

**PRECISION HYDROGRAPHIC  
SURVEYS IN THE NORTH SEA  
LOCATION OF WRECKS AND OBSTRUCTIONS**

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**INTRODUCTION**

1. At the last meeting of the Hydrographic Commission of F.I.G., a paper was presented entitled "Broadening the Hydrographic Furrow" [1]. This title was suggested by the present chairman, Rear Admiral RITCHIE, who was then Hydrographer of the Royal Navy. It neatly summarised the long-felt need of hydrographic surveyors for a means of checking bottom topography between their lines of sounding. It was also prompted by the pressing requirement for an enhanced precision in hydrographic surveys to accommodate the passage of Very Large Crude Carriers (VLCC) needing dramatically reduced under-keel clearances for their economic operation.
2. A variety of side scanning sonars have been under development since 1958. The first work of practical significance was that of Professor W.D. CHESTERMAN off Hong Kong in 1964. Commercially viable equipment did not appear until about 1965. The Royal Navy is still evaluating the relative merits of two existing systems. In addition, it is backing the development of what it is hoped will be a comprehensive solution to the problem of "reading between the lines" [2].
3. This solution is, unfortunately, many years away. One must, therefore, as always, make the best use of the equipment available, constantly bearing in mind its limitations. This paper reviews the existing methods of hydrography and examines present techniques. It also evaluates equipment

entering operational service and shows that an interim solution capable of satisfying all but the most rigorous standards may be achieved.

4. It must be understood that the contents of this paper represent the author's own conclusions. The view-point is necessarily that of a seagoing naval surveyor. The emphasis is on the practical aspects of modern precision hydrographic surveying in the sea areas covered by the North Sea Hydrographic Commission. Two illustrations are taken from recent work in the southern North Sea and Dover Strait by H.M. Surveying Ships *Beagle* and *Bulldog* and the ships of the Inshore Survey Squadron.

### THE PRESENT POSITION

#### Equipment fitted in H.M. Surveying Vessels, its operational characteristics and limitations

##### 5. *Equipment.*

The Hydrographer of the Navy operates a fleet of 13 surveying vessels. These are shown in Table I which also lists the equipment fitted in each class of ship. For the purposes of this paper, navigational aids and echosounding equipment have been omitted. In 1970 and 1971 minehunters were allocated to Hydrographer for wreck searching and identification. Their equipment has, therefore, been included in Table I. Surveying vessels of all classes have been employed on precision sounding and sonar area searches in the North Sea at some time, although at present only two coastal ships and three inshore craft are allocated to this task.

##### 6. *Operational characteristics and limitations.*

(a) The working ranges shown in column (d) of Table II are those obtained from experience at sea. In all but the case of the E.G. and G. DCS-3, they are much below their theoretical maxima. This is because sonar equipment is inevitably the result of a compromise between conflicting requirements. High definition, for example, is not compatible with long detection ranges. In consequence, any given set is usually designed for a specific purpose. The penalty is a lack of versatility. Unfortunately, neither of the "searchlight" sonars, in use at present, were designed for the detection of wrecks or obstructions on the sea bed.

(b) The maximum sonar search speeds in column (e) are rarely attained operationally but are included to show what could be achieved in the most advantageous situation. In practice, in the depths encountered in the North Sea, inshore and coastal vessels usually operate at about five knots. It is certainly wise to use this figure for planning purposes.

TABLE I  
H.M. Surveying ships and their wreck searching equipment

Serial No. (a)	SHIPS		SONAR		WIRE SWEEP		DIVERS		
	Class (b)	No. Designation (c) (d)	"Searchlight" (e)	Transit Towed sidescan (f) (g)	Single ship drift (h)	Two ship drift (i) (j)		Divers (k)	
1	HECLA	3 Ocean survey	Type 164 Q	No	Could operate but have not done so to date.	No	Yes	No	Ship's divers with self-contained compressed air sets. Depths down to 36 metres.
2	BULLDOG	4 Coastal survey	K.H. Fisherman's Sonar	K.H. MS 43/47 HMS FAWN only.	Three ships have successfully operated E.G. & G. DCS-3. Only two sets in R.N. service at present.	Single	Yes	Ship and boat	As HECLA provided ships are working as a pair.
3	ECHO	3 Inshore survey squadron	as BULLDOG	K.H. MS 43/47. (two MS 43s & one MS 47).	Two ships have successfully operated E.G. & G. DCS-3.	No	Yes	Yes	No
4	WOODLARK	2 Inshore survey — independent	as BULLDOG	K.H. MS 43	as HECLA	No	Yes	N.A.	No
5	Minehunter	—	Minehunting Sector-Scanning Sonar			Double	N.A.	N.A.	Clearance divers. Limiting depth 50 metres.

