International Hydrographic Review, Monaco, LXIII (1), January 1986

THE TIDAL SURVEY OF THE BRITISH ISLES

by Commander N.C. GLEN, MNI, RN (Retd) (*)

ORIGINS OF THE SURVEY

The first attempt at organised tidal observations in the United Kingdom was made in 1834. Admiral Beaufort, who is remembered for his many activities in the hydrographic sphere as well as the start of meteorology as a science and the Beaufort Wind Scale, was Hydrographer of the Navy at the time. This action was partly stimulated by the introduction of Admiralty Tide Tables. The first volume was prepared and published in 1832 giving tidal predictions for 1833. It seems very likely that the preparation of these tables brought to light the marked lack of tidal data around the British Isles.

During the month of June 1834, the times and heights of high and low water were observed at a large number of sites around the country. It appears that Admiral Beaufort was not entirely satisfied with the results achieved, as the observations were repeated, with the inclusion of a number of additional sites, in June 1835. The recording of the times of these events must have been very variable. The idea of an uniform system of times throughout the country had not yet been introduced. It was not until 1845, when the railway system in England reached Holyhead and it became necessary to align the timing of the trains with the ferries to Ireland, that the idea of a time system was introduced. Owing to its origins, it was known as Railway Time. Greenwich Mean Time did not become the official time in England until 1880 and even then Ireland still had its own time, which was slightly different. At some of the sites it is noted that the recorded times are based on a particular sun-dial while at others the local clock was checked by comparison with the watch carried by the driver of the Mail Coach. Thus it can be seen that the recorded times cannot be expected to be of very great accuracy. Much of this data was analysed by J.F. DESSIOU, Master RN, who was employed in the Hydrographic Department after being invalided from active duty at sea. His work books are still kept in the archives at Taunton.

This data was used for many years as the basis for the Secondary Port differences in Admiralty Tide Tables. In fact, there are some areas, particularly in

(*) Superintendent, Tidal Branch, Hydrographic Department, Ministry of Defence, Taunton, Somerset TA1 2DN, UK.

Ireland, where this is still the only tidal data available. However, as hydrographic surveys progressed around the country, opportunities were taken to obtain more accurate and more comprehensive data. This was obviously the most economical way of obtaining data, but it did result in numerous gaps in the geographical sequence. This, combined with the lack of precision in the remaining data, resulted in Tide Tables which were extremely variable in their accuracy.

In 1953 it was decided that the only way of obtaining data in a sufficiently detailed and comprehensive manner to satisfy modern requirements was to carry out a new Tidal Survey of the whole country. In addition to High and Low Waters, half-hourly observations of the height of tide were to be taken throughout the period of observations. This enabled the shape of the tidal curve to be determined in much greater detail and also provided the data for Harmonic Analysis. One of the major factors in coming to this decision was the introduction of the supertanker with a draught which was very much greater than that of any previous ship. These ships also required much greater information of the tidal regimes in offshore areas : information which could not be supplied effectively unless the coastal data was well known. The plan was to observe at a small number of sites in one particular area simultaneously, in as great detail as possible, for a period of one month, rather than try and obtain data throughout the country at one fell swoop.

The first area chosen was the east coast of England between Winterton and Southwold. This area was chosen because the channels close offshore are constricted by numerous sandbanks which frequently change their shapes and depths. To maintain adequate charting of the area regular re-surveys are necessary and, for these to be satisfactory and for the movements of the banks to be followed from year to year, the establishment of an efficient system of tide gauges and chart datums was essential. Also, this is an area where the range of the tide does not vary greatly but, due to the proximity of a nodal point, the time of the tide varies considerably in a comparatively short distance. Thus, in a distance of only 30 miles it was necessary to install six tide gauges. These were observed simultaneously for one month.

