Praia daVitoria, Azores

Part 4

COASTAL ENGINEERING PROBLEMS

Figueira daFoz, Portugal

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Chapter 40

PRINCE HENRY THE NAVIGATOR AND THE KNOWLEDGE OF THE COASTS

A. Teixeira da Mota
(Portuguese Navy)
Director, Secção de Lisboa do Agrupamento de Estudos de Cartografia Antiga (Junta de Investigações do Ultramar)

BEGINNINGS AND EVOLUTION OF NAUTICAL SCIENCE

When, under the strong impulse of Prince Henry, Portuguese maritime discoveries began, in the dawn of the XVth Century, methods of navigation were still those of coastal and estimated navigation and resulted mostly from the progress made in the XIIIth Century. During that period the knowledge of geometry of ancient Greece had spread widely and the mariner's compass had been adopted on board the Mediterranean ships. These innovations had the following consequences:

a) Rutters: to the former indication of the principal characteristics of the coasts, particularly as regards to ports and bars, and of the distance between the most remarkable accidents, was from now on added the indication of the magnetic azimuths between these accidents.

b) Nautical charts: the nautical chart, nonexistent in Europe, was created at that time.

The chart was mainly a simple graphic representation of the rutters, the coast being drawn according to magnetic azimuths, without longitude or latitude scales and with one sole distance scale for all the area comprised in the chart. At first only the coasts of the Mediterranean were drawn, then the Atlantic coast of Europe from Denmark to the British Isles and the coast of Africa up to Cape Bojador, as well as those of Madeira and the Canary Islands.

It was these types of rutters and charts that the Portuguese began to spread also to other zones when they started their maritime discoveries in the time of Prince Henry. But they soon proved insufficient to face new conditions and needs.

Actually, the regime of winds of the North Atlantic forced ships to swing far out towards the northwest on their way from Africa to Europe and thus the Azores were discovered in 1427 and the oriental side of the Sargasso Sea before 1448. The methods of estimated navigation currently used in those days became insufficient for the sailors who had to spend several weeks at the open sea, away from the coast. This gave rise to astronomic navigation and to the development of studies on oceanography and magnetism.

It is unnecessary to describe here the evolution processed in that century, it being enough to refer the progress attained around 1500:

a) Determination of latitude at sea by means of the North Star.

b) Determination of latitude at sea by means of the observation of the meridian height of the sun.

c) Knowledge of the regime of winds and currents of the North Atlantic.

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d) Discovery of magnetic declination and its variation in space.

Thanks to new knowledge and techniques, maritime discoveries were extended to all the oceans and this had its effects on rutters and nautical charts, wich now comprised much wider areas. The drawing and description of coasts also improved considerably. And it is this extension and progress that are described below.

IMPROVEMENT AND EXTENSION OF THE DESCRIPTION AND REPRESENTATION OF THE COASTS

EXTENSION

The French historian Gernez wrote the following about this subject:

"Si on examine une des meilleures cartes portugaises du milieu du 16^{e} siècle, celle qu'André Homem fit à Anvers en 1559, on constate que, à l'époque où cette carte fut tracée, soit 124 ans après que Gil Eanes eût, le premier, dépassé le cap Bojador (1434), les marins portugais avaient levé toutes les côtes de l'Afrique (y compris Madagascar), une grande longueur de côtes de l'Asie et des îles de la Malaisie, et les côtes du Brésil, et cela d'une façon relativement exacte. Ce levé hydrographique de plus de 27.000 km. de côtes africaines (Madagascar comprise), de plus de 21.000 km. de côtes asiatiques, de plus de 5.000 km. de côtes des îles malaises, de plus de 7.000 km. de côtes brésiliennes - soit, en tout, de plus de 60.000 km. de côtes, a donc été exécuté en moins de 124 ans, soit une moyenne de plus de 480 km. de côtes levées par an.

"L'ensemble de ces levés hydrographiques constitue donc un travail formidable qui, à cause des difficultés de toute nature rencontrées - faibles navires, équipages trop souvent malades et toujours mal nourris, luttes avec les indigènes aux points de relâche, grossièreté des instruments d'observation employés - est réellement unique dans l'histoire mondiale et mérite d'être admiré sans réserve par les marins de toutes les nations".

The same as with charts, rutters also began to cover a much wider range of coasts, although the increase was not so considerable as in the charts.

