

HYDROGRAPHIC CONTRIBUTIONS TO SAFETY AT SEA 1975-85

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ROLE OF HYDROGRAPHIC OFFICES

Hydrography describes the environment in which marine navigation occurs : the chief purpose of hydrographic offices is the service of navigation. The main form which this service takes is the publication of nautical charts, especially for the comparatively shallow coastal belts in which most ships are to be found. The charts are supplemented by graphic and book publications which provide certain categories of information in greater detail. To help achieve their purpose, most hydrographic offices operate small flotillas of surveying vessels, mainly in their national areas of interest, which measure the depth of the sea, determine the coastal configuration, gather information about new hazards, and so on. This sea-going effort is only part of the overall intelligence-gathering mounted by the shore establishments of the hydrographic organisations.

Hydrography has to respond both to the physical and to the man-made features of the environment. Over the last decade changes in both, and the strengthening of factors and trends discernible before 1975, have influenced the hydrographic services provided. This paper will trace these developments, and the reasons for them, from the point of view of the Hydrographic Department of the United Kingdom, which is part of the Defence Ministry. The military aspects of hydrography will not, however, be considered.

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ENVIRONMENTAL FACTORS

Since 1975 the inadequacy of knowledge of the depth and shape of the seabed on the continental shelves has become increasingly apparent, as navigational safety has been pushed to further limits in response to economic factors. Less than half of the British continental shelf, defined approximately by the 200-metre depth contour, has been surveyed by echo-sounder and only a small proportion to full modern standards. There are inevitably many natural hazards still to be discovered. Inadequate knowledge can have particularly serious effects in heavily-trafficked shallow areas, where patches of the seabed may show instability in the form of mobile sandwaves. Seabed wrecks and obstructions, some of them wartime relics, are another problem — thanks to the use of modern sidescan sonar, in 10 years the number of wrecks in the UK area databank has risen from 14,000 to 22,000.

As long ago as 1962 the North Sea Hydrographic Commission (NSHC), consisting of the national hydrographic offices of NW Europe, decided that all surveyed areas needed reassessment. New categories of survey accuracy were defined, and subsequently redefined, according to the nature of the area, the type of use, and the reliability of the measuring techniques employed. A crucial factor, fully established during the period under review, is the substantial number of very large crude carriers (VLCC), drawing up to 23 metres, which regularly pass through the North Sea with small under-keel clearances. Initially, most concern was caused by oil tankers from the Gulf transiting Dover Strait en route to Europoort. More recently, hydrocarbon exploitation in the North Sea itself — in turn leading to the establishment of the Sullom Voe oil terminal in the Shetland Isles, an example of new port developments of all kinds to which hydrographic offices have continually to respond — has increased the number of VLCCs passing through its central and northern parts and along the west coast of Scotland. Unfortunately, none of the new routeways thereby established by usage had ever been systematically surveyed. Clearly, in view of the finer safety margins, there is more than ever a need for hydrographic office publications to provide the information which each type of navigator requires — the small-craft leisure sailor, whose numbers have proliferated in recent years, no less than the deep-draught operator — and for new hazards to navigation to be made rapidly known to all.

There have been well-defined responses from national and international safety agencies to these new patterns of use of the seas. Their responses have in turn influenced the services provided by hydrographic offices. A notable measure has been the introduction of more stringent routing requirements. In international waters the International Maritime Organization (IMO) is responsible for laying down both Deep Water Routes and Traffic Separation Schemes (TSS). A prerequisite is to judge the adequacy of hydrographic surveys of the areas concerned, and for the North Sea the initiative in identifying suitable new routes has in some cases been taken by the NSHC. A further aspect is the growth of local traffic management schemes in ports and their approaches, using VHF radio and radar to guide ships inwards and outwards. A negative example of the relationship between navigation and hydrography, however, was the effect between 1977 and 1983 of Rule 10 of the International Regulations for Preventing Collisions at Sea.

During those years, until the rule was amended, surveying ships could not operate freely in TSS lanes, so that seabed changes there could not readily be detected by them.

Developments affecting aids to navigation have been a major factor during the last ten years. Most noteworthy was the worldwide rebuoyage programme initiated in 1977 by the International Association of Lighthouse Authorities (IALA), aimed at eliminating the differences between national buoyage systems by standardising the meaning of identical marks, and given impetus by three successive sinkings in Dover Strait in 1971. The third casualty struck one of the earlier wrecks several weeks after the first collision (which was caused by a vessel travelling NE in the SW-bound traffic lane) despite a manned wreck-marking lightship and five lighted wreck-buoys guarding the wreckage. The new IALA combined lateral and cardinal system has presented a major charting challenge for hydrographic offices to meet.

