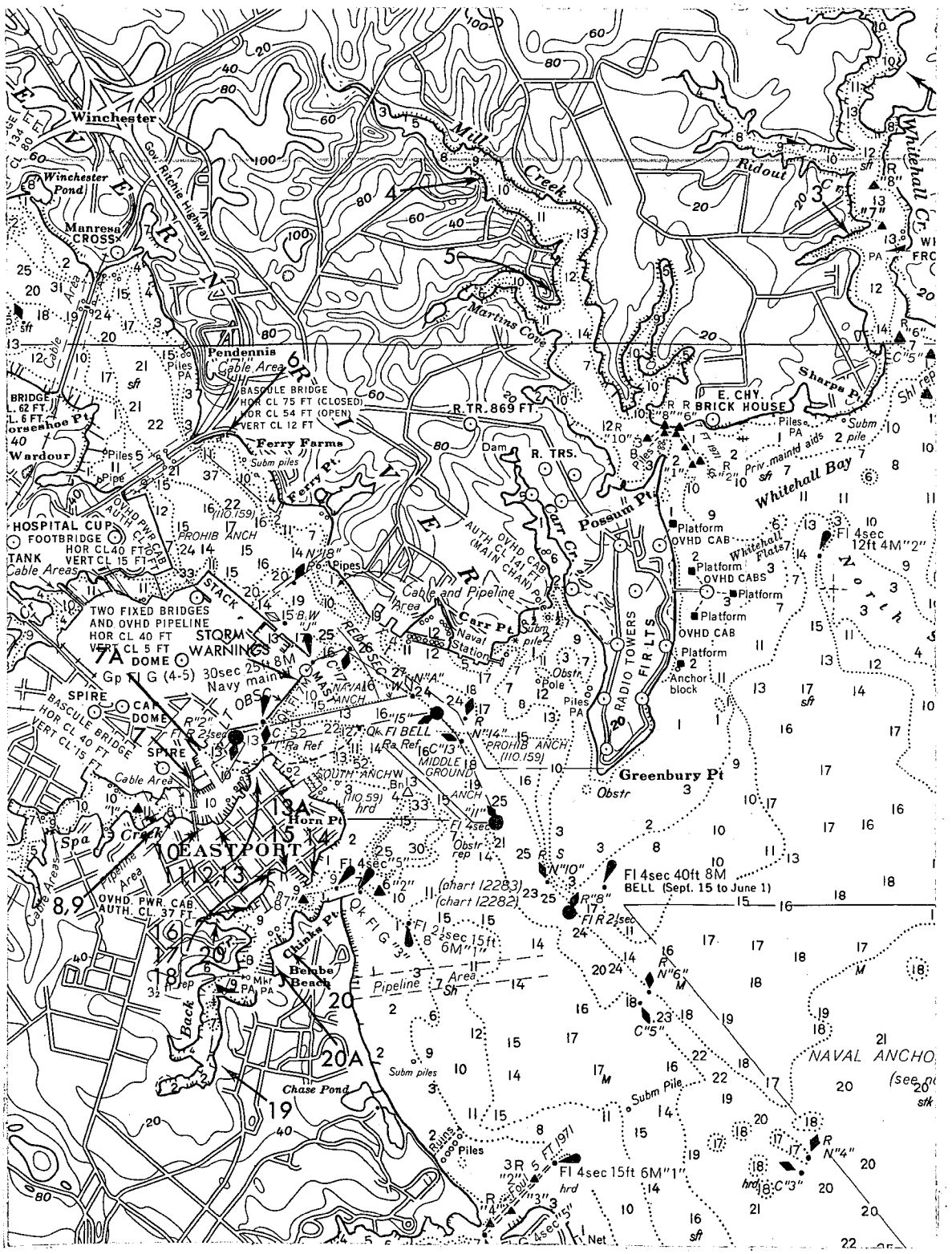
A symbol is "a written character or mark used to represent something; a letter, figure, or sign conventionally standing for some object, process, etc." (Dreyfuss, 1972, 19). "In cartography, symbols are the graphic marks by which communication is established between the map maker and the map user" (Robinson, 1971, 49).

Dreyfuss (1972, 20) has divided symbols into three categories. They may be described as being representational, abstract, or arbitrary. Representational symbols present a simplified yet fairly accurate picture of objects or actions. Abstract symbols reduce essential elements of a message to graphic terms. Although abstract symbols may have started out as representational, over a period of time they have been greatly simplified. Arbitrary symbols are those that are invented and must be learned.

The information portrayed by the symbols shown on the nautical charts of interest to this study are of two types. The symbols are either to depict a danger to navigation or an aid to navigation. In the

Figure 1

PORTION OF CHART 12271



first category falls such obstructions as rocks and shoals. In the second category are lighthouses, safe anchorages, buoys and beacons. In representing these types of information the symbols shown on nautical charts fit into one of the three categories of symbols as described by Dreyfuss (1972).

The Aim and Scope of this Study

This research will attempt to answer some of the questions posed by Robinson (1971, 49). How did the symbols on nautic charts evolve? Who originated them? What was the order of their migration from one area to another? What forces were involved in their origin, spread and continuing evolution?

To answer these questions it is necessary to divide this study into two parts. The first part is a brief history of nautical cartography prior to 1800. This history will highlight the factors influencing the development of symbols. The second part is the examination of nautical charts over a period of time from the earliest chart available, in this case the facsimile of the 1325 Dalorto portolan chart, through the many charts in sailing directions and nautical atlases up to 1800. The result of this survey of nautical charts will be a graphic tabulation of the occurrence of symbols on the charts examined.

This study is limited to the time period up to 1800 for three reasons. First, by approximately 1800, the three major charting countries in the world had set up hydrographic offices to prepare and publish nautical charts. The French established their Dépôt des Cartes et Plans in Paris in 1720 (Putnam, 1908, 10); the first hydrographer of the British Admiralty was appointed in 1795; and in 1807 the United States established the U. S. Coast and Geodetic Survey (Jones, 1923, 4). With

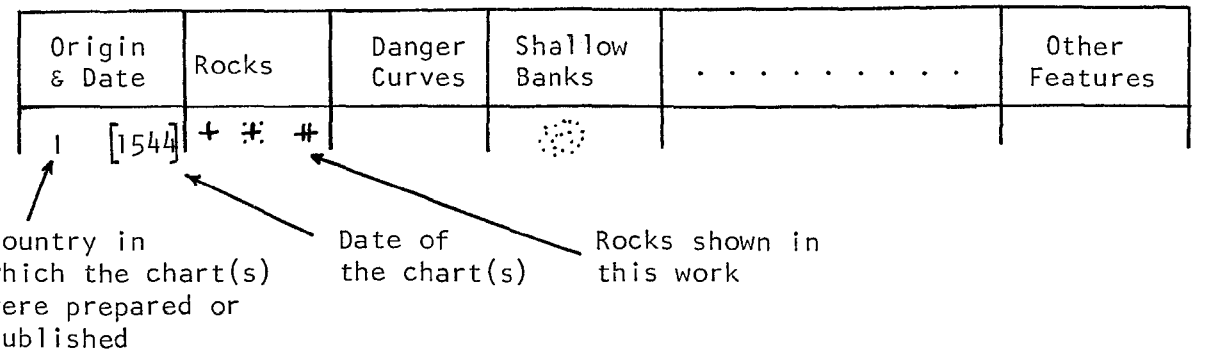
the creation of these government offices came the intoduction of standardized symbols on nautical charts. Secondly, the period just after 1800 saw an increasing trend toward the separation of sailing directions and nautical charts. Thirdly, the number of charts appearing after this date increases rapidly. This study is concerned, therefore, with the evolution of the symbols on nautical charts prior to 1800 which were to become, in fact, the standards.

