DEEP DRAUGHT SURVEYS IN THE SOUTHERN NORTH SEA

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Although it may be assumed to be a well-known fact that today giant ships of up to 300 000 tons and over are plying the oceans, this paper starts nevertheless with the presentation of a graph (figure 1). This graph relates the increase of draughts to the steady and even tumultuous increase in tonnages and illustrates very clearly why hydrographers find themselves in trouble.

The truly stormy developments over the last decade and a half saw the first supertankers of that era being dwarfed by the giants of the late

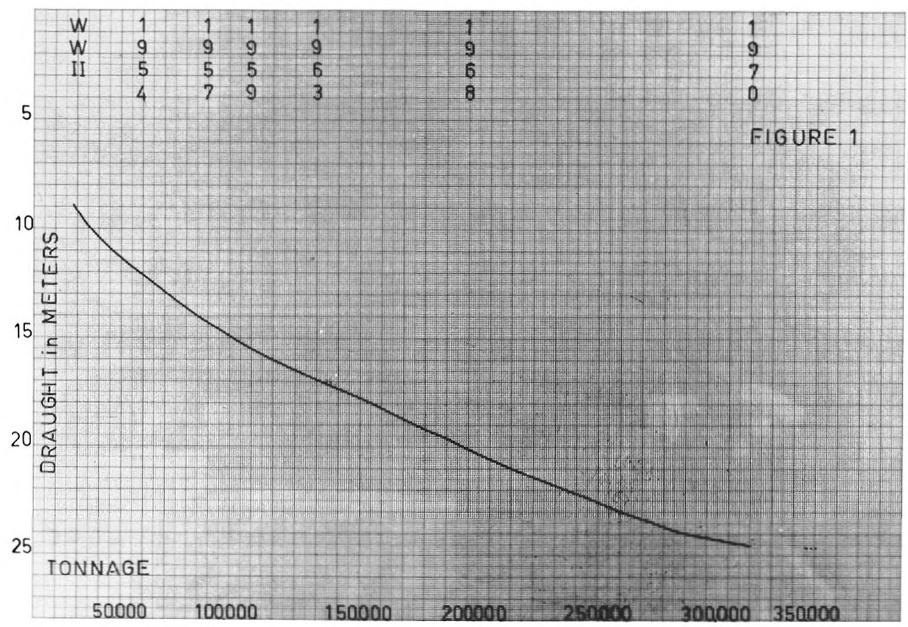
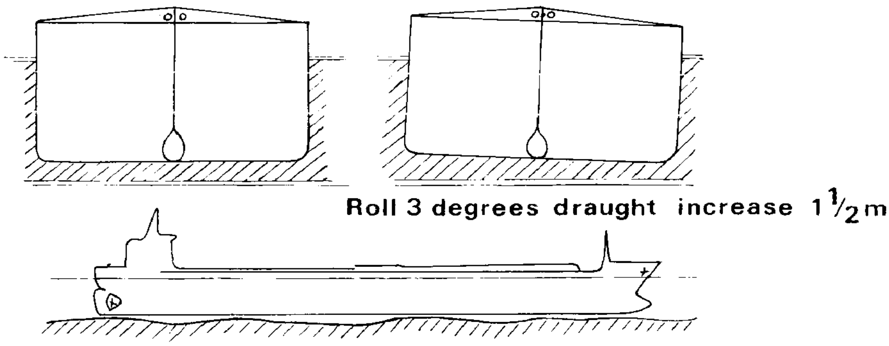


FIG. 1.

sixties, VLCC's like the *Universe Ireland*, of 326 000 tons, with even bigger ships yet to come. Draughts have at least doubled, with due impact on safe navigation and require more detailed surveying of the seas to standards until recently regarded necessary for coastal work only. In less than ten years the North Sea has become a marginal inland sea where the 20-metre depth contour spells danger to an ever-increasing number of vessels (*figure* 2).

TANKER 260.000 tons DW



Length	300m
Draught	20m
Width	50m
Waterdepth	24m
Height of sandwaves	4-5m
Keel clearance	4m

FIG. 2.

