

AUTOMATED DEPTH SELECTION FOR THE FAIRSHEET

by G.K. BROUWER
Royal Netherlands Navy Reserve

INTRODUCTION

In order to cover as much as possible of North Sea bottom depth characteristics a lot more data is sampled than the depth figures actually appearing on the fairsheet. During the past three years the Netherlands Hydrographic Service has developed a program for automated depth selection as part of the HYDRAUT system ashore [1]. This program was initiated by P. van der MOLEN and A.B. WILBRINK [2], but several modifications have had to be made to match problems encountered in its first operational phase (Spring 1975).

Depth selection from a hydrographic viewpoint should meet two criteria : minimum depths have highest priority, whereas a true representation of the sea-bottom relief should appear on the fairsheet.

NUMERICAL APPROACH, WHICH MAKES SELECTION INEVITABLE

The echosounders of the North Sea survey vessels H.N.I.M.S. *Buyskes* and *Blommendal* [3] take 10 soundings every second. Depending on the structure of the sea-bottom (which is often known approximately from previous surveys) the depth sampling rate (1, 2, 3, 4 or 5 times per second) for the Hydraul system is chosen. Assuming a sampling rate of one depth per second, a ship's speed of 12 kn ($= \pm 6$ m/s) and a scale for the fairsheet of 1:50 000, then $50/6 = 8.3$ depths are logged on tape for every millimetre of the fairsheet.

Defining a figure on the fairsheet as 2 mm high, and the free space around it as 0.4 mm, the space occupied on the track will be 2.8 mm. For every 2.8 mm track-space on the fairsheet, $2.8 \times 8.3 = 23.2$ soundings are recorded; in the case of higher sampling rates, even more soundings are recorded for every 2.8 mm. From these a selection has to be made.

ACCURACY IN DEPTH SAMPLING

Recorded depths are corrected for swell (fig. 1), tidal influence and distance of echosounder transducer below water level. Recorded swell and tidal corrections are within 15 cm and 10 cm accuracy respectively, under normal circumstances. Allowing for minor errors, such as echobeam inaccuracies and rounding off, it may be stated that corrected depths are accurate to within ± 30 cm for a depth range from 10 to 40 m.