Methodology

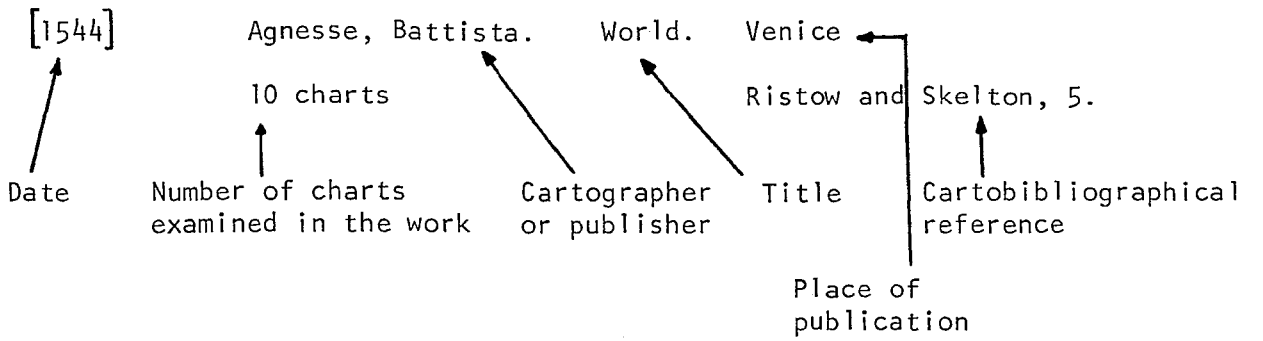
The four questions posed in the previous section will be answered through a visual examination and tabulation of the symbols shown on portolan charts and the nautical charts contained in sailing directions and nautical atlases. Each chart will be visually scanned from left to right, starting at the top. A magnifying glass will be used, when needed to aid in locating and distinguishing the symbols. The following information will be recorded for each work examined: date of the work; cartographer; place of production or publication; title of the work; cartobibliographical reference; number of charts contained in the work; and most importantly, the symbols portrayed. It must be noted that the identification of symbols on nautical charts cannot be carried out as in conventional map studies. In some instances, legends are shown on the chart or included in the text of sailing directions. However, for the most part nautical charts do not contain legends. Where no indication of symbol meaning was given, as in the case of portolan charts, the symbol meaning and usage will be taken to be the same as described in contemporary or later works.

The information gathered for each work is recorded in two places--

Figure 3 and Appendix A. Figure 3, the Graphic Summary of Symbols on Nautical Charts, is a graphic tabulation of the symbols shown in each work. For instance, a portion of the entry for the 1544 work on the Graphic Summary would be as follows:



This same work would appear in Appendix A as:



The answers to the questions will then be drawn from the information displayed on the graphic, Appendix A and the background information on the history of nautical cartography.

Specifically, the first recorded appearance of a symbol can be traced through the graphic matrix and with the information provided in Appendix A to discover the originator of the symbol. Also, the change in appearance of a symbol through time as shown on the graphic will be an indication of the evolutionary changes in the symbol. Finally, the spread and sophistication of the symbols can be discussed in light of important events in the history of nautical cartography and the

information portrayed in the graphic summary.

Data Sources

The cartographic works examined in this study are listed in Appendix A. These charts, sailing directions and atlases are in the comprehensive collections of the Geography and Map Division of the Library of Congress. Some 127 major works containing over 4200 separate charts, including both original and facsimiles, were examined. Each work listed is referenced by one of four methods to facilitate the location of its complete description. The original portolan charts are thoroughly described in NAUTICAL CHARTS ON VELLUM IN THE LIBRARY OF CONGRESS (Ristow and Skelton, 1977). These charts are referenced as Ristow and Skelton in the Appendix with the number indicated corresponding to their numbering system. Many facsimiles are found in PORTUGALIAE MONUMENTA CARTOGRAPHICA (Cortesão and Mota, 1960). These facsimiles are referenced as Cortesão and include the plate number in his volumes. Most of the atlases and sailing directions are referenced by a LIST OF GEOGRAPHICAL ATLASES IN THE LIBRARY OF CONGRESS (Phillips, 1909, 1914, 1920, and LeGear, 1958, 1963, 1973, 1974). These works are listed with their Phillips title number. Other works referenced as "Bibliography" are described in the bibliography of this paper.

Chapter 2

A BRIEF HISTORY OF NAUTICAL CARTOGRAPHY PRIOR TO 1800

To place the evolution of symbols on nautical charts in its proper perspective, an overall history of nautical cartography is presented. Since any history is subject to different interpretations, the following discussion is drawn from the writings of many authors and presents a generalized commentary. Special attention is given to the forces significant in the evolution of symbols on nautical charts and also to cartographers important in the development of these symbols. This chapter is divided into three sections: (1) the early history, (2) the portolan chart, and (3) sailing directions and nautical atlases.

The Early History of Nautical Cartography

An investigation of the early history of nautical cartography is hampered by the fact that the earliest surviving nautical chart is a portolan chart, CARTE PISANE, which was probably drawn a little before 1300 (Skelton, 1972, 9). The reason that no earlier charts have survived derives from the fact that charts are made to be used. As Nordenskiöld (1897, 16) succintly states, "The maps made for the guidance of skippers were as a rule copied for use, not as other manuscripts for preservation, and were thrown away as worthless when they became antiquated and worn out." Even so, certain facts in the history of navigation are relevant to the development of nautical cartography and can be discussed in this section.

It is speculated that the earliest information about how to navigate

from one port to another was passed on orally and never written down (deBoer and Skelton, 1969, 13). The first known written record of information about navigation was made by the Phoenicians. By 1000 B. C. they possessed written pilot-guides for sailing along the coasts of the Mediterranean Sea and the Atlantic Ocean as far north as England (Koeman, 1964, 11).

The tradition of written sailing directions continued with the Greeks who were dominant in the Mediterranean after 600 B. C. Two known sailing directions, or periploi as they were called, are HANNO'S PERIPLUS which was written about 450 B. C. and SCYLAX'S PERIPLUS of the 4th century B. C. (Koeman, 1964, 11). It is believed that these sailing directions were meant to accompany charts (Brown, 1949, 120) although, as previously mentioned, no charts from this period have survived.

Later in the Greek period, about 100 A. D., Marinus of Tyre is known to have produced charts for use by navigators in the Mediterranean (Cortesão and Mota, 1960, xx). According to Nordenskiöld (1897, 10) these charts were still extant until the middle of the 10th century and could have influenced the development of nautical cartography in the period of time just prior to the emergence of the portolan chart.

Although the content of Marinus' chart is unknown, we do know the contents of what was probably the Greeks last contribution to the knowledge of navigation. This information is contained in a periplus entitled STADIASMUS, or circumnavigation of the great sea (the Mediterranean and Black Seas) prepared in the 4th or 5th century A. D. (Nordenskiöld, 1897, 14). Nordenskiöld (1897, 11-12) writes that the following types of features were mentioned in the STADIASMUS: (1) harbors for small vessels; (2) towns without a port; (3) shallows visible above the surface;

(4) anchorage; (5) rocky shallows; (6) water deep enough for cargo boats; (7) shoals on the right; (8) cliffs; (9) where water for drinking may be found; (10) beware of the place; (11) a promontory with a fort; and (12) low rocks at the entrance.

Since there is no physical evidence of charts from this early period in the history of nautical cartography, the knowledge which has survived in the form of the periplus is extremely important. These sailing directions which are the first written navigational aids (Koeman, 1970, 8v, 7) are proof of the fact that a conscious attempt to record information about the coasts, piloting, and dangers to navigation was being made. This is significant in that before any map or chart can be compiled, the information which it is going to portray must be collected. It can thus be assumed that since the above mentioned types of features were important enough to record in the text of the periplus, they might also be those features which were represented on the charts to accompany them. But whether or not these features were symbolized, it is at least known that the information necessary for their correct location was already collected and organized in a recoverable form.

A final note on the early history of nautical cartography concerns the work of the Arabs and Chinese. It is known that the Arabs had knowledge of the works of Marinus (Cortesão and Mota, 1960, xvii) and that the charts of Marinus were still extant in the middle of the 10th century (Nordenskiöld, 1897, 10). Also, before the end of the middle ages the Arabs probably had good charts of the Indian Ocean. Grosset-Grange (1975, 448) has reconstructed an Arabian chart of the type believed in existence at the time. Less is known about Chinese nautical cartography. The Chinese are known to have used the magnetic compass as early as the

11th century (Thrower, 1972, 27), and that through their contact with the Arabs may have indirectly influenced the development of nautical charts in Europe.

No traces remain of the nautical charts produced in the period before the appearance of the portolan chart, and statements about the use of symbols on these early charts is speculative. Some conclusions which can be drawn from the study of this early period in charting is that there was much interest and activity in the preparation of sailing directions and nautical charts. Further, if as has been suggested, these charts were produced to accompany the periplus, it is known what types of information might have been symbolized. It can also be hypothesized that the first evidence we have of symbolization in use on the portolans may have come by copying symbols from charts produced in this earlier period which are no longer extant.