(1) H.M.S. *Vidal* has not been included in the foregoing Table, as she is being paid off in 1971.

(2) Line 2 (e), K.H. stands for Kelvin Hughes.

(3) Line 2 (f), Kelvin Hughes Transit Sonar may be operated with either an MS 43 dry paper recorder or an MS 47 Mufax wet paper recorder.

(4) Line 2 (g), E.G. & G. DCS-3 is a departmental abbreviation for the Edgerton, Germeshausen and Greir, Dual Channel Sidescan Sonar.

TABLE II

## Operational characteristics of sonar equipment in use in H.M. Surveying ships

Serial No.	Type	Frequency (KHz)	Working range (metres)	Maximum searching speed. (knots)	Max. depth at which 100 % cover is achieved. (metres)	Speed when working to max. depth. (knots)	Interference with echo sounder.
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
1	164 Q	14 to 22	1 350 to 1 650	10	160	5	Yes
2	K.H. Fisherman's	48	900	11 ( <i>BULLDOG</i> ) 8 (Inshore)	45	5	Yes
3	K.H. Transit (MS 47 only)	48	300	6 to 8	45	5	No
4	E G & G DCS-3	105 to 110	300	10	180 ("Fish" 30 metres approx. above sea bed.)	5	No

(c) The Kelvin Hughes Transit Sonar was never conceived as an area search tool in deep open water. In consequence, it does not merit serious consideration in the present context. Its severe limitations will be apparent from line 3 of Table II. The depth and speed in line 3, columns (f) and (g), are estimates derived from general considerations of the geometry of the transmitted beam. The MS 43 recorder has been omitted from the Table because of its very unsatisfactory performance when compared with the MS 47. The 600 metre range, claimed for the latter by its manufacturer, is also discounted.

## (1) COMPARISON OF MS 43 AND MS 47 RECORDERS.

(a) The helix system of paper marking in the MS 47 is vastly superior to the multiple stylus system of the MS 43. Uneven stylus wear, or a misplaced stylus, may cause a small contact to be missed altogether.

(b) The wet paper of the MS 47 has a wider dynamic range.

(c) The MS 47 appears far easier to tune. This may result from a combination of (a) and (b) above. For whatever reason, the MS 43 requires much longer to tune than the MS 47 to produce a usable record.

(d) The MS 47 benefits from an enlarged linear scale. The paper width of the MS 43 is 152 mm; of the MS 47, 229 mm.

## (2) COMPARISON OF 300 METRE AND 600 METRE SCALES ON MS 47.

When the 600 metre range is in use, a good record is rarely obtained beyond about 365 metres. This is due to absorption, scattering

and the masking of weaker return echoes by background noise at the greater range. Thus, 365 metres of sea bed is recorded on under two thirds of the paper's width. If the shorter range scale is selected, however, a worthwhile record will probably be obtained across the full width of the paper. So only one sixth of the range is lost but the resolution is doubled. In addition, the increased pulse repetition rate improves the quality of the record and enhances detection.

(d) The E.G. and G. Dual Channel Sidescan Sonar, as the description implies, sweeps on either side of the ship's track. Thus, its swept path is double that of a transit sonar and a much more economical use of ship's time results. Serious range losses occur in depths less than 20 metres, however, and it is here that the Kelvin Hughes Fisherman's Sonar and MS 47 come into their own. The rigid overside mounting of the transit sonar is probably better suited to wreck investigations and shallow water work generally than a towed "fish". However, it is suggested that the E.G. and G. DCS-3 instrument might be streamed from a boom well forward in the survey vessel at a depth which would permit it to look under the keel. This would obviate the need to handle the fish when manoeuvring and the double swept path might still be greater than the single swathe of the MS 47. The more economical use of the ship, mentioned earlier, would also counterbalance reductions in swept path. A towed "fish" is below the background interference caused by waves and ship noise and largely independent of ship's motion. It may, in some cases, also be below the thermocline. Unfortunately, its position relative to the ship can only be estimated, unless calibration runs can be made past some prominent feature like an oil rig or over a large wreck whose precise co-ordinates are known. As one would expect, the higher frequency 0.1 millisecond pulse of the E.G. and G. DCS-3 gives a better quality record and higher resolution than the MS 47 (pulse length 1.0 millisecond).