In 1962 the Hydrographers of the North Sea littoral states recognized the hard fact that the steady growth of the already huge crude carriers would necessitate hydrographic surveys on a scale as yet unknown and so far not planned for. The Netherlands Hydrographer, Rear Admiral LANGERAAR, taking the initiative to form the North Sea Hydrographic Commission (NSHC) convened this body's first conference at the Hague in 1962. The Commission, composed of the Hydrographers of the U.K., Germany, Denmark, Sweden, Norway and the Netherlands, carefully analysed the developing situation and concluded that the combined available survey potential for the North Sea area would require until the end of this century to survey carefully and chart the waters of the North Sea of 30 metres and less depths.

Until then the Hydrographic Services — with the exception of the British service — had given their main attention to surveying and charting of coasts and near shore waters, estuaries and harbour approaches. The need for more detailed surveys of the seas further offshore, save for the charting of off-lying sandbanks etc., did not exist. These areas were considered deep enough for safe navigation, which indeed they were under the prevailing circumstances.

The NSHC decided on a minimum programme to be carried out jointly. The aim being to pay maximum surveying attention to those areas of the North Sea where deep-draught traffic would be most likely to develop. In close liaison with the larger tanker companies in the six countries concerned a basic network of foreseeable deep-draught routes — with due regard to terminal ports and transit requirements — was established. It must here be stressed that these " routes " were based on the hydrographers' expectations on where the deeper waters might be expected.