The Portolan Chart

The emergence of the portolan chart was an important milestone in the history of nautical cartography. So significant was this development that Bagrow (1964, 63) wrote, "The advent of nautical cartography proper dates from 1311, the year of the first dated chart produced at Genoa by Petrus Vesconte." A description of the portolan chart, the events leading to its development, the cartographers who carried on this cartographic form, and the symbols used on portolan charts is the topic of this section.

A portolan chart is a harbor-finding chart. It takes its name from the earlier form of pilot guide which was called a portolano (Ritchie, 1973, 9-10). Brown (1949, 113) called the portolan chart "a coastal chart conceived by seafaring men and based strictly on experiences with the local scene, that is, with the coasts and harbors actually used by

navigators to get from one place to another."

Physically, the portolan charts were usually hand drawn on vellum, often using a whole skin and several colors of ink (Nordenskiöld, 1897, 16). The charts depicted, with a high degree of accuracy, the coastline of the Mediterranean and Black Seas, and sometimes beyond depending on where and when the portolan was drawn (Ristow and Skelton, 1977, x). Jones (1923, 2) states that, "an attempt was evidently made to draw the coasts of the various countries with the correct distances and mutual relation." Ports and harbors were clearly labeled in black; red ink being used for important places, while features in the interior of countries were often completely omitted (Ristow and Skelton, 1977, x). Another interesting feature of these charts was an exaggeration of the representation of the mouths of rivers and harbors (Koeman, 1964, 43). However, probably the most prominent feature of the portolan charts is their loxodromic network (Ristow and Skelton, 1977, x). According to Nordenskiöld (1897, 17) these loxodroms or rhumb lines are "straight lines in the directions of the different winds and proceeding from a number of crossing points regularly distributed over the map." Finally, although these charts were not drawn on any projection, they appear to be "based on nearly correct azimuths so that those compiled of the Mediterranean and Black Seas in the 15th century would closely approximate a modern chart based on the Mercator projection" (Jones, 1923, 2).

From the above description it is clear that the portolan chart appeared in an advanced state of development (Stevenson, 1911, 15), and that it was "much too accurate and detailed to be the work of any one man or any one group of navigators, nor could it represent the surveys of any one generation, the area is much too large and the details too

complex" (Brown, 1949, 139).

Unfortunately, the exact origin of these charts still remains a mystery (Koeman, 1964, 18). Historians of cartography have long searched for the predecessors of the portolan chart with no success. The only information about their origin comes in an indirect form and provides insight into the probable events leading up to the appearance of the portolan chart.

One piece of information that is significant in the probable events leading up to the appearance of the portolan chart is the fact that the magnetic compass was unknown in the Mediterranean until the end of the 12th or beginning of the 13th century (Nordenskiöld, 1897, 49). Because of this, the early periplus which preceeded the portolan chart did not give any bearings or direct distances between ports except as reached by traveling along the coasts (Nordenskiöld, 1897, 49). With this knowledge and recalling the fact that the portolan chart is based on nearly correct azimuths, the invention and use of the compass appears to be very important in the development of the portolan chart.

It is well documented that both the portolan chart and magnetic compass were in use in the Mediterranean area between 1250 and 1275 (Crone, 1966, 35). Howse and Sanderson (1973, 19) state that "the first specific reference to a chart being used on a ship came in a description of the second crusade of St. Louis of France in 1270." Additionally, Raymond Lull's encyclopedia, ARBOR SCIENTIAE (1295) states that in order to measure distances at sea "the mariners have special instruments, the chart, the dividers, the magnetic needle and the (Pole) star" (Cortesão and Mota, 1960, xxvi). The oldest surviving sailing directions for the Mediterranean Sea, IL COMPASSO DA NAVIGARE, 1296, definitely used a compass for its sailing directions (Taylor, 1951, 81).

The appearance of the first portolan chart apparently went hand in hand with the introduction and use of the magnetic compass in the Mediterranean area. Taylor (1951, 354), specifically attributes the remarkable degree of accuracy of the portolan charts to the use of the magnetic compass.

Having established the link between the compass and the appearance of the portolan chart it is possible to speculate about how the information necessary for the portolan was derived by the Genoese and Venetian cartographers who produced the first of these charts. Cortesão and Mota (1960, xxvii) suggest two possible ways in which the information could have come into the hands of these cartographers. They indicate that it is highly probable that the knowledge the Arabs had of Marinus' sea chart and the magnetic compass was learned either through trade contacts that the Venetians and Genoese had with the Arabs, or was transferred by the Arabs to the Christians in the 11th century after the Normans conquered Sicily. In either case, the Arabs appear to play an important part in the origin of the portolan chart.

The two principal locations for the production of portolan charts were in the cities of Ancona, Genoa and Venice in Italy and along the western Mediterranean in Majorca and Barcelona (Ristow and Skelton, 1977, 12). Portolan chart makers included: Vesconte, Dulcert, Pizigano, Benincasa, Andrea Bianco, Battista Agnese, Calapoda, Russinus, Crescentius and Oliva (Nordenskiöld, 1897, 45).

The portolan charts, which appeared about 1300 or shortly before, remained basically unchanged for 300 years (Brown, 1949, 139). Even though inaccuracies in the portolans were noted, few changes were made. As Nordenskiöld (1897, 18) states, "The shapes of some capes and islands were long unaltered even though the true shapes may have been known."

Although the information on the portolan charts did not change substantially, one important addition to the charts was made. As Koeman (1964, 21) points out, "After about 1500 the degrees of latitude were shown -- a necessity for navigation upon the ocean -- and this modification converted the portolan chart (harbor chart) to what we normally understand by the word 'chart', an aid to navigation on the high seas."

The most important fact about the portolan charts, in terms of the scope of this research, is the symbolization of significant marine features. Nordenskiöld (1897, 23) was the first author to indicate that the "+" represented a rock and that "⋰⋱" represented a danger curve. Bagrow (1964, 64) and Ristow and Skelton (1977, x) also indicated that offshore rocks and shoals and hazards such as reefs were shown as dots or crosses. Ritchie (1976, 143) elaborated that "Dotting in reddish brown is used to show sandbanks or shallow sandy bays."

Although these were the only features symbolized, the specific knowledge of considerably more features was necessary for safe navigation. The COMPASSO DA NAVIGARE (1296), a contemporary sailing directions to the early portolan charts, listed the following features of interest to the navigator: rocks, banks, windmills, churches, towns, hills of a particular shape, a lantern lighted on a tower at night and a buoyed river channel (Taylor, 1951, 84).

Considering the number of features which were known and important to navigation at the time it must be concluded that the reason they were not indicated is entirely due to the scale of portolan charts. At scales of approximately 1:6,000,000 to 1:13,000,000 (Nordenskiöld, 1897, 24) it would have been very difficult cartographically to accurately represent the additional features indicated in the COMPASSO DA NAVIGARE.

For this reason sailing directions continued to accompany the charts and provided the specific information necessary for the navigator.

Sailing Directions and Nautical Atlases

Hand drawn portolan charts continued to be produced until after 1600 even though several developments were taking place that would dramatically change the appearance of nautical cartography. The most significant of these developments was the invention of printing. One of the most important differences between the portolan charts and the charts contained in sailing directions and nautical atlases is the fact that the latter are, for the most part printed.

In 1472 the first printed woodcut map appeared (Robinson, 1975, 1). The woodcut technique continued to be used for maps up until the middle of the 16th century (Woodward, 1975, 40). In terms of symbolization on maps and charts, this method left much to be desired. It produced very coarse line work, lettering was quite difficult and such techniques as stippling were extremely difficult (Robinson, 1975, 7).

The next improvement in the printing technique of maps and charts was copperplate engraving. Copperplate engraving was used as early as 1477 and for the first hundred years of map printing copperplate and woodcut existed side by side -- woodcut being used north of the Alps and copperplate to the south (Woodward, 1975, 40).

There were many advantages to copperplate printing that finally made it dominate over the woodcut technique for the printing of maps. Those advantages include: (1) larger plate size; (2) a fine line could be obtained; (3) small neat lettering was possible; (4) smooth curves could be produced; (5) fine-textured, flat, and variable area tones could be produced (Robinson, 1975, 8); (6) greater precision was possible;

(7) easier to correct; (8) longer plate life; and (9) it was separate from letter press (Vekner, 1975, 51).