(e) Although not tabulated, the following capabilities of the mine-hunter's sonar are relevant. Since it is designed to locate relatively small metallic objects on or even below the sea bed, it is the nearest approach to a custom built surveying sonar in service. It is a high frequency short range set with a limited area search capability. An experienced operator can estimate heights, usually by reference to the known dimensions of a mine. It is also possible to measure the length of a wreck and assess its orientation. The accuracy of this measurement is only as good as the width of the sonar beam and discrimination of the display allow. Once again, this is not the designed function of this set.

### Precision surveys

#### 7. Background.

Prior to 1965, a dangerous wreck was defined as one with 20 metres or less of water over it. The survey task in the southern North Sea was dramatically transformed when this depth was increased to 30 metres in 1967. In the same year, precision survey methods were formulated and

came into use the following season. The adoption of these more rigorous standards was necessary to provide the sort of charting accuracies required by vessels drawing up to 30 metres and working to under-keel clearances of one metre. Coincident with this step, hydrographers were made fully aware of the properties of sandwaves. These were researched and publicised by Dr. R. L. CLOET, Director of the National Environmental Research Council's (N.E.R.C.) Unit of Coastal Sedimentology. As a result, the Hydrographic Department was faced with the daunting prospect of re-surveying, to its new self-imposed standards, an area of the southern North Sea, which stretched from the Goodwins to the North Falls and encompassed the Sandettie and Fairy Banks. This re-survey is still in progress.

#### 8. *Considerations.*

(a) **SOUNDING.**—Precision sounding methods are adopted to some extent for all surveys inside the 200-metre contour. The criteria are applied with increasing rigour with reducing depth down to 31 metres when all the following standards are observed, where applicable.

- (1) Reduction of soundings.
  - (a) The tidal reduction curve is drawn on the echo sounder trace as a continuous line to which the zero of the trace reader is continuously aligned.
  - (b) Soundings are given to the nearest 10 centimetres.
  - (c) Bar checking of the echo sounder is mandatory at least once a day.
- (2) Tidal data.
  - (a) Great care has to be taken with the selection of sites for tide gauges. Bottom recording gauges in the survey area are the optimum requirement. The gauges must be accurate and easily read to 10 centimetres.
  - (b) Co-tidal charts should invariably be used.
  - (c) Block adjustment for co-tidal corrections is permitted over very small areas only.
- (3) Control.
  - (a) High order electronic control is essential. Ideally, this should be monitored in the area. Frequent independent checks must be made.
  - (b) Lines may have to be run in two or more directions to establish both the general contours of the area and the alignment of the axes of sandwaves.
  - (c) Lines of sounding should not normally be opened out to double spacing until the 60-metre contour is reached.
- (4) Sea state.

Precision sounding should not be undertaken in critical areas, i.e. under 31 metres, if the height of sea waves exceeds 50 centimetres. However, in a re-survey, where the bottom is known to be regular, wave heights up to one metre may be accepted.

(b) SONAR. The inadequacies of the present equipment make it more difficult to lay down rigid instructions for its use. Generally, except in re-surveys of sandwave fields or when scientific personnel are embarked for a specific survey, use of transit sonar equipment remains at the discretion of the surveyor in charge. No official doctrine exists for the use of Dual Channel Sidescan equipment. Suggestions for its use are given later. Working rules for "searchlight" sonars in order of precision are as follows.