PROGRESS IN THE DRAWING

It is still Gernez who says:

"Quand on compare les oeuvres des grands cartographes italiens du 15^{e} siècle avec les cartes nautiques portugaises, on constate une différence entre le dessin des côtes exécuté par les Italiens et le dessin portugais. Tandis que les Italiens représentaient la côte d'une façon presque schématique, en forme d'arcs de cercles plus ou moins courbes présentant souvent en leurs milieux une coupure ressemblant à l'embouchure de quelque fleuve, les Portugais arrivèrent à donner au dessin de la côte un tracé plus conforme à la véritable forme des côtes. Ou remarque encore, sur les cartes portugaises, de représentations un peu schématiques, comme celles des embouchures de rivières, qui sont figurés relativement étroites, mais avec un élar-

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gissement un peu en amont de l'embouchure; mais on peut dire que, en général, le tracé de la côte devient plus conforme à la nature".

LATITUDE SCALE

Besides this improvement in the drawing of charts, a new element, also introduced by the Portuguese, increased considerably the accuracy of the reproduction of coast in nautical charts: the scale of latitudes.

Once sailors had found the means of determining latitude at sea (which they did in the middle of the XVIth Century with a mean error of 1/6 of a degree) it became necessary to reform the traditional nautical chart, wich was drawn only according to estimated distances and magnetic courses, as the position of ships determined by astronomic methods ceased to be correct in relation to the coastline. To obtain agreement the drawing must be based on the corresponding determinations of latitude, and, if possible, with greater accuracy than at sea.

About the year of 1485, king John II sent José Vizinho, Duarte Pacheco Pereira and other cosmographers to Africa to determine the latitudes of numerous points on the coast, with a view to reforming the traditional nautical charts. This was the first time that a group of scientists and technical men were sent on a study mission to make new hydrographic surveys by working on land and sea, and it is yet another thing in which the Portuguese were the beginners.

And thus the scale of latitudes was introduced in nautical charts, which, together with the fleur-de-lis as the symbol of the north, are two Portuguese innovations still used.

When the Portuguese reached the Indian Ocean they found there a nautical science based on astronomical observations, with the determination of star heights on their meridian passage, but the Orientals did not have real nautical charts. The nautical chart based on compass courses and on astronomical latitudes - this latter case being a Portuguese innovation - was the great symbol of the superiority of the European sailors and the basic instrument for their expansion in the seas all the world over.

Likewise Portuguese started recording the new data - the latitude of coastal points - on the rutters, what rendered them far more accurate.

MAGNETIC DECLINATION

It was the Portuguese, and not Columbus, as many people erroneously believe, that discovered the phenomenon of magnetic declination and its variation in space. In the early XVIth Century they were already aware of the great values of the magnetic declination in Newfoundland and in the South Atlantic, as well as they knew the agonic lines then passing near Azores and in South Africa. In the XVIth Century they carried out a large number of magnetic observations in the Atlantic and the Indian Ocean.

The knowledge of the magnetic declination, its variation in space and in time (this last instance was noticed in the beginning of the XVIIth Century) brought about a progressive need for new hy-

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drographic surveys where true courses and not magnetic ones were used, in order to correct prior influences of the magnetic declination on the drawing of coasts. This correction, carried on through numerous doubts, took a long time to be fully perfomed, and Portuguese also played an important part in it.

A similar improvement was made on the rutters, where true azymuth replaced magnetic ones and the local values of magnetic declination were indicated.

The first observation of the deviation of the mariner's needle on board (Moçambique, 1538) as well as the finding out of local magnetic anomalies (Chaul and Bacaim, 1538) were also due to a Portuguese, D. João de Castro.

In this way, the nautical chart, and therefore the representation of the coasts, were much improved.

COASTAL VIEWS ON THE COASTLINE

It is also on Portuguese works - D. João de Castro's rutters (1538-1542) - that an important progress in the field of the representation of coasts was made for the first time.

It is the drawing of coastal views as seen from the sea, the basis of this drawing following the coastline on the hydrographic plans.

This practice, that is no more currently used, quickly passed to the Dutch and afterwards to other peoples, and was a feature of the nautic cartography of the XVIIth and XVIIIth Centuries.

Nowadays, coastal views are given independently of the coastline, but , in that time, such a representation helped to secure a better knowledge of the coasts.

SOUNDINGS

The origin of the numerical record of soundings in nautical cartography is not plain. It is usually said that they appear, for the first time, on Dutch charts of Western Europe, in the last quarter of the XVIth Century. Nevertheless, on a set of charts owed to the Portuguese cartographer Bartolomeu Velho and dated from 1561, some soundings can already be seen near Newfoundland. Although this seems to be their most ancient appearance on dated charts that were known up to the present, we cannot assure, however, that the record of soundings is a Portuguese invention, since the soundings could have been already entered on other charts that were lost.