In the 16th century along with new printing techniques a new aid to navigation was emerging. Up until the early 16th century nautical charts and sailing directions were separate works which of necessity continued to be used together. In about 1520 Pirī Re'is completed his book BAHRIYE - ON NAVIGATION. In this work Pirī Re'is combined sailing directions and descriptions of the coasts with charts (Afetinan, 1954, 17). As one of the most outstanding scholars of the science of navigation of his time (Afetinan, 1954, 15) his BAHRIYE is considered to contain the most advanced techniques of cartography of the early 16th century (Afetinan, 1954, 19). In one book he combined large scale charts and text.

Following Pirī Re'is in 1544 Cornelis Anthonisz published the CAERTE VAN DIE COSTERSCHE SEE in Amsterdam. This work was also a book of sailing directions and charts (Bagrow, 1964, 119), and after its publication, charts were regularly included in sailing directions (Bagrow, 1964, 120).

In 1584 Lucas Janszoon Waghenaer published his sea atlas DE SPIEGHEL DER ZEEVAERT in Leyden. This work went beyond the earlier attempts of cartographers and is considered "the first printed sea atlas with charts and sailing directions assembled systematically in one book so as to give the mariner all the hydrographic information he needed about a specific area" (Howse and Sanderson, 1973, 41).

Waghenaer's DE SPIEGHEL DER ZEEVAERT was important for another reason. In the English language text it contained "A shorte Instruction of the forme and fashion of Buyes, Beakons, and other markes etc which are set for

shoaldes, sands, or hidden rocks . . ." (Waters, 1958, 172), which showed the actual representation of symbols to be used on the charts. Waters (1958, 172) summarized the significance of this information as follows: "This is apparently the earliest printed description of such aids to navigation, and although English navigators were already adopting definite cartographical symbols to denote different types of terrain, Waghenaer's symbols, since they were printed, can be taken as the first to initiate standardized symbols for buoys, sea-marks, safe anchorages, hidden and dangerous rocks, and greater rocks hidden by water."

By the end of the 16th century Waghenaer's DE SPEIEGHEL DER ZEEVAERT had been translated into many languages and his symbols were adopted by the British and French (Ritchie, 1976, 147). Amsterdam had thus become the center for nautical cartography.

In 1599 Willem Janszoon Blaeu established himself in Amsterdam as a maker of nautical instruments, globes and maps (Skelton, 1964, v). He followed Waghenaer's lead in the production of sailing directions with charts and made several important improvements over the latter's work. Blaeu discarded Waghenaer's practice of showing harbors, etc., on an enlarged scale (Howse and Sanderson, 1973, 49). Instead, he enlarged the scale of his charts and was then able to draw estuaries and harbors in the same scale as the rest of the coastline (Skelton, 1964, vii). For this reason Blaeu's pilot-guide HET LIGHT DER ZEEVART published in Amsterdam in 1608 is considered "a milestone in the development of marine cartography" (Howse and Sanderson, 1973, 49).

The tradition of producing sailing directions and nautical atlases continued in Amsterdam through the 17th century. The most productive publishers during that period were Willem Blaeu, Jacob Colom, Pieter Goos,

Johannes van Loon (Brown, 1949, 146), Frederick de Wit, Anthonie Jacobsz, Hendrick Donker and Pieter Van Alphen (Phaff, 1924, 135).

John Seller established himself as a chart publisher in England in 1670. His first charts were considered inferior to the work of his contemporary Dutch cartographers because he purchased out of date copperplates and lacked the resources for getting information and correcting charts (Robinson, 1962, 124). His work, however, initiated the "independent production of pilot books in England which ultimately overcame Dutch predominance" (Koeman, 1970, xiii).

By the middle of the 18th century the dominance of Dutch nautical cartography began to decline. One of the major reasons for this decline was the invention of the sextant and chronometer in England (Phaff, 1924, 137). These two inventions gave the English the tools needed to accurately locate positions in both latitude and longitude and began the rise to prominence of British nautical cartography in the latter half of the 18th century (Robinson, 1953, 127). As the British gained dominance in nautical cartography they developed symbolization to show such complex natural features as tidal streams, overfalls and whirlpools. They also developed a system of abbreviations for the nature of the sea bed (Ritchie, 1976, 149). In fact, the system of conventional signs and abbreviations developed by Murdoch Mackenzie in 1776 became the basis for the Admiralty charts and are virtually identical to those on Admiralty charts today (Howse and Sanderson, 1973, 105). Other prominent English chartmakers of the 18th century included Dalrymple, first hydrographer of the Admiralty (Lanegran, 1966, 14), William Heather, Robert Sayer and John Bennett, Steel, and Laurie and Whittle (Robinson, 1953, 127).

The period after 1720 when the Dépôt des Chartes et Plans

was established in Paris also saw a tremendous growth in French nautical cartography. Bellin, Michelot and Mannevillette were the leaders in French nautical cartography in the 18th century. Figure 2 is a summary of the important events in the history of nautical cartography prior to 1800 as presented in this chapter.

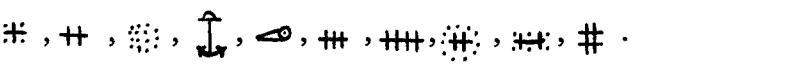
Figure 2

A SUMMARY OF THE IMPORTANT EVENTS IN THE HISTORY OF NAUTICAL CARTOGRAPHY PRIOR TO 1800

9th century B. C.	Phoenician Pilot-guides
6th century B. C.	Greeks became dominant in the Mediterranean
5th century B. C.	Hanno's Periplus; Scylax's Periplus (Greek)
1st century A. D.	Marinus of Tyre sea charts (Greek)
4th-5th century	STADIASMUS (sailing directions - Greek)
10th century	Arabs have knowledge of Marinus' charts
13th century	Magnetic compass in use in Mediterranean
1300	Portolan chart and COMPASS DA NAVIGARE (Italian)
1472	First woodcut map (Bavarian)
1477	Copperplate engraving (Italian)
1520	Pirî Re'is BAHRIYE - sailing directions and charts (Turkish)
1584	Waghenaer's DE SPIEGHEL DER ZEEVAERT first printed legend for symbols on nautical charts (Dutch)
1608	Blaeu's LIGHT OF NAVIGATION - larger scale more accurate charts (Dutch)
1670	John Sellers established as a chart publisher in England (Dutch still dominate charting)
1720	French establish Dépôt des Charts et Plans
1760	Sextant and chronometer developed in England (English take over domination in charting)
1795	Dalrymple, first hydrographer of the British Admiralty

Chapter 3

DATA PRESENTATION AND ANALYSIS

The Graphic Summary of Symbols on Nautical Charts (Figure 3) is the collection of data obtained by examining the cartographic works listed in Appendix A. The works on Figure 3 are listed chronologically in the same order in which they appear in the Appendix. For each work there is a summary description consisting of two parts. The first description is for the country in which the charts were produced or published. The countries of origin and the abbreviation used are as follows: Italy (I); Portugal (P); Spain (S); Turkey (T); Germany (G); America (A); Uruguay (U); England (E); France (F); Cuba (C); and the Netherlands (N). The second description is the date of production or publication of the work. Ten categories of symbols were devised to assemble the data in an orderly fashion. The categories are: (1) rocks; (2) danger curves; (3) shallow banks; (4) anchorage; (5) beacons; (6) sea markers and buoys; (7) lighthouses; (8) tide; (9) miscellaneous rocks and dangers; and (10) other features. Each cartographic work listed in the Graphic Summary of Symbols on Nautical Charts contains the actual representation of all of the different symbols shown in that work. For instance, the 1689 entry contained all of the following symbols:  .