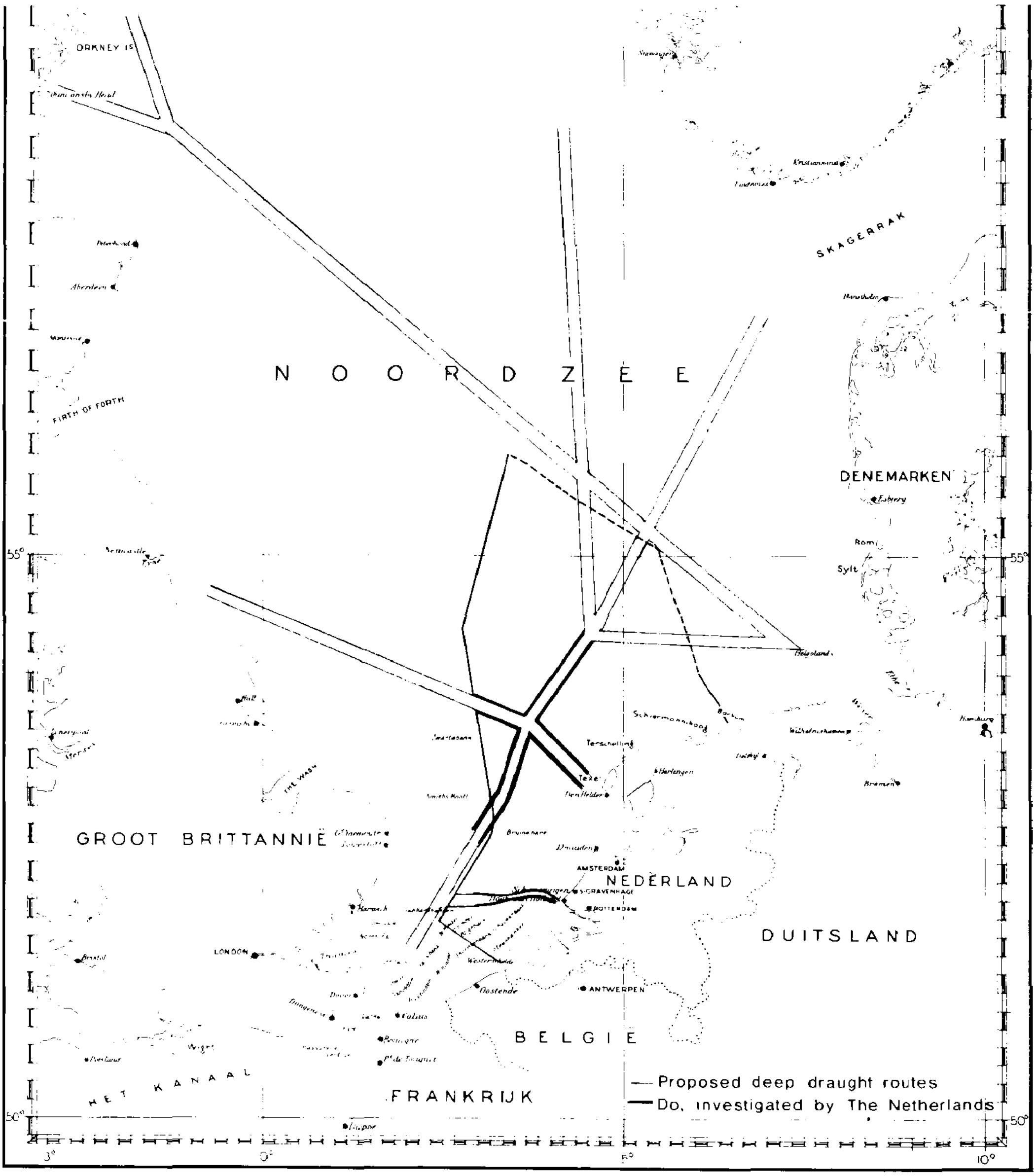


FIG. 3.

FIG 4.