HYDROGRAPHIC SURVEYING

During most of the last ten years the UK Hydrographic Service has operated a surveying flotilla consisting of four ocean survey ships, four coastal survey vessels, and five inshore survey craft, all of them ships of the Royal Navy. They have been supplemented recently by a chartered trawler carrying a naval surveying team, and by effort commissioned from commercial surveying companies. The electronic position and depth sensors with which each ship is equipped largely free the modern hydrographic surveyor from the constraints of weather and daylight, and greatly enhance the accuracy and amount of his work and hence of the information he provides. Positional control of surveys is mainly by means of the Hi-fix and Trisponder radio position-fixing systems, using phase comparison or range measurement to generate hyperbolic or circular position lines. Multi-position line fixing, making use of three or more pairs of transmitters/receivers, increases the reliability of the systems. The Minicomp plotting system, consisting of a micro-computer and a line plotter, uses position-system input to improve sounding-line spacing and ensure that sonar cover is comprehensive — it is especially useful in areas of strong tidal streams. Position accuracy is to be further improved by the introduction of roll-and-pitch sensors, to measure antenna movements from the vertical. In less developed parts of the world such as South Georgia, which lack modern geodetic networks into which hydrographic surveys can be tied, accurate positions of control stations ashore are determined by satellite Doppler positioning, requiring multiple observations of Transit navigation-system satellite passes.

There have been comparable advances in seabed depth measurement during recent years. Each surveying vessel is equipped with a modern echo-sounder and a towed sidescan sonar system. The latter allows almost the whole of the seabed between the sounding lines to be examined and all wrecks, rocks and other obstructions to be located for subsequent examination to establish the least depth over them. In consequence, about 15 per cent of the UK continental shelf is now surveyed to full modern standards. Hydrossearch, a forward-looking sector-scan-

ning sonar, is soon to be fitted to a second survey ship — it establishes the least depth over shoals and wrecks without the need for wire-sweeping and, unlike towed sidescan sonar, does not require ship's speed to be reduced. The introduction of heave compensators will further add to depth measurement accuracy.

The annual UK hydrographic surveying programme in response to the requirements of merchant shipping is determined by the government's Transport Department, the funding authority which allocates priorities in surveying the shipping routes and outer approaches to ports, with advice from the Hydrographic Department. In common with the practice of those members of the NSHC most closely concerned, emphasis is placed on sounding and sonar-searching the more changeable areas of the southern North Sea, the most critical parts of the traffic lanes being monitored every twelve months. The object is to ensure the safe passage of ships which occasionally have to operate, in the case of the largest vessels, with little more than two metres of water under their keels. Modern surveys over the last ten years have revealed serious hazards previously unknown or imperfectly known; notably, in 1975, a pinnacle like a church steeple rising to within 9 metres of the surface, from depths of 30 metres, just off the fairway to the port of Holyhead; and, in 1977, the mast of a wreck in Dover Strait, standing 30 metres above the seabed in 54 metres of water.

The complication of the areas of unstable seabed off the east coast of England, frequently straddling or impinging on important shipping lanes at depths which are critical to safe navigation, has been alluded to. Some of them consist of parallel sandwave ridges, rising several metres between crest and trough, which form a wave pattern which may slowly move across the seabed within the limits of the area of instability, causing least depths to vary from year to year or month to month. One such area was discovered for the first time in 1982. Re-surveys are regularly examined in the Hydrographic Department to observe past trends and hence the degree of instability; the reason for the changes is sought from tidal stream data and by interpreting the effect of underwater relief. Thereby future developments can be predicted and the required survey periodicity decided; by this means it may be possible, for example, to reduce the frequency of surveys from one year to three.

Another activity ashore in support of the field surveying effort is the extraction of land and depth detail from photography obtained by fixed or rotary-wing aircraft, and more recently from imagery provided by bands 4 and 7 of the LANDSAT multi-spectral scanner. The photography is sometimes used to chart coastline, drying features, and new cultural detail, and in clear tropical water can also yield approximate depth measurements down to 20 metres. The imagery is primarily of use for the initial location of reefs and other dangers, and of the channels between them, in poorly-surveyed waters.