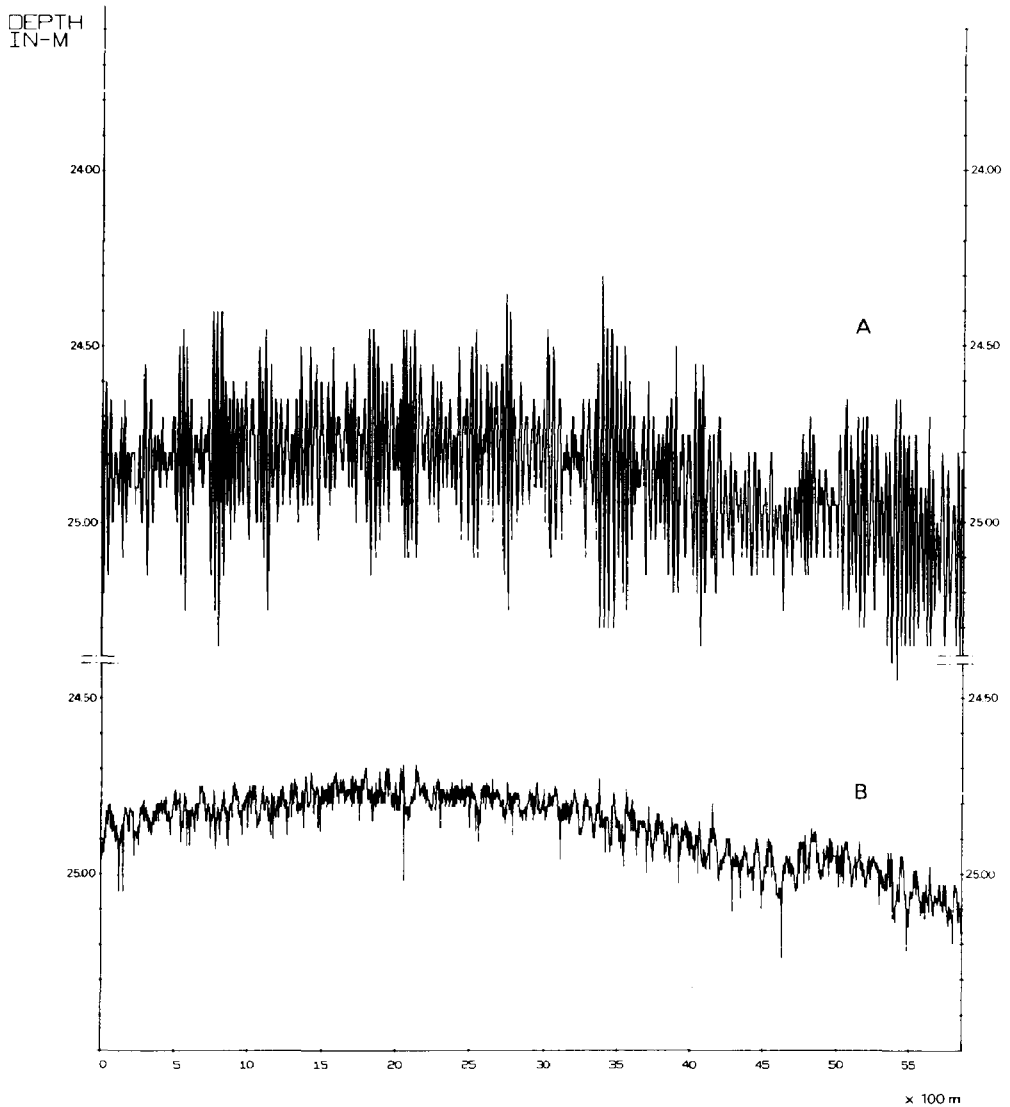


FIG. 1. — Depth profile along track recorded by H.N.I.M.S. *Buyskes* (North Sea).

A. Actual measured depths corrected for tidal movements.

B. The same depth profile, but also corrected for swell.

DIFFERENT PRIORITIES IN SELECTION

The selection is executed in three stages :

1. Selection of depths *not to be plotted*.
2. Selection of depths *definitely to be plotted*.
3. Selection of those depths not primarily selected in stage 1 or 2, which still get a chance to be plotted additionally, because the distance between 2 soundings already selected is too large.

Each sounding-track can be submitted to the process of selection as a whole or (as is normal) in sections, but due to the limited memory capacity (8 K) of our IBM-1130 computer, sections can contain no more than 1 100 logged depths. These sections have a small overlap to achieve a well-balanced selection in the transition zones.

The selection method is based on a well-known property of a function (considering the profile of the seabottom as a kind of function) by which it is possible to detect a minimum or maximum by looking at the difference between two successive values. In figure 2 point i is found to be a *minimum* depth, because the difference between successive depths has changed from negative to positive. Likewise point j is detected as a *maximum* depth because the sign of the difference has become negative.