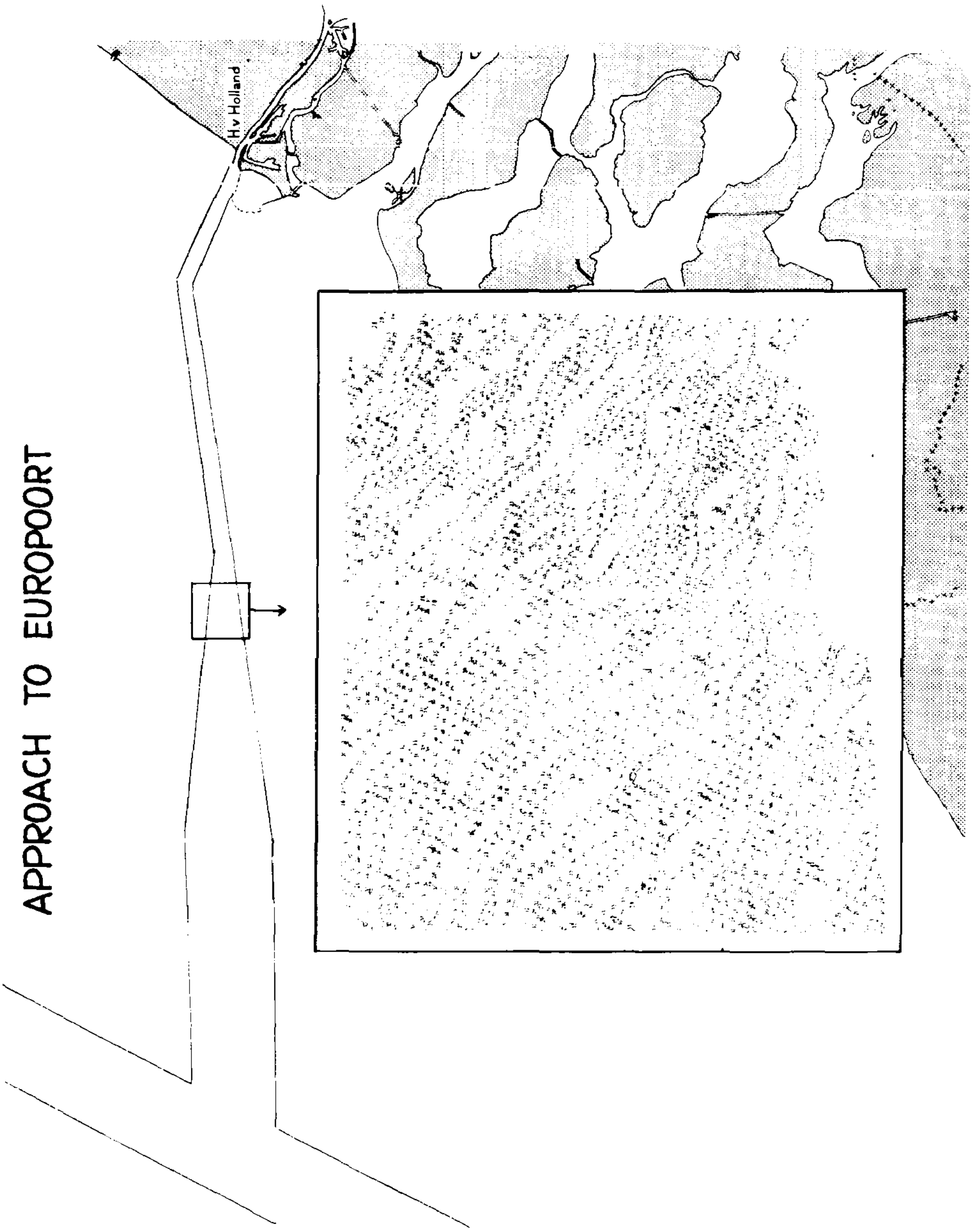


FIG. 5.

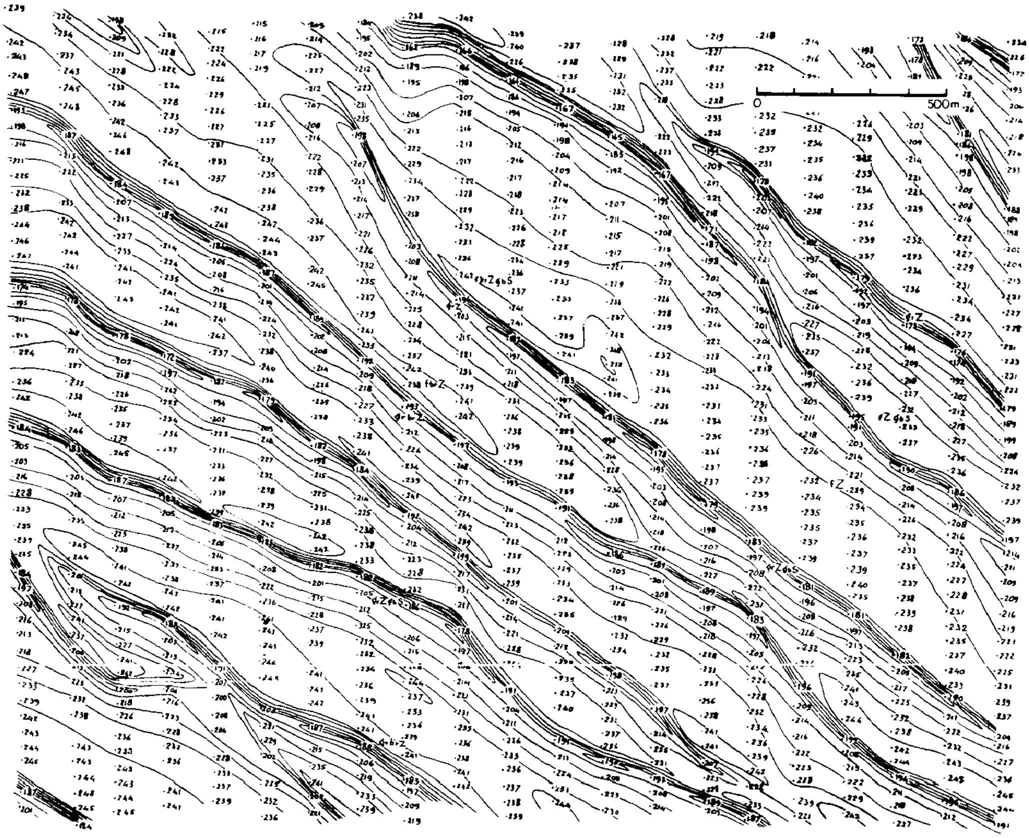


FIG. 5 (continued)

The next step involved reconnaissance surveys by the six Hydrographic Services in order to ascertain whether the actual depths in the routeing areas were indeed the more favourable ones. This reconnaissance resulted in a few minor corrections to the pattern. Figure 3 shows the resultant network, and is illustrative of the first step to be taken when having to survey and chart for deep-draught shipping — namely, to decide on the minimum requirement.