In the British home area, apart from the offshore work by major surveying units already described, separate use is often made of the motor boats borne by them in order to carry out surveys of small harbours and estuaries which lack their own port hydrographic unit. Abroad, the UK Hydrographic Service's tradition of providing surveying ship assistance to small or developing countries was continued between 1975 and 1985, but necessarily for economic reasons on a smaller scale than previously. Work was carried out mainly in the Middle East, East and West Africa, the Caribbean, the South Atlantic, and Antarctica.

RADIO NAVIGATIONAL WARNINGS

The most urgent hydrographic contribution to safety at sea is the communication of important changes by radio. The triple sinking in 1971 emphasised the need to coordinate the existing systems of long-range warnings. To this end, the International Hydrographic Organization (IHO) and the International Maritime Organization cooperated to devise and establish the Worldwide Navigational Warning Service (WWNWS), which was initiated in 1976 and comprises 16 NAVAREAS. Each is coordinated by a hydrographic office, which arranges for the transmission of warnings that can be received throughout the area and over a radius of about 700 nautical miles outside it. The messages are concerned in particular with information which may cause changes to planned routes. Important local warnings already promulgated by coast radio stations are supplied for promulgation as area warnings, and adjacent coordinators exchange appropriate messages for repromulgation as thought necessary.

For the dissemination of shorter range warnings the new NAVTEX system is being introduced. By means of automatic direct-printing methods it aims to provide shipping with the latest urgent navigational information, weather warnings, and initial distress messages, and it will cover major port approaches and high-density shipping lanes up to 400 miles offshore. The dedicated ship-borne equipment consists of a low-cost receiver fixed-tuned to 518 kHz and a printer using "cash-roll" paper, the equipment being switched on continually. After trials carried out in Sweden in 1977, NAVTEX was extended in 1983 to cover all NAVAREA I (NW Europe) from eleven coast radio stations, and its use is increasing progressively elsewhere in the world.

NAUTICAL CHARTING

The main hydrographic contribution to safety at sea is in the form of the navigational chart. Due to the progress achieved between 1975 and 1985 with the Hydrographic Department's recharting programme, almost one half of the 3,400 charts of its worldwide Admiralty series are now in modern style and use metric units. Each new chart has been recompiled from the latest source material, its limits being reviewed to obtain optimum coverage of the stretch of coast and water area included. The navigator benefits because these modern charts are more open and, therefore, easier to read and update, and lend themselves to the use of automated production techniques. In British waters the chart cover of new areas of commercial interest — the Orkneys and Shetlands for example — has been improved, and large-scale plans of minor harbours and riverways have been introduced or restored. Several dozen medium and large-scale charts have been allocated INT numbers to include them in the IHO's basic selection of "international" charts, which are available for adoption and republication in modified facsimile form by any of its member hydrographic offices. Overseas, apart

from the systematic replacement of older sheets, charts of some new ports have been published at the request of the national authorities — for example Bintulu in Sabah and Yanbu in Saudi Arabia.

The international standardization of nautical chart style and symbolisation has proceeded in parallel within the IHO, and the UK has supplied much of the effort required to expedite this work. The aim has been to avoid the use of descriptive terms as far as possible and to make charts instantly comprehensible — greater use is made of pictorial symbols for beacons and other prominent objects, *for example* — and an increasing number of hydrographic offices are implementing the new international chart specifications. Among the improvements introduced on Admiralty charts, inset source data diagrams show, whenever possible, the date, scale and origin of the source material on which the chart is based; estimated clearance depths are stated over unsurveyed wrecks; disused submarine cables are shown in likely anchorages in addition to the charting of all active cables; and conversion notes, which give the local difference between WGS and chart datums, facilitate the use of satellite navigation systems. In order to ease congestion caused by the need to show more and more linear boundaries, they are printed in black or magenta according to whether they represent physical limits or superimposed, often regulatory, limits devised by man.

Of the developments in the navigational environment which have most affected nautical charts during the last ten years, three are worthy of special mention : offshore oil and gas exploitation, the IALA rebuoyage programme, and the proliferation of mandatory and recommended routes. The southern North Sea gasfields occupy areas crossed by heavy traffic, and they have given rise to novel navigational difficulties which the Hydrographic Department has helped to solve in promulgating and charting the installations. Further north, the towing of huge oil platforms with draughts of as much as 150 metres called for a different kind of advice. For the IALA programme to be a success, it was imperative that it be scheduled so that hydrographic offices could issue new editions of the thousands of charts affected in step with the implementation of the changes. The UK took the initiative in making known to IALA the implications for hydrographic offices in general : a ten-year worldwide implementation programme was proposed, and the discussions included consideration of the navigational problems which might arise when the conversion programme began in British waters in 1977. Hydrographic experience was drawn on to ensure that the IALA system would be easily understood at sea and on the charts, and a systematic multi-stage promulgation procedure was devised. The charting of new routeing measures requires similar anticipation, and one response has been the publication, after extensive user consultation, of a new type of Admiralty chart, the Mariners' Routeing Guide to the English Channel and southern North Sea (5500), composed of diagrams and textual panels to summarise navigational regulations and assist safe passage through these busy waterways.