Anyway, Portuguese were amoung the first who used such an improvement, which also represented an important step in the study of the coasts.

TIDES

When the Portuguese started their maritime discoveries, the usual sailing directions gave already some guidance with reference to the characteristics of tides in the various European harbours.

On the new rutters for the coasts they discovered, the Portuguese followed the same methods and successively recorded the va-

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lues of tides in accordance with the observations they carried out.

SPREADINGS OUT OF NEW NAUTICAL AND HYDROGRAPHICAL METHODS

It was not only through their own discoveries that Portuguese contributed to the progress of the representation and knowledge of coasts. All the Atlantic peoples from Western Europe that threw themselves into overseas undertakings after the Portuguese - the Spaniards, the French, the Dutch and the English - fully adopted the new nautical and cartographic methods created by the Portuguse. Therefore also their maritime expansion brought about an extension and progress in the representation and knowledge of the coasts.

The spreading out of the new techniques was due to direct translations from Portuguese originals (or from Spanish works based on them), to the use and reproduction of Portuguese charts or to the services of numerous Portuguese pilots and cosmographers in other countries. Among these men, many bound their name to the history of the discoveries and of the cartography, such as João Dias Solis, Fernão de Magalhães, João Rodrigues Cabrilho, Estêvão Gomes, Diogo Ribeiro, Duarte Barbosa, Pedro Fernandes de Queirós, João Baptista Lavanha, João Afonso Francês, André Homem and Bartolomeu Velho.

Through the abundant documentation of that period, it is often possible to follow the efforts of authorities of several countries - specially of Spain and of France - with a view to secure the services of skilled Portuguese pilots and cartographers, and also the measures taken by Portuguese rulers against that aim.

Likewise, Portuguese cartography strongly influenced that of several countries in the XVth and the XVIth Centuries as regards the representation of coasts.

Numerous Portuguese rutters were widely used and translated in other countries too, a better knowledge of the coasts of recently discovered regions becoming thus more general.

To end up with, and as we do not wish to indicate only those Portuguese influences, it may be useful pointing out that the ancient Portuguese cartography and rutters can still be of practical interest today inasmuch as they supply data enabling to understand the evolution of some coastal phenomena. Two examples will be given for evidence.

In his "Tratado Breve dos Rios da Guiné de Cabo Verde" (1594), André Álvares de Almada said that bore was met at Rio da Furna (perhaps the now called R. Kapatchez in the Republic of Guinea). Today the phenomenon is no more observed in that region, from what we can infer that the coast underwent some alteration.

On several Portuguese charts of the beginning of the XVIIth Century the island of Luanda appears quite more distant from the continent in the south side than at present. Rutters and other contemporary documents show that ships could take this way for entering the harbour, what is no more possible long since.

A careful analysis of ancient charts and rutters will surely provide a large number of examples of coastal evolution. There-

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fore it seems useful that in the different countries a collaboration in this domain could be established between the modern scientists and the historians working on ancient cartography.

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Chapter 41

THE ASH WEDNESDAY EAST COAST STORM, MARCH 5-8, 1962
A HINDCAST OF EVENTS, CAUSES, AND EFFECTS

Charles L. Bretschneider
Director, Washington Office
National Engineering Science Co.
Washington, D. C.

ABSTRACT

Hindcasts were made for winds, waves and tides for several east coast locations for the storm of 5-8 March 1962. A limited amount of recorded data and a considerable amount of other observations were available from near-by and remote stations. The data were analyzed for correlation or "calibration" purposes in order to improve the "state of the art" of wave and storm surge hindcasting for locations where recorded data were not available. Wind records were analyzed to obtain sustained wind speeds, average gust factors, and probability distribution of gust factors. Isobaric patterns were used to determine sustained wind speeds over the water fetch for deep and shallow water waves and storm surge hindcasts. Wave run-up calculations were made to determine the wave activity on the beach and the dunes and were used to estimate the probable rate of beach erosion and dune evolution. The off-water wind speeds were modified to determine wind speeds over the beach and over the top of the dunes. Finally, by summarizing the time-history of the various meteorological, oceanographic, and coastal engineering events, a very interesting scientific and engineering evaluation of the causes and effects can be made.