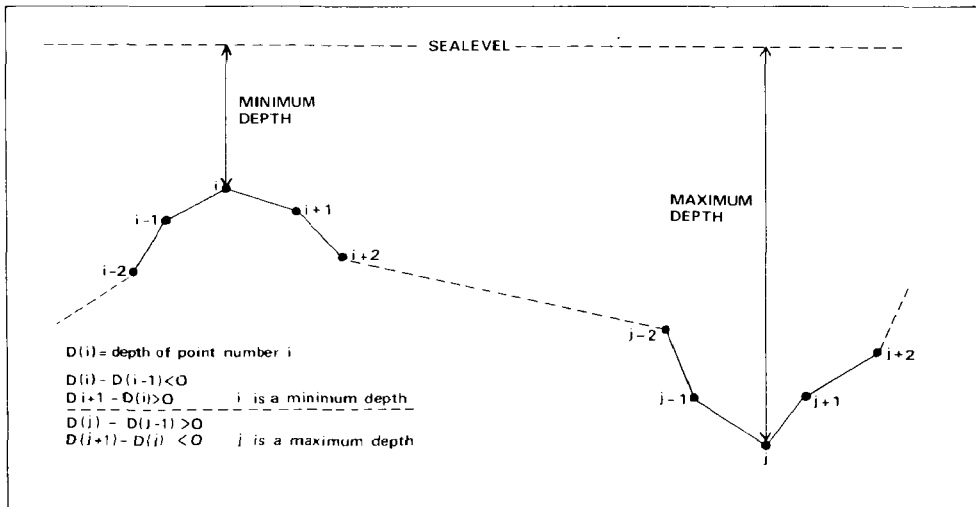


FIG. 2. — Detection of extreme depths.

Stage 1 : Selection of depths not to be plotted

The first step in the selection procedure is to determine the minima of all depths; these are called the minima of the first order. These minima are connected and a first smoothing of the bottom profile is obtained (fig. 3).

All depths not selected as first order minima are coded accordingly, and excluded from further consideration.

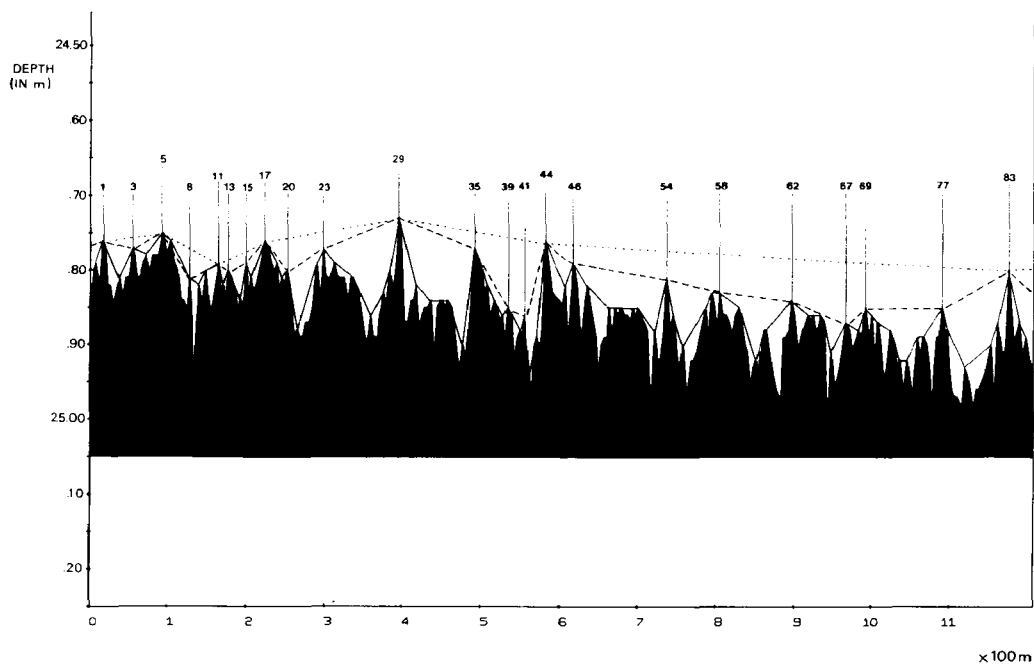


FIG. 3. — Different order minima :

- 1st order
- 2nd order (numbered)
- 3rd order Nos. 1, 5, 11, 17, 29, 44, 83
- . - . - . 4th order Nos. 5, 29

Successive orders of minima showing a smoothing of the bottom-profile with the most important minima conserved.