Close surveying of these high priority routes now became a matter of apportioning. The Netherlands share thereof has been marked by thickening portions of the relevant lines. Close surveying in this sense meant that the route area to a width of about 5 n.m. had to be covered by sounding lines much less apart than hitherto considered necessary. Presently, sounding lines in some of these areas are planned as close together as 125 metres, and even 75 metres. Apart from sounding the routes, sonar searches were carried out in order to detect any obstacles such as wrecks.

The situation in the southern North Sea, where an alluvial seabed obtains, is complicated by the existence of a large number of sand-waves or ripples. These ripples manifest themselves in depths from 10 to 40 metres, and may reach amplitudes of 15 metres on occasion. In this case one may fairly call them megaripples! Although not sufficient details are available thus far, there seems to be enough evidence to indicate that these ripples move, and also vary in height with time. Their gradients vary greatly, the more common slopes being in the order of 1/8, although 1/3 slopes have also been noted. This phenomenon clearly makes regular resurveying a must. The Netherlands Hydrographic Office, with the aid of numerous echographs collected by men-of-war of the R.Nl.N. over the period 1963-1968, has inventoried the occurrence of sand ripples in its area of responsibility, and the resultant picture tends to a state of affairs where 5 metre and higher ripples are more common in appearance than a flat seabed or shallow ripples. (see figures 4 and 5).

Until quite recently the proven means of checking on obstacles in a large area or shipping lane was the wire drag, whereby a steel rope was towed through the water at a preset depth. If no obstacles were encountered the swept area was considered safe for shipping drawing less than the aforementioned preset depth. However, the rigging of the dragline and the checks on the proper depth setting and towing are very time consuming, whilst the operation itself is restricted to being carried out downstream. The side-looking or transit sonar has made this method obsolete. This sonar on a display gives the seabed reflectivity and shows obstacles abeam the ship, thus filling in between sounding lines (see figure 6). Now only obstacles detected with this sonar need to be investigated, and if deemed necessary swept with a small wiredrag.

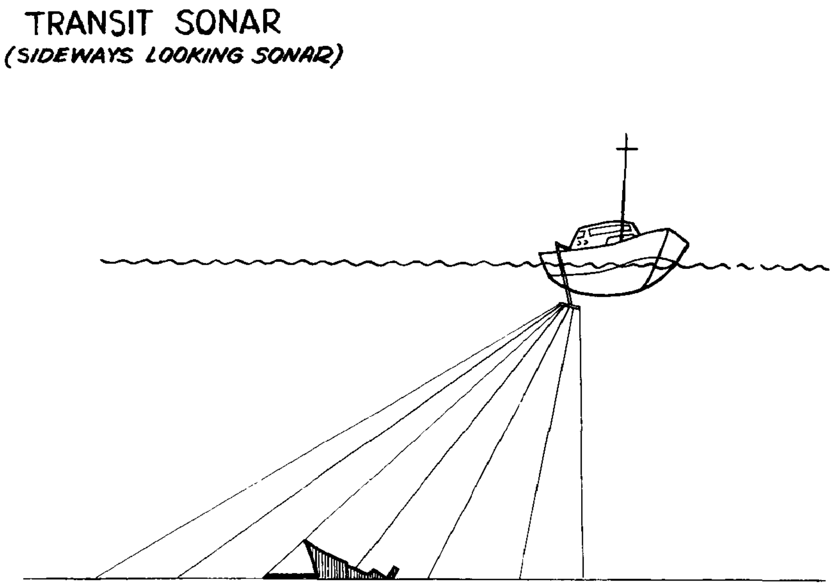


FIG. 6.

It may be stressed at this point that it is quite impossible to reduce the distances between sounding lines beyond certain practical minima. The aim must be to find a proper balance between accuracy and detail on the one hand, and speed of promulgation on the other. The surveyor should not do more than is needed, nor less than is wanted !

In the 1970 joint British-Netherlands survey in the Sandettié, Fairy Bank and North Hinder area, Netherlands naval vessels covered about 450 square miles, 50 of which with a sounding line interval of 75 metres, the remainder with a 250-metre interval. Since the fair sheets still have to be compiled by hand, this laborious and conscientious job was not completed until 4 months after the termination of the survey itself.