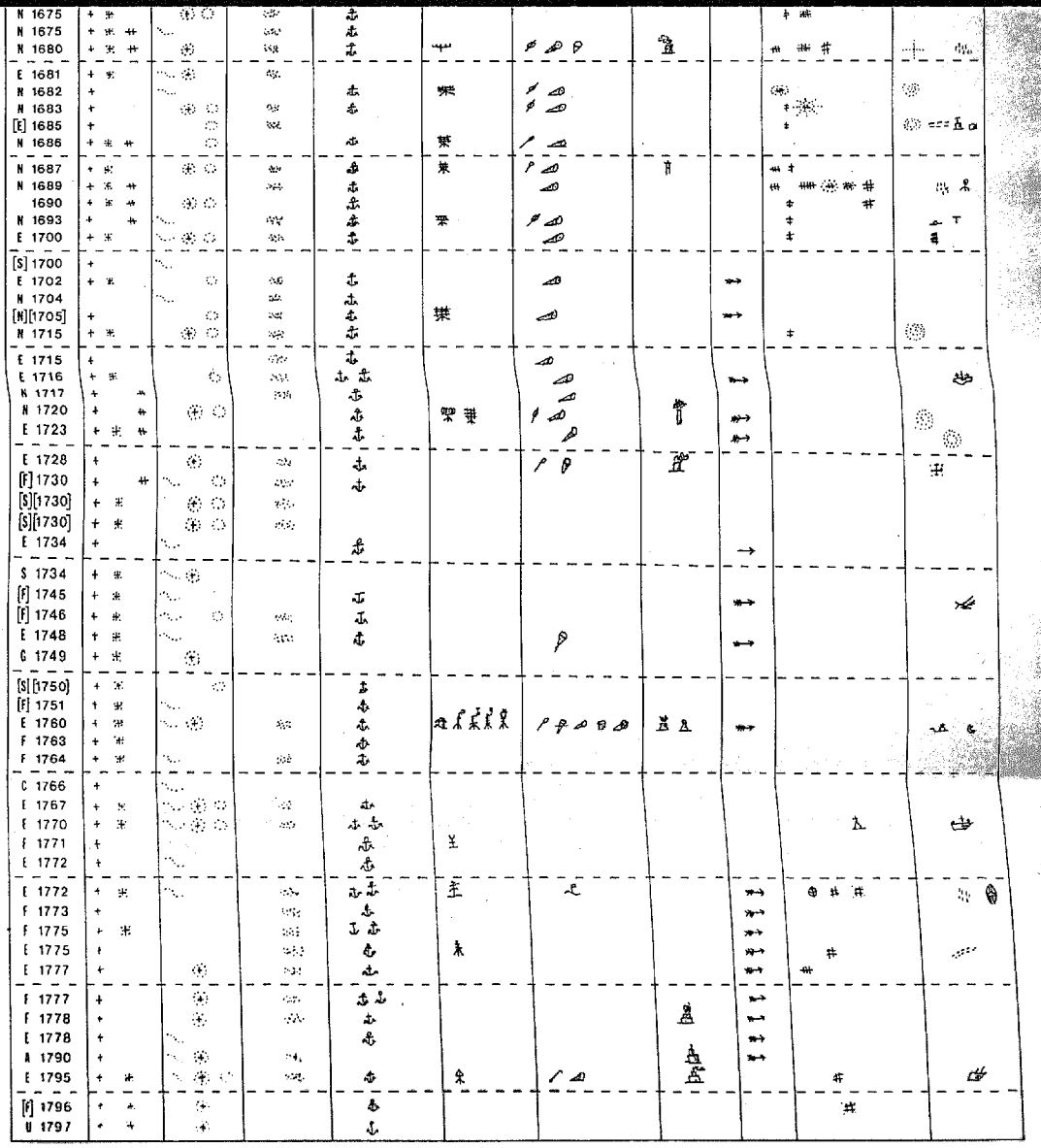
The Graphic Summary tabulated in chronological order to correlate with the historical perspective previously presented provides a basis for the analysis of the data collected. Much of the information on the graphic is self-explanatory and allows the reader to follow the historical sequence of events.

The question -- "How did the symbols on nautical charts evolve?" is

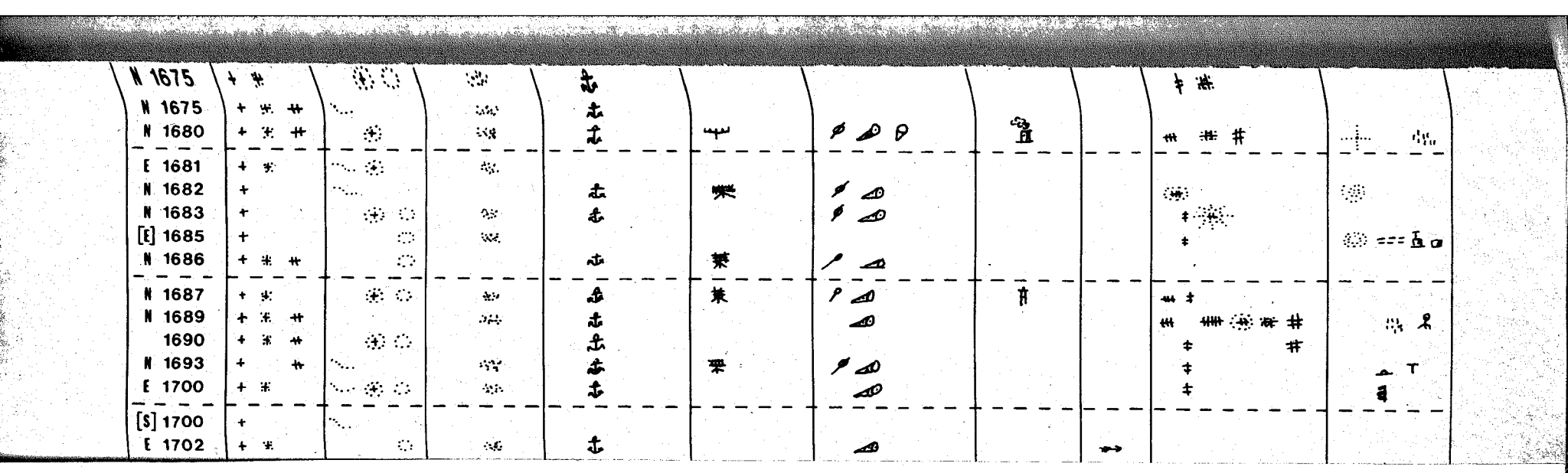
Figure 3

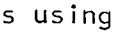
GRAPHIC SUMMARY OF SYMBOLS ON NAUTICAL CHARTS

ORIGIN[a] & DATE	ROCKS	DANGER CURVES	SHALLOW BANKS	ANCHORAGE	BEACONS	SEA MARKERS & BUOYS	LIGHT-HOUSES	TIDE	MISCELLANEOUS ROCKS/DANGERS	OTHER FEATURES
[I] 1325										
[I] [1325]										
[1339]										
[I] 1425										
S 1468										
[P] [1470]										
P [1500]										
1502										
I 1512										
P 1513										
P [1519]										
T [1520]										
I 1524										
P 1525										
1528										
P [1535]										
1537										
P [1537]										
P [1540]										
P [1543]										
I [1544]										
P 1546										
F 1550										
[I] [1550]										
[I] [1550]										
P 1558										
S 1559										
P 1559										
P [1560]										
[I] [1560]										
[S] [1561]										
P 1563										
P 1565										
P 1568										
P 1569										
P 1570										
P 1571										
P 1572										
[I] [1575]										
P 1580										
N 1584										
P 1586										
S 1587										
N [1588]										
P 1590										
[I] [1590]										
P 1601										
1603										
[F] 1607										
N 1608										
N 1620										
N 1622										
P 1631										
P 1633										
I 1640										
N 1640										
I 1646										
T [1648]										
N 1656										
N [1660]										
N 1661										
N 1661										
N [1661]										
I 1664										
1666										
N 1669										
F 1670										
E 1671										
E 1671										
E 1672										
E 1672										
N 1675										

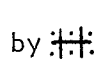


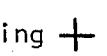
*COUNTRIES OF ORIGIN: I - Italy; P - Portugal; S - Spain; T - Turkey; N - Netherlands; E - England; F - France; G - Germany; C - Cuba; U - Uruguay; A - America


N 1675
N 1675
N 1680
E 1681
N 1682
N 1683
[E] 1685
N 1686
N 1687
N 1689
1690
N 1693
E 1700
[S] 1700
E 1702

basic. The early cartographers who were first faced with the job of locating dangers to navigation on a nautical chart had a difficult problem. Many of the features they had to depict were beneath the surface of the water and invisible to the mariner. For this reason, one may assume that many of the first symbols to appear on nautical charts were of the type which Dreyfuss would call arbitrary. They had to be invented and learned. The earliest work examined, the 1325 portolan chart, depicts dangerous rocks using four arbitrary symbols:  .

These being arbitrary symbols, one may expect to find many variations of the "+". In this study, 35 variations and embellishments of the "+" were found. Generally speaking, the Dutch tended to use a larger variety of rock symbols (in some works as many as eight) while the French and English used as few as one or two types of rock symbols. It should also be noted that the number of different types of rock symbols appearing on charts was considerably reduced in the early 18th century when the British and French took the lead in chart production.