Stage 2 : Selection of depths definitely to be plotted

The same algorithm as outlined above is used to determine the second order minima out of the first order minima "function", and so on.

This selection process is continued until the minima of the n^{th} order have such a density that they can be plotted reasonably on the fairsheet, on average one minimum every 4 mm of fairsheet.

The fact that selection of soundings is continued until there is on average one minimum depth for every 4 mm on the fairsheet may occasionally result in plotting two minima on top of each other. In this case only the shallower depth will be plotted and the deeper one rejected.

Stage 3 : Selection of depths not selected in stage 1 or 2 which will be plotted additionally because the distance on the fairsheet between 2 minimum depths from stage 2 is too large

It cannot be guaranteed that after stage 2 the distance between every 2 depth-figures on the fairsheet will be reasonably small; the following is considered to be a solution to this problem.

If the distance between two depth-figures is more than 7 mm, then

the possibility of inserting one or more depths between 2 selected minimum depths is successively investigated in three substages :

3.1 If in the profile an interim-point can be found, situated more than a specific tolerance *above* the connecting line between the 2 selected minima at the beginning and the end of a suitable interval, then that point is plotted too, e.g. (fig. 4) point A between B and C. The tolerance is specified by the operator.

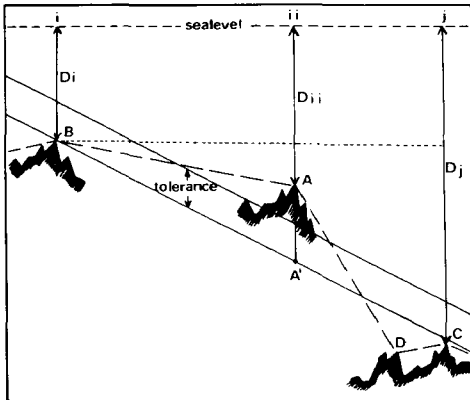


FIG. 4. — Insertion of a minimum depth (stage 3.1) :

- Di, Dj Depths of n^{th} order selected minima, with too large a gap between them.
- Dii Depth of a point which can be inserted possibly.
- BC Connecting line between n^{th} order minima.
- BADC Connecting line between $(n-1)^{\text{th}}$ order minima.
- If AA' exceeds the tolerance more than other points ii ($i < ii < j$), point A will be plotted.

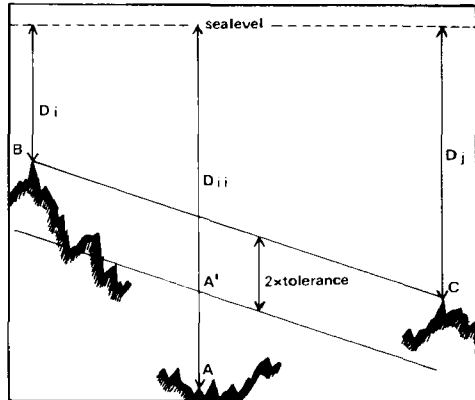


FIG. 5. — Insertion of a maximum depth, where A represents a first order minimum.

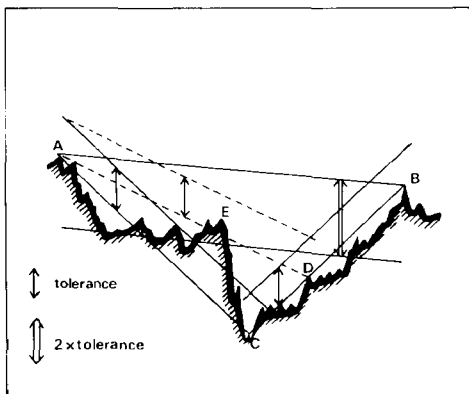


FIG. 6. — Selection of a maximum depth : Point C is rejected because a minimum (E) is situated more than the tolerance above the connecting line AC. Point D will be inserted instead because there are no depths more than the tolerance above the connecting lines AD and BD.