METHODS OF ANALYSIS

The data obtained was analysed both non-harmonically, for the time and height differences to be used in Admiralty Tide Tables, and also harmonically. Before doing these analyses, the data was plotted out on a series of squared sheets in such a way that the data at all the gauges for any particular day was on the same sheet. This gave an immediate visual indication of the changes in the tidal regime along the coast, not only in terms of the changing range and time of the tide, but also in the changing shapes of the tidal curves. This method has proved very sensitive in detecting any temporary errors in the setting of the gauges or in the time records. Thus, if all the curves show a degree of parallelism of regular change, very much more confidence can be placed in the data than is the case for a single set of observations.

Should the readings from one gauge not fit the regular sequence along the coast, the records can then be examined to see whether this is due to errors in the records or some particular feature of this site. Impounding is very noticeable when the records are plotted out in this way. One major advantage of this method is that the level of confidence which can be placed in the final results obtained is certainly greater than that which can be expected from an individual set of observations. A disadvantage is the large amount of plotting and drawing by hand involved.

The first area was observed in 1954 by the East Coast of England Survey, of which I was in charge at the time. In this case, the observing was carried out by the use of visual tide scales and human observers. This required at least 18 men solely employed on tidal observations. It was obvious that this was a very uneconomical use of manpower and steps were taken to acquire a number of portable automatic tide gauges. Experience since then has shown that a simple type of pressure gauge can give remarkably accurate data when one considers both the cost of the equipment and the ease of installation.

THE TIDE GAUGE

The gauge now in use, and also regularly used by HM Survey Ships, is based on a simple pressure recorder marketed by Kent Ltd. The pressure sensor is a small stack of pressure capsules and the time mechanism an ordinary clockwork clock, so that no outside power supplies are necessary. The clock rotates the paper disc once every 24 hours and requires winding once every seven days. The record is made by a small felt-tip pen which is specially made for this type of application.

This recorder is connected by a very small bore plastic pipe to a metal diaphragm box. As this pipe can be easily damaged, it is normally threaded through a larger pipe which is merely used as a protection. The pipe is usually either 50 or 100 feet in length. This places a considerable restriction on the distance between the diaphragm box and the recorder at any site. A longer pipe can be used, but only in areas where either the range of the tide is quite small or a much larger diaphragm box is used.

As the recorder is open to the atmosphere, it acts as a differential pressure gauge recording the difference in pressure between the diaphragm box and the atmosphere. Thus no correction for the barometric pressure is necessary. It has been found in practice that, provided great care is taken with the choice of site, and with installation and operation of the gauge, it is possible to obtain observations accurate to about + or − 3 cm. This is clearly as good as, or often better than, observations obtained visually. Of course, a great deal depends on the amount of wave motion experienced at the station and great care is taken in the choice of sites. Naturally, in bad weather, which nearly always seems to occur at least once during the month chosen, the accuracy is bound to suffer.

The height readings obtained are dependent on the density of the sea at the site as well as on the calibration of the pressure sensor. These effects are combined by making regular checks between the recorded height and the level obtained by reading a visual tide scale. In order to make these checks, one man is stationed at

each gauge site for the period of the survey. He makes regular — at least once daily — checks of the tide gauge. He records the height shown by the gauge, the height read at the same time on a visual tide scale and the state of the sea in the vicinity of the scale, so that the accuracy of the readings can be judged. He also notes the time shown by the recorder and compares it with an accurate watch.

If these checks are carried out at approximately the same time each day, a regular check on the calibration and stability of the zero of the tide gauge can be made. Also, as the tide progresses from springs to neaps and back again, the height checks are made over the whole range of the tide and so form an effective calibration of the gauge. The visual tide scale is levelled in to the National Levelling Network; in the United Kingdom this is Ordnance Datum (Newlyn), and through this levelling all the tidal heights can also be referred to the national datum. This is essential if changes in the tidal regime along a stretch of coast are to be detected and compared effectively. However, experience has shown that observations taken with this system are sufficiently accurate for all modern navigational requirements. They are also found to be of great value to engineers and may assist in the design of mathematical models.