At one end of the user spectrum, the small-craft navigator has benefited from the improved charting of minor British harbours, and his needs have been further met by increased inshore detail on many large and medium-scale sheets, and by the overprinting on some of them of special symbols to denote facilities of particular interest to him. At the other end, the recharting of the world ocean is almost complete, although the source data still consists largely of sporadic sounding lines.

Fifty small-scale charts of varying scale and age, showing depths in fathoms, are being replaced by 123 modern metric charts on consistent scales of 1:10M or 1:3.5M, about half of them originally published by other hydrographic offices and forming part of the IHO's "international chart" series. They show ocean-bed bathymetry in greater detail than previously, even if the depth contours are of necessity partly conjectural. Most of the 1:3.5M sheets are also available with lattice overprints for use if desired with the Omega trans-oceanic navigation system.

NAVIGATIONAL BOOKS

Prompted by the re-think to which nautical charts had been subjected, the modernisation of the 74 volumes of Admiralty Sailing Directions, which began in 1972 after thorough consultation of users, has more recently been taken a stage further. Description in words of the physical detail shown on charts is being severely reduced, and emphasis is placed on waterways as navigational entities — a channel, a passage along a stretch of coast, a bay, an estuary, or a harbour — instead of the traditional step-by-step description of the coastline. Within each waterway the information is to be presented on a logical standard pattern. Oblique aerial photographs of harbours are included, and views to illustrate landmarks and leads, as well as panoramic coastal views. The weekly correction of pilot books by notice to mariners has also been introduced. In the expanding field of radio assistance to navigation, two books in the Admiralty List of Radio Signals series now provide details of the traffic management systems in the approaches to ports and within them, supplemented by an atlas of diagrams illustrating the schemes in 25 complex areas across the world.

The Hydrographic Department's tidal publications, during the last ten years, have responded to the environmental hazard represented by the shallow areas along VLCC routes, as in the southern North Sea, where knowledge of the tidal level is of utmost importance. Harmonic constants for standard and secondary ports throughout the world have been included in the three Admiralty Tide Tables (ATT) volumes, enabling tidal predictions for all such ports to be made, and the recommended graphical method has been made simpler and more accurate. Alternatively, a programmable pocket calculator can be used for predictions by making use of standard forms devised for the purpose and included in the ATT. Most recently, the inclusion of harmonic constants for tidal streams allows predictions of hourly rates and directions, where tides are complex and navigationally important and the tidal stream atlases are not sufficiently detailed. For the determination of the times and heights of tides offshore, co-tidal charts are required. The accuracy of these is being enhanced by measurements from new sensors, positioned on the floor of the North Sea, which observe variations in pressure as the tide rises and falls.

FUTURE CONTRIBUTIONS

New electronic instrumentation in the hands of hydrographic offices, and of the users of their products and services, will inevitably continue to change the shape of the latter. Information, whether in chart or book form, will increasingly take a digital form, including that of "electronic charts" — the micro-form stage seems likely to be largely bypassed in the electronic revolution. Hydrographic data will thereby become more easily portable and more flexible, but its successful use will depend upon the development of dependable ship-borne equipments, and it is most probable that maritime safety organisations will demand that paper charts and books continue to be carried until full electronic reliability has been achieved. Hydrographic offices are being faced with the huge task of transferring much of their graphic and written information holdings to digital databases, but in future more and more hydrographic information is likely to be supplied by surveyors in digital form from the outset. In the more distant future, it is conceivable that data could be transmitted almost immediately to navigational users, for whom, ideally, all hydrographic information should be fully up-to-date — though the sheer volume of information involved might be inhibiting — whereas traditional time-consuming handling processes inevitably impart a slightly historical flavour to most of it. Another possibility is the updating by radio, conceivably via satellite, of the ship-borne hydrographic digital databank — perhaps directly, perhaps via a keyboard. In the meantime, progress in the more conventional services of hydrographic offices will undoubtedly continue, particularly in the standardisation of all IHO Member States' nautical charts, and in the designation of a selection of these to constitute a recommended basic international set.

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