- (1) A search is made along lines in two directions at right angles to each other spaced at the working range ( $R$ ) of the equipment (see Table II). Sonar work should be limited to days when the best water conditions prevail. Sea state should not impose a roll in excess of  $5^\circ$ .
- (2) The method is as in (1) above but lines can be opened out as dictated by sea conditions and time available. They need not be exactly at right angles. Extent of the roll should not exceed  $10^\circ$ .
- (3) A search is made with lines in one direction only. Spacing is determined as in (2) above.

(c) K.H. MS 47. A suggested mode of operation for the equipment would be to run lines in two directions at right angles up to 500 metres apart, dependent upon the accuracy of control available. Only the short range scale should be used for the reasons given in Paragraph 6.(c) (2). The limiting sea state for this equipment will be reached when the transducer is rolled out of the water.

## 9. *Practical Application.*

The survey task may be divided into phases. The ancillary tasks which accompany any hydrographic survey are not listed. The phases will undoubtedly overlap but are given in order of importance.

(a) PHASE I. This is the sounding survey of the main area. The full requirements of Paragraph 8.(a)(3)(b) need not be satisfied at this stage.

(b) PHASE II. The sonar area search is either commenced or perhaps continued if it has been possible to carry it out during Phase I (see Table II). This phase is of vital importance. It must be constantly borne in mind that one is searching for irregularities as little as a metre in height on any part of the sea bed with a charted depth of 31 metres. With all the present equipment, this demands the unceasing attention of the surveyor on watch. Only if he is completely satisfied that he has enough qualified men and his equipment is suitable for the task, should the officer in charge attempt sounding and sonar work concurrently. This phase will be conducted as in Paragraph 8.(b). The speed of advance will be determined by the maximum detection range of the sonar and depth of water in the case of "searchlight" sonars. (see Paragraph 6.(b)). In the most precise sweep, theory holds that each part of the sea bed will be looked at four times [3]. With sideways-looking sonars, line spacing is a function of the working range, with appropriate overlaps. Speed is a function of horizontal beam width and of pulse repetition rate. With outboard transducers, there may be physical limitations to speed below the theoretical maximum.

(c) PHASE III. This involves the classification of all contacts obtained in (b) above. It is a combination of field and chartroom work and is discussed in detail later [Paragraph 10.(b)].

(d) PHASE IV. Investigations and examinations follow logically from (c) and supplement the work of Phase II. Any sonar or echo sounder contacts classified as possible wrecks must be closely investigated. All shoal soundings must be examined in the traditional way. Methods of investigation are illustrated in the examples which follow. Least depths over non-dangerous features may be obtained by echo sounding or sonar heighting at this stage.

(e) PHASE V. This involves obtaining the least depth by positive methods over all dangerous obstructions. This must be by wire drift sweep or diver [see Paragraph 10.(d)].

(f) PHASE VI. In the worst possible case this may involve re-sounding the whole area on a different orientation. At best, it would probably mean running further interlines. Transit or sidescan sonar traverses should also be run to supplement sandwave information.

## EVALUATION OF NEW TECHNIQUES

### Operational methods used in recent surveys

#### 10. *Southern North Sea. H.M. Ships Beagle and Bulldog. Autumn 1970.*

(a) ACKNOWLEDGMENTS. The following account of relevant aspects of this survey is based on H.M.S. *Beagle's* "Reports of Survey". (Commander J.B. DIXON, R.N.). The same officer also wrote the first naval evaluation of the E.G. and G. DCS-3. The perusal of the written reports was supplemented by discussions between the author and H.M.S. *Beagle's* Diving and Wrecks Officers. Information on the employment of minehunters was obtained from a report by Commander DIXON and conversations with hydrographic officers who had been employed in these vessels on survey work. The contribution of all the officers concerned is duly acknowledged. The opinions expressed and conclusions drawn are the author's own.