THE SURVEY

The survey began on the east coast of Norfolk and has proceeded in a clockwise direction around the English coast. Each year, except when such events as the fuel crisis in the United Kingdom have prevented operations, a section of coastline has been carefully surveyed. The length of coast has depended on the complexity of the tidal regime in the area.

THE THAMES ESTUARY

The Thames Estuary, which is a very complex area, took about five years to complete, with a total of 35 stations. Some of these were observed more than once so as to provide links between the data obtained in other years. Advantage was taken of the existence of a number of towers so that data from sites in the middle of the estuary could also be included. The analysis of such a large mass of data is very complex. Firstly, each station was compared with simultaneous observations at a Standard Port which was chosen to act as a basis for the whole estuary; in this case, Sheerness was used. Next, small sections of the area were taken and referred to a more local standard. The first analysis indicated a considerable spread in the results obtained, due to the differing effects of the wind on the various parts of the estuary. The second analysis reduced these spreads considerably, and clearly showed that Standard Ports on each side of the estuary would be necessary if a reasonable standard of accuracy was to be obtained. Finally, the local standards were compared with each other to ensure that the data gave as good agreement as possible all over the estuary. The result of this work was a series of time and height

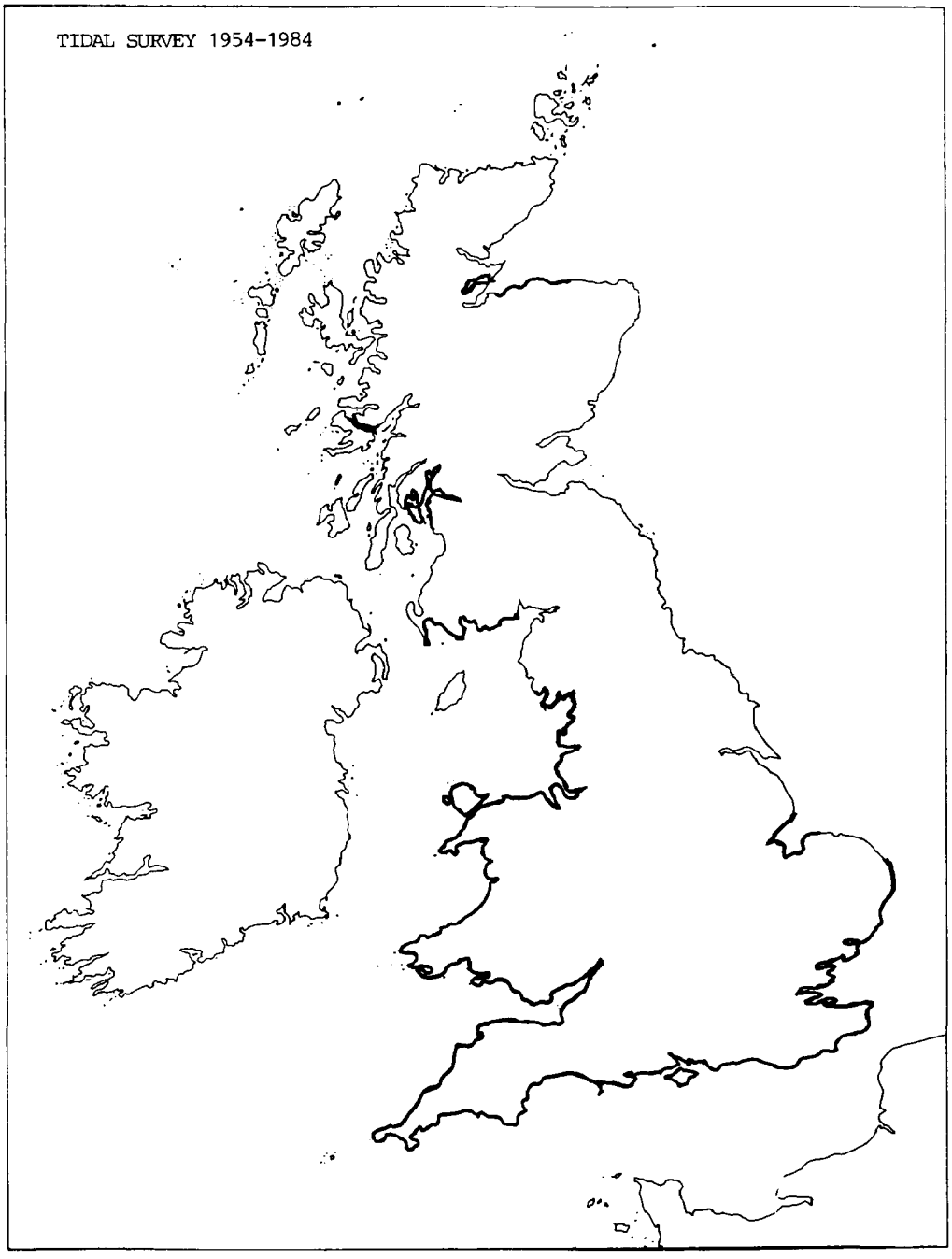

FIG. 1.

differences which were, as far as possible, independent of meteorological effects. From the results, it was possible to see clearly that the estuary needed three Standard Ports if satisfactory predictions were to be obtained. It was possible to see how the estuary should be divided between these ports to give the best predictions. Before finally dividing the estuary up, as is now shown on the published co-tidal charts, it was also necessary to consider the directions of the main shipping routes. Throughout, the object kept most in mind was the need to provide the mariner with the best data in the simplest manner.

THE ISLE OF WIGHT