The various symbols devised for depicting rocks often appeared interchangeably. The same marine feature was sometimes symbolized two or more different ways, even by the same cartographer in the same volume. An example of this may be found in the 1587 ATLAS of Joan Martines. In this work the same rock feature, located in the same geographic position was indicated by  , and  on three different charts of the same coast. In each case, the word "roca" appeared next to the symbol.

One could possibly explain this through the great diversity of rock symbols which appeared over the 14th, 15th and 16th centuries. In the opinion of the author, in the early evolution of the rock symbol, no definitive reason for using  could be determined.

Cartographers freely invented variations of the "+". One fact that is clearly evident in the examination of Figure 3 is that the +, ⁜, and ++ appear with a great deal of regularity on all nautical charts, while other rock symbols appeared less frequently, in some cases on only one chart.

In contrast to this arbitrary use and invention of rock symbols, an early attempt to apparently standardize the use of various rock symbols appears on the 1559 portolan chart by Mateo Prunes. Although this chart contains no legend, the use of the rock symbols ⁜ and + was very consistent. On this chart there is a clear distinction between rocks which are close to the coast, shown as "+" and isolated rocks which are far from shore, shown as "⁜".

A later more definite step towards standardization of the rock symbol came in 1584 when Waghenaer included a form of symbols legend in the text of his DE SPIEGHEL DER ZEEVAERT. In this legend, he noted "+" as "rocks, hidden-dangerous" and "‡" as "double crosses lye greater rocks covered with the water." Had these two rock symbols been the only ones shown on Waghenaer's charts, the influence of this work on the evolution of rock symbols would be very clear. However, DE SPIEGHEL DER ZEEVAERT contained several other rock symbols. The following rock symbols were shown in the 1558 English version of this work: +, ⁜, ‡, ⧻, ‡, ⁜, ⁜, and ⧻. The large variety of miscellaneous rock symbols which appeared in the late 16th and 17th century on charts does not support the conclusion reached by Waters (1958) that DE SPIEGHEL influenced standardization of rock symbols on nautical charts. The evolutionary trend of standardization that might be expected after 1584 with the appearance of Waghenaer's printed legend is not reflected in the graphic

summary of symbols.

The reason probably lies in the use and advantages of copperplate engraving which were previously stated, and also the fact that the charts were accompanied by sailing directions. Copperplate engraving gave the cartographers and engravers a great deal of freedom because of the greater precision and finer line that was available to them. Again, because the rock symbol was arbitrary, variations of the "+" were easy to invent. This fact can be supported through comparison of rock descriptions in the text of the sailing directions and the charts which accompanied these descriptions. In the FIERIE SEA COLVMNE of Jacob Colom (1640) various rocks all described as sunken rocks were shown as ++, ⁝+⁝, ⁝+ and ‡ . Also, as long as sailing directions and charts were in one volume it was apparently not necessary to absolutely standardize rock symbols.

At the beginning of the 18th century a more definite trend in the evolution of the rock symbol began to appear, namely a marked reduction in the variation of rock symbols being shown. After 1700, the only two rock symbols which appear consistently are the "+ " and "⁝+⁝". Only 7 other rock symbols are shown and most of these appear on only one work. Although the specific reason for this is not clear there appears to be a connection between this fact and the fact that the Dutch were becoming less influential in nautical cartography at this time and the English and French were beginning to dominate.

The evolution of rock symbols on nautical charts is best summarized by Figure 3. It can be characterized by the fact that here presented is the evolution of an arbitrary symbol. The variation of symbols which appeared and the lack of consistent direction in the definition and use of these various symbols contributed to the long evolutionary period of the rock symbol. It is interesting to note that two of the four symbols which were used in 1325 were the same symbols which reached the close of

this period at 1800. These two symbols are very simple, the "+" and "⁜". Other more complicated symbols appeared and disappeared over this period, but never really gained acceptance. The answer may lie in the fact that there are only two distinct types of rocks -- submerged rocks, which are always covered by water and rocks awash which are sometimes above the surface, or cause the surface to break. Two types of rocks and two symbols -- a very logical solution to the problem of how to symbolize two different types of rocks in an arbitrary fashion.

The other two symbols shown on the 1325 portolan chart, the danger curve, and the shallow banks symbol, , are in a different category. They may be considered by Dreyfuss' definition as being abstract symbols. They appear to be simplified versions of the features they depict. Both of these symbols represent marine features which are visible. The danger curve might represent the line at which the waves break around a reef or other dangerous submerged feature. The stipple of the shallow banks is visible as a sandy shoal. Because these features were not purely arbitrary and had some basis in the visible marine environment, they remained unchanged throughout the period of this study. In terms of evolution, these symbols have remained static and are in fact still in use on modern nautical charts.

The next type of symbols to appear in this study would be considered by Dreyfuss as representational. These include the symbols for anchorage, buoys, beacons, and lighthouses. All of these symbols are pictorial in nature. Their evolutionary path is somewhat similar to that of the abstract symbols just discussed. In the case of anchorage, where the shape of the anchor remained constant, the symbol also remained unchanged. Variations were added at a later time to distinguish between small and

large vessel anchorage, but the symbol was still clearly an anchor. In the case of the buoys and beacons, the form of the symbol underwent little change and remained a pictorial symbol throughout the period, somewhat simplified, but not in the opinion of the author to the point where they would be considered abstract symbols.

It is interesting to note that the pictorial beacon and buoy symbols which were widely used by both the Dutch and English were not adopted by the French. In fact the French in contrast to the two later countries used far fewer symbols on their nautical charts.

The variations which appeared in the forms of the representational or pictorial symbols is not considered to be of the same magnitude as the variation in the arbitrary rock symbols. The variously shaped land beacons depicted as  , , or were obviously intended to represent the prominent features of the different beacons. Similarly, the characteristics of the several lighthouses could also be an indication of the different lighthouse structures. These changes and variations are not seen as evolutionary, but rather as an attempt by the cartographer to accurately represent an important, visible aid to navigation.

In terms of evolution, the symbols on nautical charts took one of two paths. If the symbol was abstract, but clearly based in the visual marine environment, or representational and pictorial in nature the symbol remained basically unchanged throughout the period up to 1800. If, on the other hand, the symbol was arbitrary, the evolutionary path was more complicated and took many directions before a logical solution was reached which seemed to satisfy the cartographer and the mariner.

The next question, "Who originated the symbols?" is straight forward, but not easy to answer. All of the conclusions about this subject carry the stipulation of "based on what has been examined."

In terms of the first symbols -- rocks, danger curves and shallow banks -- there is no possible answer from this study. These symbols appeared on the first portolan charts, but that is by no means a definitive indication that these cartographers originated the symbols. It is highly probable, as previously discussed that these symbols were developed in an earlier period and copied from charts that are no longer in existence.

The symbol for anchorage appears to have been originated by the Turkish navigator Pirī Re'is in his BAYRIYE of 1520. The charts in this volume were among the first charts of a scale large enough to meaningfully show an anchorage location within a harbor.

The symbolization of beacons, buoys and sea-marks, if not originated by Waghenaer in 1584 were at least standardized by his publication and descriptive legend in the text of his sailing directions.

The first indication of a lighthouse was found in the 1661 LIGHTING COLOMNE OR SEA-MIRROUR of Peter Goos.

The third question, "What was the order of migration of symbols from one area to another?" can be only partially answered as a result of this study. The graphic summary offers a chronological list of symbol appearances and country of origin but relates nothing of the two ways in which cartographic symbolization migrated, either through trade contacts, as was the case with the Genoese and Venetians who traded with the Arabs, or the more direct fashion through the purchase of copperplates as was the case of John Seller in establishing his charting firm in London. In either instance, this study produces no clear indication of symbol migration.

Finally, "What forces were involved in the origin, spread and

increasing sophistication of symbols on nautical charts?" Of this three part question, only the last part remains to be discussed.

The most important force involved in the increasing sophistication of symbols was the invention of printing, and most particularly the invention of copperplate engraving. This printing technique enabled the cartographer to produce fine line work and draw symbols with greater precision. Also, the longer life of the plates and the ease with which corrections and additions could be completed made it possible to update the charts as necessary and add new symbols where needed. Another factor in the increasing sophistication of the symbols derives from the advances in navigation which encouraged the cartographers to develop new and better symbols to present a clearer picture of the marine environment. The more information that was known about an area, the more the navigator demanded on nautical charts. The cartographer had to constantly strive for better, more concise symbols.