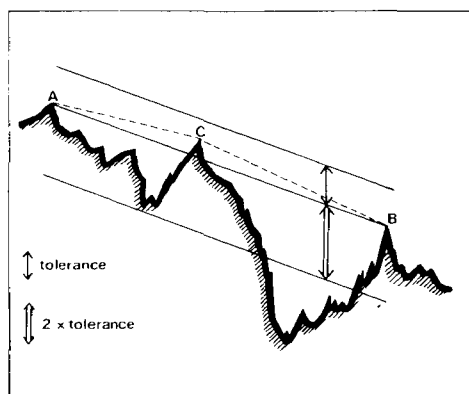


FIG. 7. — Selection of a minimum depth (C) in the range three times the tolerance.

3.2 If such a point does not exist, that depth is plotted which exceeds the connecting line by the greatest amount twice the value of the tolerance downwards (point A in figure 5).

Stage 3.1 and 3.2 are repeated with the newly found interval if necessary. Inserting a point which exceeds by the greatest amount twice

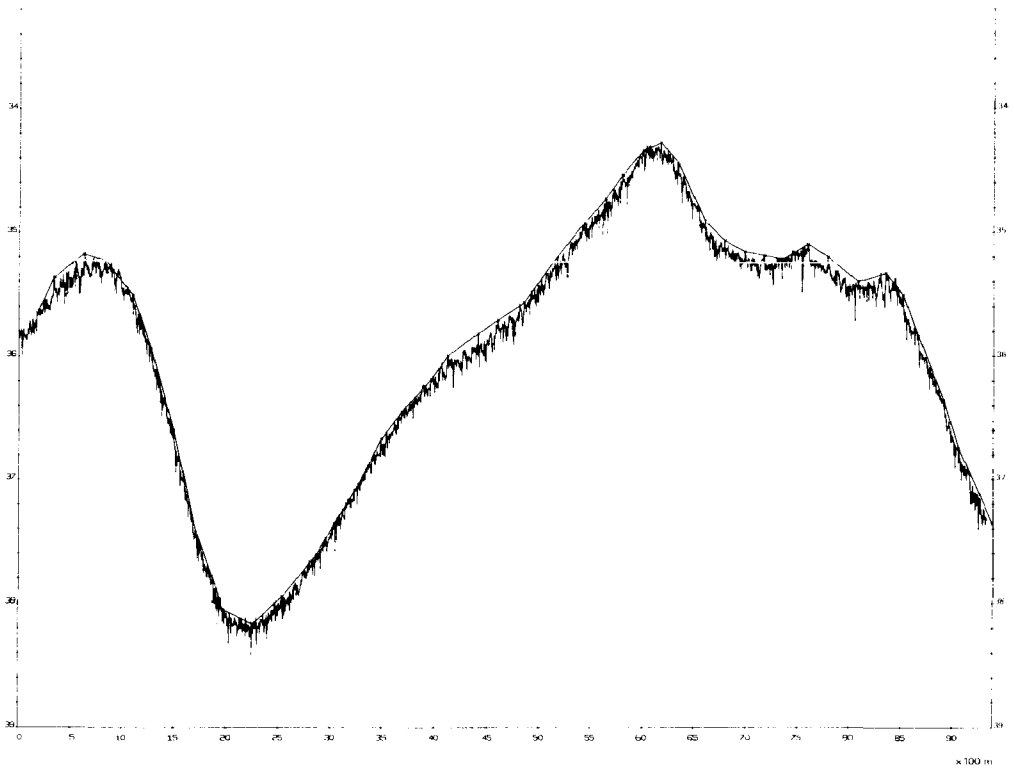


FIG. 8. — Actual sampled North Sea bottom profile with generalisation thereof by selection.
Specified tolerance 5 cm, sampling rate 2 per second.