The area between Portland and the eastern extremity of the Isle of Wight is another area of great tidal complexity. While the Thames Estuary is an area of considerable shallow water effects, the Isle of Wight is an area where the semi-diurnal tide is very reduced with a sort of nodal situation, while in the same area the quarter-diurnal tide is at its maximum. Again a large number of stations and several years' work were required. In this case, it was found that the complexity of the tidal curves is so great that a special method of tidal prediction is required. In this area, the tidal curve is so distorted that, either two high waters occur or there is a long stand of several hours' duration. In either case, the time of high water becomes extremely difficult to determine with any degree of accuracy. To cope with this situation the various curves used in the prediction of heights at times between high and low water are referred to low water. It is immediately apparent from the observation that low water can be clearly defined and hence much more easily predicted. In addition, a new method of interpolation is being introduced in Admiralty Tide Tables Vol. 1, which will greatly simplify the determination of tidal heights at times between high and low water.

THE BRISTOL CHANNEL

The Tidal Month for 1977 concentrated on the Bristol Channel between Avonmouth and a line joining Ilfracombe and Milford Haven. In this area, 16 stations were observed simultaneously. This was only possible with the assistance of the Port of Bristol Authority, the South Wales Division of the British Transport Docks Board and a research student from the Oceanography Department of the University of Swansea. Even with all this assistance it was not found possible to observe over the full range of the tide at all stations. The mean Spring Range in this area varies from 6.3 metres at Milford Haven to 12.3 metres at Avonmouth. Also, in some parts of the area the beach is so flat that at low water the sea is as much as a mile from the shore line.

As a result, it was not always found possible to observe the low waters. However, sufficient data was obtained to enable a new, and noticeably different,

co-tidal chart of the HW data to be drawn. This, combined with such low water data as was available, is now to be used to assist in the studies concerning the possibility of building a barrage across the Severn Estuary for the production of electric power from the tides.

PROGRESS

The survey has now reached Morecambe Bay, though certain other areas such as the Salway Firth, the Firth of Clyde and the Sound of Mull have been surveyed as opportunities offered. The area from Barrow-in-Furness to the Salway Firth is under consideration for 1985, with the possibility of a return to Norfolk and the Wash areas for 1986 and proceeding northwards up the east coast in subsequent years.