Chapter 4

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

The conclusions drawn from this study are of two types: (1) those based on the historical research, and (2) those derived from a critical review of the methodology.

The examination of over 4200 nautical charts and the graphic summary of their symbol content has led to the important conclusion that the evolution of symbols, at least those on nautical charts is closely related to the type of symbol--arbitrary, abstract, or representational. Arbitrary symbols clearly displayed the greatest variety of portrayal and showed the longest period of evolutionary changes. Abstract symbols remained virtually unchanged and representational symbols also underwent little change through the time period. This conclusion is significant because it presents the evolution of symbols from a cartographic rather than historic point of view.

The second conclusion to be drawn from this research focuses on the methodology. It appears that the visual examination and graphic summary of findings is valuable for tracing the evolutionary changes in the symbols, and in fact, may be the only way to present the results, but its usefulness may be limited in determining the migration of symbols.

The main question which this study was unable to adequately resolve deals with the migration in the use of symbols. It is the feeling of the author that the answer to this question must come from a different type of research. Specifically, the movement of cartographers, engravers, and their apprentices would have to be documented. Also research into the movement of copperplates from one chart publisher to another would add insight into the migration of symbol usage.

The tabulation of symbols presented on Figure 3 does provide, though, significant insight into the spatial distribution of their use by cartographers and also their varying usage through time. The reasons for this distribution and usage are not totally apparent, and this information would have to be further interpolated to mesh with a time line of trade contacts and dominance in discoveries at sea. The political and technical constraints of the period would also closely tie in with the dominance in charting as indicated by Figure 3.

Did the question of nationalism play a part in the usage of symbols, or the lack of usage as in the case of the French? Why were the buoy symbols dropped for the most part after 1723? Questions such as these come to light and strongly recommend further research.

The value of this research, therefore, lies in the complete documentation of all charts examined. Future research of the type recommended could be correlated to this study for an even more complete picture of the evolution of symbols on nautical charts.

APPENDIX A

LIST OF CARTOGRAPHIC WORKS EXAMINED FOR SYMBOLS

1325 Dalorto, Angelino. LA CARTA NAUTICA CONSTRUITA NEL 1325 DA ANGELINO DALORTO. [Italy.]

Portolan chart (facsimile) Bibliography.

[1325] Anonymous. MEDITERRANEAN SEA. [Genoa.]

Portolan chart Ristow and Skelton, 3.

[1339] Dulcert. MAPPEMONDE DE DULCERT.

Portolan chart (facsimile) Phillips, 254.

1425 Giroldi, Giacomo. MEDITERRANEAN SEA. [Venice.]

Portolan chart (facsimile) Phillips, 4178.

1468 Roselli, Petrus. MEDITERRANEAN SEA. Majorca.

Portolan chart (facsimile) Phillips, 4178.

[1470] Anonymous. ATLANTIC COAST OF SPAIN AND AFRICA. [Portugal.]

Portolan chart (facsimile) Cortesão, 2-3.

[1500-1540] Reinel, Pedro and Jorge. WORLD AND MEDITERRANEAN CHARTS, Portugal.

8 Portolan charts (facsimile) Cortesão, 7-15.

1502 Janensis, Nicolo de Canerio. MARINE WORLD CHART.

Portolan chart (facsimile) Bibliography.

1512 Maiolo, Vesconte de. MEDITERRANEAN SEA. Italy

Portolan chart (facsimile) Phillips, 4178.

1513 Rodrigues, Francisco. MANY PARTS OF THE WORLD. Portugal.

3 charts (facsimile) Cortesão, 34-36.

[1519-1554] Homem-Reineis, Lopo. WORLD CHART. Portugal.

16 charts (facsimile) Cortesão, 16-32.

[1520] Pirī Re'is. KITABI BAHRIYE. Turkey.

72 charts (facsimile) Bibliography.

1524 Freducci, Conte Hoctomanno. WORLD CHART. Italy

Portolan chart (facsimile) Phillips, 4178.

1525-1529 Ribeiro, Diogo. WORLD. Portugal.

5 charts (facsimile) Cortesão, 37-41.

1528 Bordone, Benedetto. LIBRO DI BENEDETTO BORDONE. NEL QUALE SI RAGIONA DE TUTTE L'ISOLE DEL MONDO CON LI LOR NOMI ANTICHI & MODERNI, HISTORIE, FAUOLE, & MODI DEL UIUERE, & IN QUAL PARTE DEL MARE FTANNO, & IN QUAL PARALLELO & CLIMA GIACCIONO.

111 charts Phillips, 162.

[1535] Anonymous. MALAY ARCHIPELAGE. Portugal.

1 chart (facsimile) Cortesão, 58.

1537 Freducci, Conte de Ottomano. PORTOLAN ATLAS.

5 Portolan charts (facsimile) Bibliography.

[1537] Anonymous. ATLAS. Portugal.

16 charts (facsimile) Cortesão, 45-57.

[1540] Anonymous. INDIAN OCEAN. Portugal.

1 chart (facsimile) Cortesão, 71.

[1543] Afonso, Joao. WORLD. Portugal.

1 chart (facsimile) Cortesão, 73.

[1544] Agnesse, Battista. WORLD. Venice.

10 charts Ristow and Skelton, 5.

1546 Freire, de Joao. WORLD. Portugal

1 chart (facsimile) Cortesão, 76.

1550 Olives, Jaume. MEDITERRANEAN AND WESTERN EUROPE. Marseille.

Portolan chart Ristow and Skelton, 6.

[1550] Anonymous. MEDITERRANEAN SEA. [Italy]

Portolan chart Ristow and Skelton, 13.

[1550] Anonymous. MEDITERRANEAN SEA. [Italy]
Portolan chart — Ristow and Skelton, 12.

1558 Homem, Diogo. WORLD. Portugal.
8 charts (facsimile) — Cortesão, 100-108.

1559 Prunes, Mateo. MEDITERRANEAN AND WESTERN EUROPE. Majorca.
Portolan chart — Ristow and Skelton, 7.

1559 Homem, Diego. WORLD. Portugal.
7 charts (facsimile) — Cortesão, 109-115.

[1560] Anonymous. LIVRO DE MARINHARIA DE JOAO DE LISBOA. Portugal.
11 charts (facsimile) — Cortesão, 88-97.

[1560] Anonymous. WORLD, EUROPE, MEDITERRANEAN. [Messina.]
Portolan chart — Ristow and Skelton, 8.

[1561] Anonymous. CENTRAL AND SOUTH AMERICA, PACIFIC COAST. [Spain.]
2 charts — Ristow and Skelton, 9&10.

1563 Luis, Lazaro. ATLAS. Portugal.
15 charts (facsimile) — Cortesão, 211-226.

[1565] Anonymous. ATLAS. Portugal.
14 charts (facsimile) — Cortesão, 392-406.

1568 Duorado, Fernao vaz. ATLAS. Portugal.
16 charts (facsimile) — Cortesão, 242-258.

1569 Homem, Diogo. WORLD. Portugal.
1 chart (facsimile) — Cortesão, 144.

1570 Duorado, Fernao vaz. ATLAS. Portugal.
18 charts (facsimile) — Cortesão, 259-277.

1571 Duorado, Fernao vaz. ATLAS Portugal.
16 charts (facsimile) — Cortesão, 278-294.

1572 Homem, Diogo. ATLAS. Portugal.

3 charts (facsimile) Cortesão, 147-150.

[1575] Oliva, Placido. MEDITERRANEAN SEA. [Messina.]

1 chart Ristow and Skelton, 14.

1580 Dourado, Fernao vaz. ATLAS. Portugal.

14 charts (facsimile) Cortesão, 314-328.

1584 Waghenaer, Lucas Jantiz. SPIEGHEL DER ZEEVAERDT. Leyden.

44 charts (facsimile) Bibliography.

[1586] Anonymous. RUTTER-ATLAS OF BRAZIL. Portugal.

2 charts (facsimile) Cortesão, 364-365.

1587 Martines, Joan. ATLAS DE JOAN MARTINES 1587.

5 charts (facsimile) Bibliograhy.