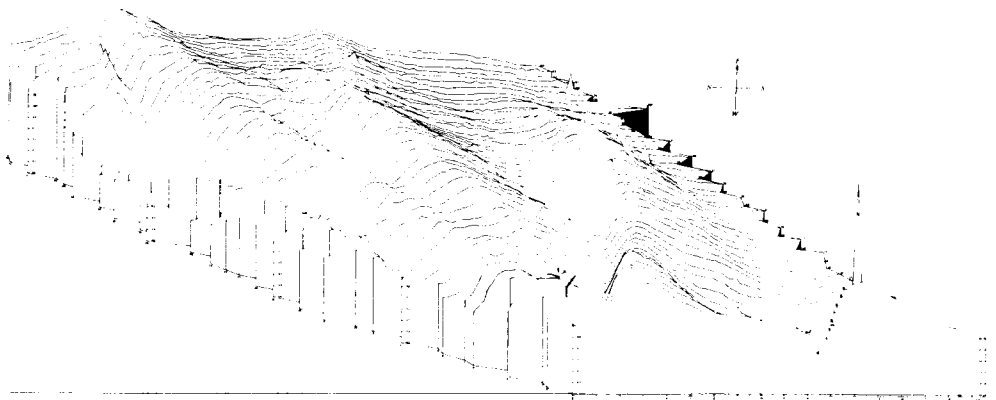


FIG. 9. Three dimensional plot of part of the North Sea (60 miles N.W. of the exel).
Horizontal scale 1:200 000, vertical scale 1:400.

the value of the tolerance downwards has one restriction : from figure 6 we see that point C would be selected. In a repeated insertion-procedure between A and C, point E would be selected, because it is situated more than the tolerance *above* the connecting line between A and C. Looking at the space on the fairsheet needed for the depth figure of point C (2.8 mm as you may remember) we see that point E would be rejected for lack of space. In this case both points C and E are eliminated and the interval A-B is re-investigated to find another point, e.g. point D (fig. 6).

3.3 With a very irregular bottom topography it is possible that no point between the already selected minima will be found in stages 3.1 and 3.2. Only depths in the range *three times* the tolerance between A and B (fig. 7) have to be considered. The minimum depth (C) is here chosen.

Figure 8 shows an actual sampled profile and the generalization thereof resulting from the application of this selection procedure.

As a final quality check, a three dimensional picture (fig. 9) of all selected depth figures for the fairsheet is plotted automatically. Bottom relief can then easily be recognised. Selected depths resulting from inaccurate depth sampling will be marked on the fairsheet for final approval by the Commander of the hydrographic vessel.

SUMMARY

All measured depths are corrected for swell, tidal influence and depth of echosounder transducer.

A first reduction of the slice of sounding data is obtained by eliminating all depths not selected as a first order minimum in stage 1.

The first order minima are the data with which we continue the selection process.

The extreme minimum depths are selected for plotting (stage 2), and later on additional depths are selected for insertion, depending on the interval (stage 3).

Only actually surveyed depths are plotted, in their real positions; no mean values are used.

REMARKS

1. The program has been operational in this form since Summer 1975.
2. The program is written in Fortran 4 language and could be made available, together with documentation in the Dutch language, on request to the Dutch Hydrographic Service.
3. The selection program proper takes up about 5 K words of 16 bits of memory.

REFERENCES

- [1] BUIS, B., and L.P. van der POEL : The HYDRAUT automatic data logging system. *Int. Hydr. Review*, LII (2), July 1975, pp. 77-91.
- [2] MOLEN, P. van der, A.B. WILBRINK : Automatisering bij de Afdeling Hydrografie van de Koninklijke Marine (in Dutch). *Ned. Geod. Tijdschrift*, 2, Feb. 1975, pp. 27-35.
- [3] ANTONIDES, L.J., and J.C. KREFFER : The new Netherlands hydrographic vessels *Buyskes* and *Blommendal*. *Int. Hydr. Review*, LII (2), July 1975, pp. 71-76.