(b) WRECK SURVEY OF MAIN AREA. The whole area was sonar swept by Fisherman's Sonar at five knots, with lines run in two directions about 900 metres apart. Seven out of eight charted wrecks were found by this method. A total of 113 other contacts were obtained which merited analysis. The plot of these was laid over the sounding tracing and, where a contact coincided with an abrupt rise in the sea bed, mostly sandwaves in this area, it was arbitrarily assumed to be a bottom echo and plotted as such. In this way, 42 of the contacts were classified and no further investigation was carried out. Of the remainder, 11 were classified from



their position in the Wreck List as known, but uncharted, wrecks. Every other contact was then investigated with the E.G. and G. DCS-3. Runs were made close to the plotted position of the contact with the recorder switched to the long range scale (305 metres). When using this scale, the "fish" was towed 30 metres off the bottom when the depth of water allowed. Small or doubtful contacts were investigated on the 150 metre range scale. During these searches, a succession of sandwaves and other irregularities on the sea bed were recorded. At the position of the majority of sonar contacts, no marked anomalies were revealed. As the equipment had been proved on a known wreck, sufficient confidence was felt to accept these results. In this manner, 19 contacts registered as definite bottom irregularities and were classified as such. A further 35 gave no response at all and were classified as ephemeral. The remaining six contacts were new wrecks. The least depth over these was established by echo sounder. Throughout the period that the E.G. and G. sonar was embarked in H.M.S. *Beagle*, Mr. N.C. KELLAND from N.E.R.C.'s Unit of Coastal Sedimentology supervised its use. He instructed the ship's staff in the operation of the equipment and was chiefly responsible for the interpretation of the records.

(c) SONAR SEARCH BY MINEHUNTERS. Two of these vessels were allocated for 10 days to carry out the sonar search of the Fairy—Sandettie gap and an area off the Southfalls Tail. The most significant results were achieved in the former area, where eight old wrecks were confirmed, one uncharted obstruction was disproved and three new wrecks were found and fixed. Accurate depths over five wrecks were obtained by diver. Only a small area of the Southfalls Tail was examined, which contained one known wreck. This was located but nothing else of significance was found. The ships were fitted with Hi-Fix and embarked a Surveying Officer for the duration of their work. Great confidence was felt that the sweeps resulted in a thoroughly reliable search of the areas involved.

(d) USE OF DIVERS

(1) Ship's divers.

The Commanding Officer of H.M.S. *Beagle* is a qualified ship's diver. He is also a sub-aqua enthusiast and has pioneered the use of free swimming to assist with survey tasks. In addition, the ship's Senior Assistant Surveyor and two of the Survey Recorders are divers. Consequently, the ship was in a unique position to evaluate the use of divers to obtain the least depth over a wreck. If the diving boat is fitted with Hi-Fix, it is possible for her to anchor on the wreck unaided, allowing the ship to proceed with the survey. In the absence of a suitable fixing aid, the ship can be anchored within sonar range of the wreck and con the boat into the "on top" position. Once the boat is anchored, two divers follow her cable to the bottom and locate the wreck. One of the divers carries a marked line tended from a Gemini dinghy on the surface. The divers locate the apparent highest point of the wreck and signal to the surface. The attendant craft then manoeuvres the line up and down. The diver checks the perpendicularity and places the zero of

his line on the wreck. He then signals for a measurement to be taken. This operation is repeated and the divers then move on to other prominent features on the wreck. A visual estimate of the dimensions of the wreck, its orientation and any identifying features may be made if time allows. One of the wrecks over which H.M.S. *Beagle's* divers obtained the least depth was later checked by a single ship drift sweep. The agreement in least depth obtained between the two methods was better than one metre.

(2) Clearance divers.

The capabilities of the minehunting sonar allow a diver to be placed within one or two metres of an object to be investigated on the sea bed. Minehunters carry trained teams of clearance divers but it is advisable that a surveyor should be attached to the team when precision work is required. The divers operate from a Gemini dinghy as in (1) above. Once over the wreck, the method is identical to that employed by ship's divers.

11. Operation VARNESWEEP [4]

(a) The multiple sinkings in the Dover Strait of the *Texaco Caribbean*, *Brandenburg* and *Nikki*, early in 1971, and the resultant wreck marking and clearing operations, have reduced the navigable width of the recommended down-channel route for VLCC to  $1\frac{1}{2}$  nautical miles (2.7 kilometres) at the point where the sinkings occurred (see fig. 1.) In March