[1588] Waghenaer, Lucas Janszoon. THE MARINERS MIRROVR WHEREIN MAY PLAYNLY BE SEEN THE COURSES, HEIGHTS, DISTANCES, DEPTHS, SOUNDINGS, FLOUDS AND EBS, RISINGS OF LANDS, ROCKS, SANDS, SHOALDS, WITH THE MARKS FOR TH' ENTRINGS OF THE HARBOUROUGHS, HAVENS AND PORTS OF THE GREATEST PART OF EUROPE: WITH THEIR SEURAL TRAFICKS AND COMMODITIES: TOGETHER Wth THE RULES AND INSTRUMTETS OF NAUIGATION. London.

45 charts Phillips, 3981.

[1590] Lasso, Bartolomeu. ATLAS. Portugal.

7 charts (facsimile) Cortesão, 369-376.

[1590] Scotto, Giacomo. MEDITERRANEAN SEA, NORTHWEST EUROPE, NORTHWEST AFRICA. [Civita Vecchia.]

8 charts Ristow and Skelton, 11.

1601-1616 Eredia, Manuel Godinho de. WORLD. Portugal.

2 charts (facsimile) Cortesão, 411-413.

1603 Palacios, Gerónimo Martín. PUERTO DE NAIVIDAD HASTA EL CABO MENDOCINO.

33 charts Bibliography.

1607 Champlain, Samuel de. NE COAST OF NORTH AMERICA. [France]

1 chart Ristow and Skelton, 15.

1608 Barendsz, Willem. DESCRIPTION DE LA MER MĒDITERRANĒE, AUQUEL FONT DĒLINIĒES & DESCRIPTES AU VIF TOUTES LES COSTES DE LA MER MĒDITERRANĒE. Amsterdam

9 charts Phillips, 188.

1620 Blaeu, Willem Janszoon. LE FLAMBEAV DE LA NAVIGATION, MONSTRANT LA DESCRIPTION & DĒLINEATION DE TOUTES LES COSTES & HAVRES DE LA MER OCCIDENTALE, SEPTENRIONALE & ORIENTALE. Amsterdam.

44 charts Phillips, 2829.

1622 Blaeu, Willem Janszoon. THE LIGHT OF NAVIGATION WHEREIN ARE DECLARED AND LIVELY PORTRAYED ALL THE COASTS AND HEAVENS OF THE WEST, NORTH AND EAST SEAS. Amsterdam.

41 charts Phillips, 5177.

1631 Albernaz, Joao Teixeira. ATLAS. Portugal.

8 charts (facsimile) Cortesão, 473-481.

1633 Roiz, Pascoal. ATLANTIC OCEAN. Lisbõa.

1 chart Ristow and Skelton, 16.

1640 Cavallini, Giovanni Battista. MEDITERRANEAN SEA. Livorno.

2 charts Ristow and Skelton, 17.

1640 Colom, Jacob Aertszoon. THE FIERIE SEA-COLVMNE, WHEREIN ARE SHEWED THE SEAS, AND SEACOASTS OF THE NORTHERN, EASTERN, AND WESTERN NAVIGATION, MANIFESTLY INLIGHTENED, AND THE FAILINGS AND MISTAKES OF THE FORMER LIGHT OR SEA-MIRROUR AMENDED. Amsterdam.

49 charts Phillips, 3332.

1646 Dudley, Sir Robert. DELL' ARCANO DEL MARE . . . LIBRI SEI: NEL PRIMO DE' QUALI SI TRATTA DELLA LONGITUDINE PRATICABILE IN' DIUERSI MODI, D'INEUNZIONE DELL' AUTORE, NED SECONDO, DELLE CARTE SUE GENERALI, E DE' PORTOLANI RETTIFICATI IN LONGITUDINE, E LATITUDINE, NEL TERZO, DELLA DISCIPLINA FUA MARITTIMA, E MILITARE. Firenze.

130 charts Phillips, 457.

[1648-1687] Nûh, Sejjid. DER SEE-ATLAS DES SEJJID NÛH. Turkey.

5 charts (facsimile) Bibliography.

1656 Colom, Arnold. ZEE-ATLAS, OFTE WATER-WERELDT. Amsterdam

18 charts Phillips, 464.

[1660] Goos, Pieter. EUROPE AND NORTH ATLANTIC. Amsterdam.

1 chart Ristow and Skelton, 18.

1661 Goos, Peter. THE LIGHTING COLOMNE OR SEA-MIRROUR, CONTAINING THE SEA COASTS OF THE NORTHERN, EASTERN AND WESTERN NAVIGATION: SETTING FORTH IN DIVERS NECESSAIRE SEA-CARDS ALL THE PORTS, RIVERS, BAYES, ROADS, DEPTHS AND SANDS: VERY CURIOUSLY PLACED ON ITS DUE POLUS-HEIGHTH FURNISHED WITH THE DISCOVERIES OF THE CHIEF COUNTRIES, AND ON WHAT COURSE AND DISTANCE THEY LAY ONE FROM ANOTHER: NEVER HERETOFORE SO CLEARLY LAID OPEN, AND HERE AND THERE VERY DILIGENTLY BETTERED AND AUGMENTED, FOR THE USE OF ALL SEA-MEN. Amsterdam.

60 charts Phillips, 5164.

1661 Loon, Joannes van. KLAER LIGHTENDE NOORT-STER OFTE ZEE ATLAS; WAER IN VERTOONT WORDT DE GELEGENTHEYDT VAN ALLE DE ZEE-KUSTEN DES GEHEELEN AERDTBODEMS. Amsterdam.

46 charts Phillips, 470.

[1661] Doncker, Hendrick. DE ZEE-ATLAS OFTE WATER-WAERELD, VERTOONENDE ALLE DE ZEE-KUSTEN VAN HET BEKENDE DEEL DES AERD-BODEMS, MET EEN GENERALE BESCHRYVINGE VAN DIEN. Amsterdam.

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Figure 3

GRAPHIC SUMMARY OF SYMBOLS ON NAUTICAL CHARTS

ORIGIN[a] & DATE	ROCKS	DANGER CURVES	SHALLOW BANKS	ANCHORAGE	BEACONS	SEA MARKERS & BUOYS	LIGHT-HOUSES	TIDE	MISCELLANEOUS ROCKS DANGERS	OTHER FEATURES
[I] 1325										
[I] [1325]										
[1339]										
[J] 1425										
S 1468										
[P] [1470]										
P [1500]										
1502										
I 1512										
P 1513										
P [1519]										
T [1520]										
I 1524										
P 1525										
1528										
P [1535]										
1537										
P [1537]										
P [1540]										
P [1543]										
I [1544]										
P 1546										
T 1550										
[I] [1550]										
[T] [1550]										
P 1558										
S 1559										
P 1559										
P [1560]										
[I] [1560]										
[S] [1561]										
P 1563										
P 1565										
P 1568										
P 1569										
P 1570										
P 1571										
P 1572										
[I] [1575]										
P 1580										
N 1584										
P 1586										
S 1587										
N [1588]										
P 1590										
[I] [1590]										
P 1601										
1603										
[F] 1607										
N 1608										
N 1620										
N 1622										
P 1631										
P 1633										
I 1640										
N 1640										
I 1646										
T [1648]										
N 1656										
N [1660]										
N 1661										
N 1661										
N [1661]										
I 1684										
1665										
N 1669										
F 1670										
E 1671										
E 1671										
E 1672										
E 1672										
N 1675										
N 1675										
N 1675										
N 1680										
E 1681										
N 1682										
N 1683										
[E] 1685										
N 1686										
N 1687										
N 1689										
1690										
N 1693										
E 1700										
[S] 1700										
E 1702										
N 1704										
[N] [1705]										
N 1715										
E 1715										
E 1716										
N 1717										
N 1720										
E 1723										
E 1728										
[F] 1730										
[S] [1730]										
[S] [1730]										
E 1734										
S 1734										
[F] 1745										
[F] 1746										
E 1748										
C 1749										
[S] [1750]										
[F] 1751										
E 1760										
F 1763										
F 1764										
C 1766										
E 1767										
E 1770										
F 1771										
E 1772										
E 1772										
F 1773										
F 1775										
E 1775										
E 1777										
F 1777										
F 1778										
E 1778										
A 1790										
E 1795										
[F] 1796										
U 1797										

[a] COUNTRIES OF ORIGIN: I - Italy; P - Portugal; S - Spain; T - Turkey; N - Netherlands; E - England; F - France; C - Germany; C - Cuba; U - Uruguay; A - America