Another problem when closely surveying well away from the coast is the correct registration of the vertical tide during the survey. In areas where navigable depths are becoming so marginal, each decimetre is beginning to count, and it is therefore absolutely necessary to correct precisely the recorded depths for the height of the tide in the survey area as well as for any additional effect caused by exceptional meteorological conditions. In the case of coastal and estuarial surveys one can always fall back on the readings of shore tide gauges or poles in the vicinity. Tidal conditions however, — certainly in the southern North Sea — change rather quickly and quite considerably from place to place. The only way to cope with this problem is to place a tide gauge or pole in the survey area. This is not a simple affair. The way the R.Nl.N. tackles this problem is to lay a couple or more pressure tide gauges and have these register the vertical tidal movement throughout the period of the survey. At the same time data are collected from shore tide gauges on both shores of the southern North Sea to have a check on possible anomalies. The trouble with these tide gauges — taking optimum working order for granted — is the uncertainty whether the gauge has remained at its original level. It may well have moved due to scouring and/or sand wave effects. Using more than one gauge, however, does give a check by comparing the daily means, and as often as not a " wandering " gauge can be recognised and its registration discarded or corrected. Another drawback lies in the fact that these gauges are often tampered with. Although clearly marked by buoys, practice has it that these buoys are often disengaged and stolen, presumably by fishermen, so that many a gauge has not been found when the survey vessel returned to reclaim its instrument. Furthermore, with respect to the vertical tidal movement a very unpleasant phenomenon lies in the occurrence of tidal surges. These do occur irregularly due to meteorological circumstances, and insufficient knowledge about them has been gained so far. It is worthwhile to mention these surges, not only because of any direct influence on surveying, but because of their existence with consequent lowering of the sealevel in case of negative surges to the amount of several feet, is yet another factor to cause the local surveyor to establish his corrected depths as exactly as possible.

A problem apart is formed by the large number of wrecks in the North Sea. The Netherlands part of the continental shelf alone harbours a known number of close on 1200 wrecks, to which on the average 15 are added each year. Any wreck in relatively so shallow a sea forms a problem if in the vicinity of deep draught routes. The more so as with the ever-shifting seabed wrecks once buried have been known to reappear, to change position, and once of little or no consequence to have become dangerous once more.

In the case of wreck searching too, the use of sonar and side-looking or transit sonar has become indispensable. The problem of ascertaining the exact minimum depth, however, still remains, and very often requires the use of wire dragging or divers.

Thus far local problems and the present state of the art of dealing with them have been reviewed. It will be clear that there is ample room for improvement. Two items would seem to stand out — to wit, greater accuracy and, in particular, much more speed both in surveying and data handling.

For normal close surveying purposes Decca Hi-Fix is presently being used, and may be expected to be used for some time to come. Although the accuracy varies depending one one's whereabouts in the area covered by any one Hi-Fix chain, the degree of accuracy generally would seem to be sufficient for the surveyors' needs for some time yet. If it comes, however, to a close study of the behaviour of sandwaves, on how they build up, move, crumble, etc., one would require the highest position accuracy obtainable in order to reach any valid conclusions.

As regards speed in surveying, it is possible to imagine different ways to cope with this problem. Given a certain survey platform, one could increase the number of sounding miles per hour by increasing the speed of the vehicle and/or enlarging the number of echosounders operated therefrom. A case in point is the use of a number of side boats. The latter are small, fast, and shipborne survey launches that are operated in formation with the parent ship. The formation proceeds at some 15 knots in line abreast, with the side boats thus running tracks parallel to the survey vessel, the latter controlling the side boats as regards relative positions by means of radar and radiotelephony. Thus using n side boats, $n + 1$ sounding lines may be run and the number of sounding miles per hour is equivalent to $n + 1$ times the formation's speed of advance. Of course, with regard to the small boats, near to perfect conditions of wind and sea are required to operate in this fashion. Given these, this method most certainly meets with the requirement of fast data collection. In areas of high shipping density, however, it would seem that not only the weather but also the shipping present adversely affects the use of this method. Handling a formation as described amidst dense shipping and at the same time adhering to planned sounding lines would become close to impossible.

The Netherlands Hydrographic Service has opted for a survey vessel with two towed echosounders in addition to the hullmounted one, and two fast survey launches to be used as side boats, circumstances permitting.