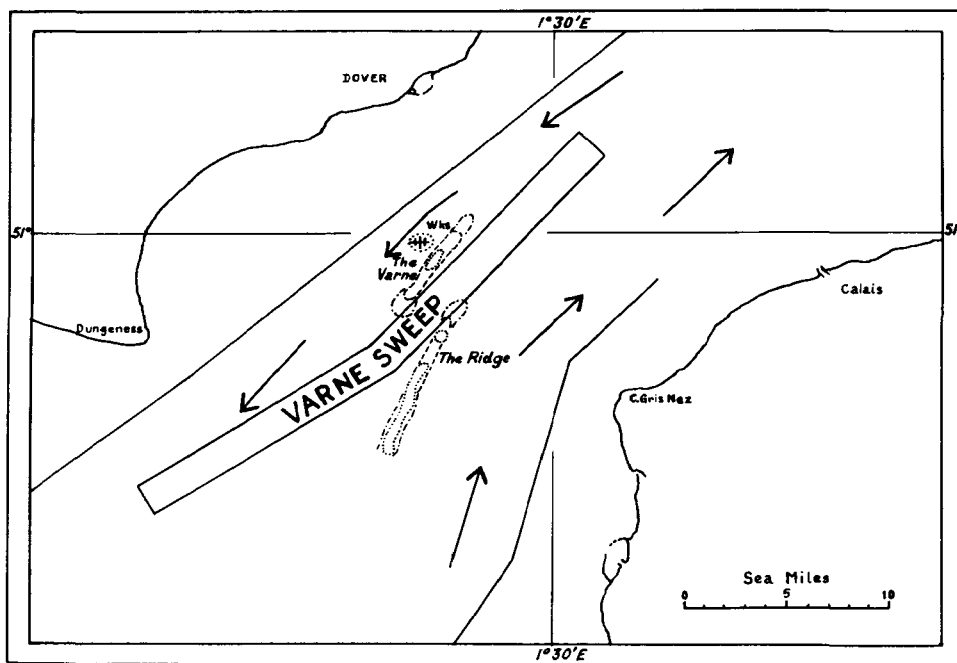


FIG. 1. — The Dover Strait, portion of chart BA 2675 showing the effect of the recent multiple sinkings on the westbound Separation Route.

1971, an alternative route to the east of the Varne Bank, as shown in fig. 1, was proposed by the Department of Trade and Industry. Part of the route was surveyed in 1970 but the remainder relied on older surveys, some of which were sounded with lead and line. The proposed route was considered safe for vessels drawing under 22 metres but, at the same time, an urgent re-survey was put in hand to confirm this assessment. A selection of the most significant wrecks and shoal depths found was promulgated by radio warning on the 2nd of April and the route then recommended to shipping whilst corrections to the charts were prepared.

(b) The survey methods adopted were dictated by the need to obtain rapid results. Consequently, very few of the provisions of Paragraph 8 were satisfied. The survey was controlled by navigational Decca using the Admiralty Chart No. 1892 on a scale of 1/75 000 as a plotting sheet. A co-tidal chart, extrapolated from the co-tidal chart of the southern North Sea, was supplied by the Tidal Branch of the Hydrographer of the Navy. Fortunately, the area was close to Dover and the automatic tide gauge there could be used.

(1) RESULTS OF THE SURVEY.

- (a) *General.* In four and a half weeks, an area of approximately 180 kilometres square was sounded on a scale of 1/75 000: parts of it were examined on a scale of 1/25 000. The same area was also thoroughly searched by E.G. and G. DCS-3 and all suspicious contacts examined by minehunting sonar or divers. A wire drag sweep was passed through about 75% of the deep water (over 22 metres). One known and one unknown wreck were drift swept clear to 22 and 23 metres respectively.
- (b) *Sonar area search and wreck investigations.* The area was sonar swept by E.G. and G. DCS-3 using the 305 metre range. Searching speed was five knots and lines were run 365 metres apart along the axis of the channel. The "fish" was towed 10 to 15 metres below the surface in general depths of from 25 to 55 metres. A zig-zag pattern was also run across the area to delineate sandwave areas. No new contacts were obtained during this second sweep. The sweep detected 30 contacts worth investigating. All but three of these were examined by minehunter. Divers were sent down in six instances. The three unexamined contacts were judged to be sandwaves and, as the drag sweep had cleared them to 22 metres, no further action was taken. Some idea of the size and type of contacts that were obtained by E.G. and G. sonar is given in Table III. There were seven previously-known wrecks in the area. The positions of some of these were very approximate and some of the wrecks themselves were very small. All the Wreck List positions were examined by the minehunter and the results are given in Table IV. It can be seen from Tables III and IV that the minehunter's classifications are not infallible. However, the obstructions were located even if they were misnamed.