INTRODUCTION

The Ash Wednesday East Coast Storm, 5-8 March 1962, was perhaps the most severe storm of the century along the east coast of the United States. It occurred during spring tide conditions, and as a result produced near-record-breaking high tides enabling large waves to attack the shoreline and cause extensive beach erosion, and combined with exceptionally high winds caused a tremendous amount of property damage along the Atlantic coast from Long Island, New York, to Cape Hatteras, North Carolina. The effects of the storm even reached northern Florida where swell greater than 12 seconds was a record observed for the first time. In many cases the dunes were moved back 20 to 40 feet or more. Figure 1 shows the areas of interest along the east coast of the United States.

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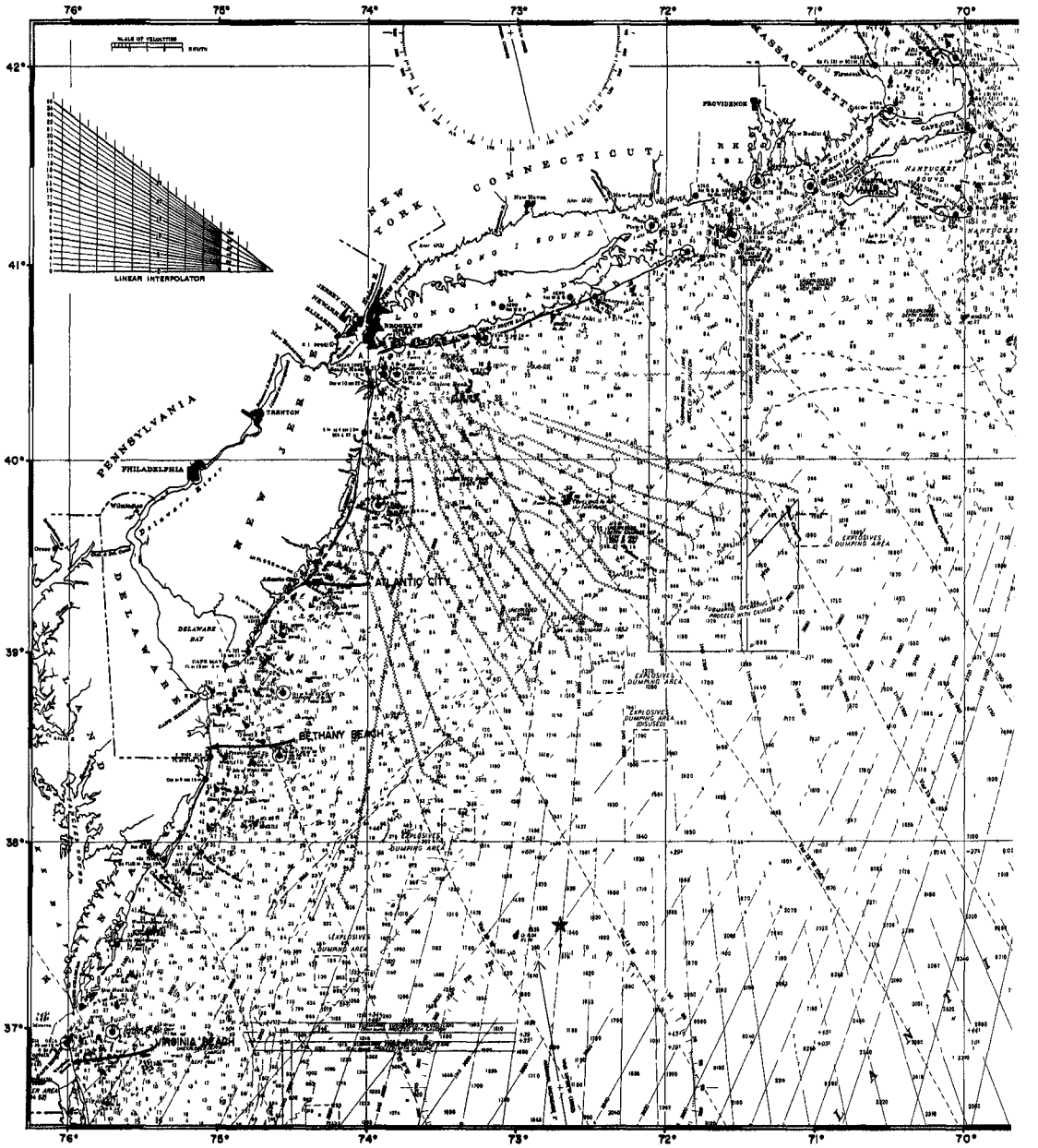

FIG. 1.--LOCATION MAP, EAST COAST OF UNITED STATES

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