It is hoped to be able to stream the towed echosounders up to about 100 metres parallel to the ship's track, using standard minesweeping gear and techniques. The strain on the towline prohibits the use of excessive speeds, but 10-12 knots is strived after. It may well be expected that the towed echosounders can still be used effectively when the hullmounted sensor has ceased to be operable. This is due to the effect that the towed fish forms a much more stable and silent platform than the ship itself once weather conditions deteriorate.

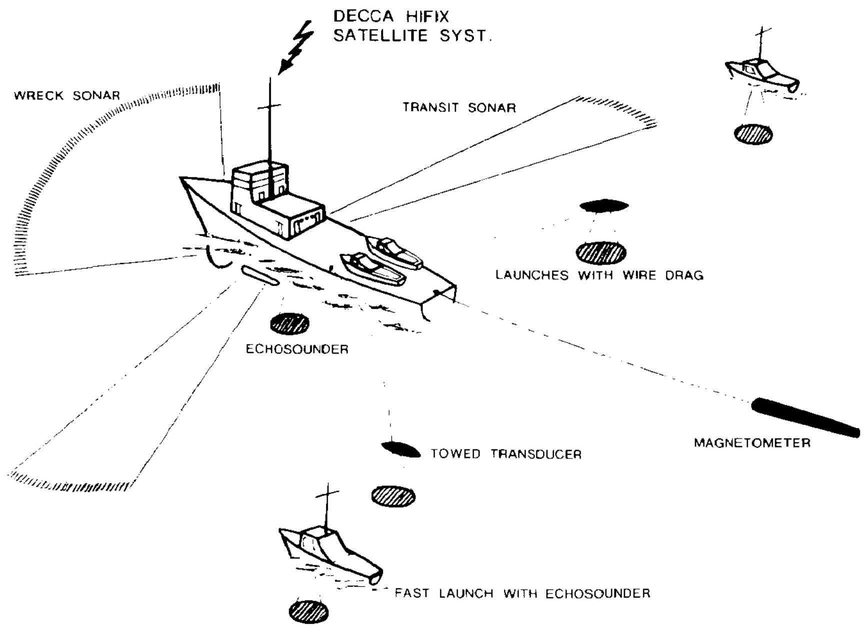


FIG. 7.

Given favourable conditions, the two side boats could be operated as well, and thus five close sounding lines would be run simultaneously (see figure 7).

It will be obvious that the quantity of raw depth data collected in this fashion may be as much as five times more than has hitherto been the case. This necessitates some sort of automation. In order to solve this problem H.Nl.M.S. *Snellius* was fitted out with a prototype HYDRAUT installation in 1970 and is presently carrying out sea trials. This system envisages the continuation of fair sheet production on board, with the computer doing the depth selections in lieu of the surveying officer. The system is fairly involved and is grouped around an IBM 1130 computer that includes a Calcomp 502 flatbed plotter for on-line track reproduction whilst a Haromat line follower has been included for off-line inputs. If for any reason echosounder inputs on-line fail to be digitized properly, the echographs can still be digitized using the line follower later on. Whilst sounding, the ship's position is being kept up-to-date on the construction sheet by the Calcomp plotter. Positions are marked and numbered as the print-outs appear on the typewriter, giving serial numbers, times, Decca readings, UTM coordinates, and depths. Plot and print-out enable the surveyor to carry out a direct check on the correctness of data stored and the pattern of sounding lines. Depths are being sampled every second, and stored on a 500 K disc. At a later stage, once the surveyor has processed his tidal data, derived his reductions therefrom, and added these to the stored depth samples, the computer can be put to work to produce a fair sheet on the Calcomp plotter. The computer is programmed for depth selection, and selected depths in decimetres appear on the plotter in their corresponding position as a three figure value, the middle figure marking the position. The number of sampled depths available for each selection process depends on ship's speed and the scale used.