**TABLE III**  
**Analysis of contacts obtained by E.G. and G. Dual Channel Sidescan Sonar**

Serial No. (a)	Classification by E.G. & G. (b)	Classification by minehunter/divers (c)	Whether dived on (d)
1	Doubtful wreck. Probably isolated sandwave.	Large sandwave.	No
2	Possible wreck or isolated sandwave.	Small area of large sandwaves.	No
3	Area of intense sandwaves.	Confirmed.	No
4	Possible small wreck.	New wreck 30 to 36 metres long.	No
5	Probable wreck. Two contacts from opposite directions.	U-boat about 36 m long lying on port side on hard bottom. (listed wreck)	Yes
6	Possible wreck or isolated sandwaves.	Rock 2 m × 1 m × 1 m high. Sonar indicated a small metallic object.	Yes
7	Almost certainly a small sandwave but could be a small wreck.	Sandwaves and rocks. Maximum height 1 m.	No
8	Possibly small wreck.	Rock about 1 m 50 high.	No
9	Wreck.	Confirmed new wreck, 27 m long.	Yes (not measured)
10	Wreck.	Confirmed known wreck about 30 m long × 4 m 50 high.	No
11	Possible wreck.	Large sandwave.	No
12	Good possible wreck.	Rock about 12 m long, maximum height 1 m. Sonar indicated small metallic objects.	Yes
13	Possible small wreck.	Small sandwaves with three rocks, one of 1 m 50, two of 1 m height.	No

## 12. Evaluation.

(a) E.G. AND G. DCS-3 [5]. This instrument proved itself in VARNESWEEP to be excellent and reliable in relatively deep open water. It was still giving good results when the surveying vessels using it were forced to take shelter from a gale. In the hands of a skilled and experienced operator (H.M.S. *Beagle's* survey), it may also be used in the investigation and classification role. It is significant, however, that the Varne sweep results were obtained by a Charge Surveyor and a Junior Assistant, who had each received only one day's sea instruction from Mr. N.C. KELLAND [see Paragraph 10.(b)]. The N.E.R.C. Unit of Coastal Sedimentology is programmed to further evaluate this equipment and to compare it with the K.H. MS 47 in the Thames Estuary later this year [6]. Like most modern surveying equipment, the E.G. and G. DCS-3 requires a high level

TABLE IV  
Analysis of results obtained by minehunting Sonar

Serial No. (a)	Wreck list description (b)	Minehunter's report (c)	Whether found by E.G. and G.DCS-3 (d)	Remarks (e)
1	Scuttled drifter. Upperworks removed.	Wreck 30 m x 5 m.	Yes	—
2	Dumped boiler.	Not found. Sandwave in the vicinity.	No	Outside 40 m contour.
3	Small motor yacht.	Not found.	No	Outside 40 m contour.
4	Two barges. (no masts)	Both barges found broken up and heavily silted about 1 m 50 clear of bottom.	No	—
5	Wartime M.L.	Located lying in a dip between two sandwaves. Partly broken up and silted to N.E. Approx. 30 m long and standing approx. 1 m 50 off bottom.	No	—
6	U-boat.	Not found	No	Intense sandwaves in area.
7	U-boat	Confirmed wreck.	Yes	This wreck was some way from its listed position and was not found in the minehunter's initial investigation. Located in Sonar sweep. (see line 5, Table III)
8	Not listed.	Probable wreck.	Yes	Small peak almost under survey vessel. Investigated by divers ; sand ridge only.

of technical support. The surveyor in charge must make the tuning of the set and interpretation of the records his province.