Without going into too much detail it serves to know that we based ourselves on a hand-drawn fair sheet where depth values drawn as 2 mm high figures are plotted at about 7 mm intervals, giving therefore one figure per 7 mm sounding line. Using a scale of 1/25 000 as an example this would represent 175 metres — and with a ship's speed of let us say 12 knots — about 29 seconds run. The HYDRAUT system uses these 7 mm " brackets " for its depth selection. In this particular case the system would have sampled 29 depth readings for each 7 mm " bracket ". The absolute minimum value per " bracket " is always selected and plotted in its correct position. The Calcomp plots at 1.5 mm figure height, using a minimum interval of 0.5 mm between selected depth figures; this leaves room per 7 mm " bracket " for about 2 more depths to be plotted if the bottom profile calls for it within the scope of the programme.

Whilst on paper this would seem reasonably simple and straightforward, experience has taught that it is quite another thing to have this software- and hardware-wise in a shipborne configuration.

Calling to mind that the North Sea survey vessels under construction will be able to operate up to 3 shipborne depth sensors simultaneously, to which under favourable circumstances two more may be added, a larger computer would certainly be required to cater for all the raw depth data collected. The shipborne equipment would consequently become rather too intricate and involved for a relatively small survey vessel, paying due regard also to the size and composition of the crew.

Since it is an absolute requirement to increase the speed of surveys in these waters, some sort of automation must be arrived at. In this case it is the R.Nl.N. philosophy to go for data logging on board the vessel, as well as on each of the side boats, for each of the echosounders. The ships would be fitted out with a small computer that would be used to carry out quality control programmes on digitized stored data. It is also planned for the computer to control a flatbed plotter for on-line reproduction of sounding lines run. This will enable the surveyor to have a check on the survey work done before these checked data are sent ashore to the Hydrographic Office.

It is hoped by then to have gained sufficient experience with the *Snellius'* HYDRAUT system to use it as a basis for a large selection programme to be handled by the main R.Nl.N. computing system in the Hague. The ship's data could then be fed into the big capacity shore computer that would produce the plotting programme for a large XY flatbed plotter curve draughting machine. This last item would be installed in the Hydrographic Office which would produce the fair sheets on the premises.

It is deemed unavoidable to have paid some attention to automation in this paper, as this is tied in with the speed element.

In the area under consideration depths are generally less than 40 metres, and this corresponds to echosounder depth settings that allow something like 5 soundings per second. As shown above, the 12-knot survey vessel using one echosounder will produce 29 sampled depths out of 145 soundings for one " bracket " at a scale of 1/25 000, out of which the old-time hydrographer produced one depth to be plotted on his fair sheet. It is our firm belief that, in order to improve on the speed element, automation comes much before higher speed vehicles.

In this context it must also be stressed that in areas of megaripples one is actually restricted in survey speed. Assuming a beamwidth of 15 degrees, one sounding of the seabed at a depth of 25 metres would cover an area of that seabed circular in the plane with a diameter of about 5.5 metres, assuming also an absolutely ideally stable platform. Were this platform to move at, let us assume 20 knots — which is not all that high a speed — it would make good about 10 metres per second, barely enabling any system using the rather high sampling rate of one per second to register a ripple crest. Fast survey launches of the Netherlands Ministry of Waterworks engaged in local surveys off Europoort in connection with the engineering projects in the area have indeed already experienced this and, wise to the fact, bring down their speeds to cope with this problem which in the shallower depths prevailing results in speeds of 8 and less knots.

Summarizing the R.Nl.N. approach to try and tackle the survey problem of international waters encountered in the southern North Sea with the advent of the VLCC, the following pattern would seem to apply.

1. Get together with one's neighbours to assess the size of the job and develop regional cooperation and divide survey tasks.

2. To do this, if this joint effort is most likely to produce early results from available bathymetric data, select the most likely deep draught routes, paying close attention to terminals in, and transits of, the area (figure 3).

3. Conduct reconnaissance surveys to ascertain whether the selection meets with depth requirements in general.

4. Carry out detailed surveys aiming at the use of a number of echosounders simultaneously using :

(a) The very best position fixing method feasible.

(b) As high a speed as is consistent with proper data registration.

(c) Locally recorded tidal data.

5. Use sonar and transit sonar — if possible in conjunction with echosounders — for wreck searches (figure 7).

6. Ascertain that the vast amount of depth data is properly logged together with relevant time and position data.

7. Employ automation to effect depth selection and consequent fair sheet production, thus providing for earliest dissemination to the mariner in the way of Nautical Charts, and wherever necessary warning by way of Notices.