(b) **EMPLOYMENT OF MINEHUNTERS.** Interest in the use of these vessels stems from Commander C.E.K. ROBINSON's favourable report of the hydrographic by-products of Operation NEW BROOM in 1968. He was attached to the British element of that operation and assisted in analysing the results. The assistance afforded to H.M.S. *Beagle's* work in 1970 stems from this association. The lessons learned in the North Sea were subsequently applied to good effect on VARNESWEEP. A study of the relevant tables and reference to Paragraphs 10.(c) and 11.(b)(1)(b) reveal the extent to which the employment of these vessels reduces the time taken for a precision survey and greatly enhances its reliability. It is stressed, however, that the minehunter must be well worked up, be fitted with the same fixing aid as the survey ship and carry a hydrographic specialist.

(c) **USE OF DIVERS.** With all the modern aids to underwater work, there is still none to equal the human eye and brain. An exact parallel with space exploration and research suggests itself. An initial assessment of the potential for effective use of divers in the murky waters of the areas reviewed above would be to discount them. The slack water period in the Dover Strait, for example, only permits about an hour's actual diving time a day at Springs. However, it has been shown that, provided the diver can be precisely positioned, he can make very worthwhile use of the little time available. Not all surveying ships are as fortunate as H.M.S. *Beagle* in the diving talent at their disposal. Since the North Sea and Dover Strait are no place for unworked-up diving teams to learn their job, it is probable that the best recourse would be to request assistance from the Fleet Clearance Diving Team, if no minehunter were available.

(d) **KELVIN HUGHES FISHERMAN'S SONAR.** This much-maligned instrument should not be overlooked in the enthusiasm which may be felt for newer tools. It will be noted that the six new wrecks in H.M.S. *Beagle's* survey [Paragraph 10.(b)] were actually located with this set. It was not employed on VARNESWEEP; so no direct comparisons are available. However, provided due allowance is made for its limitations, this set can still be regarded as an adequate area search device in depths between 20 and 45 metres. The author's experience over the past three years certainly supports this view.

## CONCLUSIONS

### 13. *The Situation today.*

The surveyor's task has ever been laborious, painstaking and unending. This has never been more apparent than today. New equipment, faster ships or survey speeds just seem to bring more work instead of less time on the same work. The problems of modern surveys to meet the new standards are formidable. But VARNESWEEP showed what it is possible to achieve even under the pressure of these new requirements. The comforting aspect of that survey was that, not only could it be completed

satisfactorily using the tried methods of the profession, but that our predecessors had only missed one shoal area. Even that would scarcely have been deemed a hazard as recently as 1945. Confidence is felt that the methods outlined above, allied to the improvisational skill of the resourceful surveyor in adapting new equipment to his purposes, will enable present demands to be met. The limitations of equipment in service are admitted to and deplored. But there is a well-known English proverb which inhibits too harsh a criticism of the tools of one's trade. Before exulting too much over the success of VARNESWEEP, it must be remembered that the clearing depth was 22 metres, not 30 metres. However, the latter standard was achieved in H.M.S. *Beagle's* work.

#### 14. *The way ahead.*

Clearly, some of the expedients adopted at present are only interim measures. Research and development must proceed even if we appear to be keeping on top of our job at present. The E.G. and G. DCS-3 should be employed for sonar area surveys in critical areas outside the 30-metre contour. The employment of minehunters must be considered mandatory for critical area surveys inside the 30-metre contour. In any area where the rapid production of results is of vital importance, serious consideration must be given to employing minehunters for wreck searching, while survey vessels progress with sounding. Oropesa sweeping is no longer feasible now that clearances have to be checked so close to the bottom. In addition, the uncertain depth keeping qualities of this sweep require too large a safety margin in the modern context. A wire drift sweep, however, remains the only positive method of determining an accurate least depth over an obstruction. This will continue to be so until an instrument is produced capable of detecting a ship's mast with absolute certainty and heighting it to better than one half metre. The challenge of VARNESWEEP has been met, providing a vindication of the old methods and revealing future trends. However, even though hydrographic surveyors may feel confident in their ability to face whatever problems the 1972 season may bring, this must diminish as the decade advances unless considerable improvements are forthcoming in certain areas. The problem of measuring off-shore tidal heights has only been touched on here. But all other advances will be nullified unless this vital matter can be resolved. Survey vessels of the future will unquestionably have to acquire data over 100% of the sea bed, particularly on the Continental Shelf. For the moment, surveyors must be satisfied that when they leave an area, all hazards to prudent navigation have been located.

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