

Annex – A : Example of determining vertical quality of a MBES survey.

To demonstrate the complexity of data quality from ping to chart, a survey area in the NL part of the North Sea is used. This area is surveyed using a Multibeam Echosounder with a vessel position using GNSS with a accuracy of 8 cm (2σ) and direct ellipsoid to Chart Datum conversion -Ellipsoid Reference Survey - with an accuracy of 10 cm (2σ). The survey meets S-44 standard 1A for all elements of this standard.

A certain portion of the survey is selected:

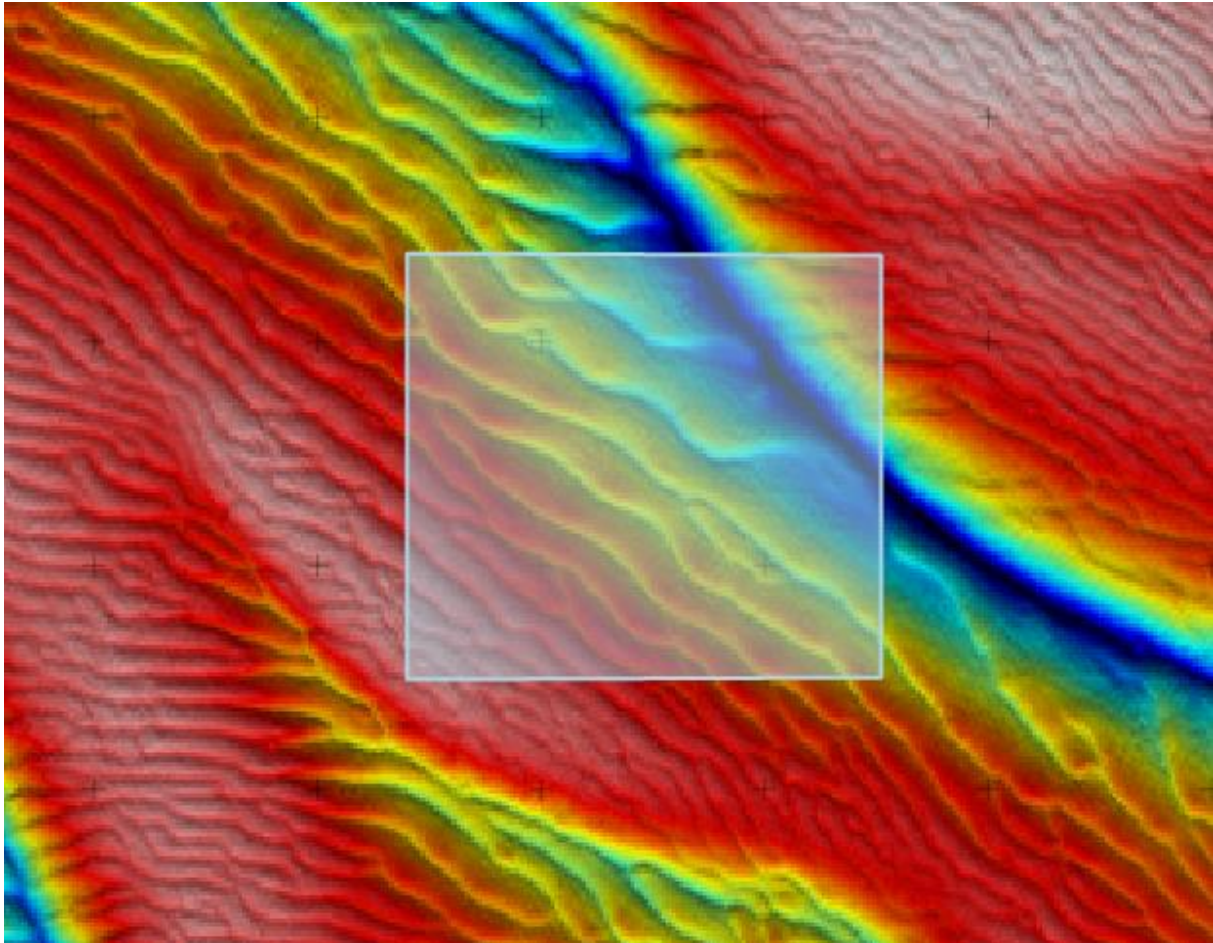


Figure 1: selection area of the MBES survey

The depth range of the area selected is 31 to 21 m below Chart Datum (LAT). The bottom consists of sand, thus creating a mobile seabed floor which is resurveyed every four years.

The coordinates of the selection area are:

item	Selection area	Easting	Northing
1	Left bottom	531540.00	5761950.00
2	Right bottom	531752.00	5761950.00
3	Right top	531752.00	5762138.00
4	Left top	531540.00	5762138.00

Table 1: coordinates selection area

The area is 212x188 metres. This area is divided into grids of different resolution:

Level 1: 2x2 metres

Level 2: 4x4 metres

Level 3: 8x8 meters

Level 4: 16x16 metres

Level 5: 32x32 meters

Level 6: 128x128 metres

(due to software error, the 64x64 grid is missing.)

For each Level, the following characteristics are given:

1. Number of grid cells
2. The total number of DTM points used calculating avg, depth and 2σ .
3. Average depth per cell, deepest value in range.
4. Average depth per cell, shallowest value in range.
5. Minimum depth per cell, deepest value in range.
6. Minimum depth per cell, shallowest value in range.
7. The 2σ value for vertical uncertainty, minimum value in range

Grid size	No.cells	DTM pts	Avg. range		Min. Depth range		2σ range	
2x2	10005	121511	30.43	22.10	30.43	21.86	0.03	0.93
4x4	2544	123590	29.60	22.63	29.38	22.03	0.18	1.01
8x8	624	121218	30.78	-23.71	30.30	22.57	0.14	1.48
16x16	168	130426	29.92	24.49	29.25	22.98	0.43	2.18
32x32	42	130426	30.78	25.93	30.18	23.85	0.34	2.81
128x128	2	99392	30.87	29.84	29.22	26.75	1.63	2.93

Table 2: overview of cell characteristics

When validating these 2σ values with S-57 CATZOC we have:

ZOC=A1: $0.50+1\%d$

ZOC=A2: $1.00+2\%d$

ZOC=B: $1.00+2\%d$

ZOC=C: $2.00+5\%d$

For each ZOC value, the quality is computed using 31m and 21m. All data points fall inside this depth range.

ZOC	Formula	Acc.@31m	Acc@21m	2x2	4x4	8x8	16x16	32x32	128x128
A1	$0.50+1\%d$	0.81	0.71	0.93	1.01	1.48	2.18	2.81	2.93
A2	$1.00+2\%d$	1.62	1.42						
B	$1.00+2\%d$	1.62	1.42						
C	$2.00+5\%d$	2.55	2.05						

Table 3: computation and validation of CATZOC depth accuracy

From S-44 the computation of TVU can also be applied to the depths of 21 m and 31m:

order	a & b	Acc.@31m	Acc@21m	2x2	4x4	8x8	16x16	32x32	128x128
special	0.25 / 0.0075	0.54	0.47	0.93	1.01	1.48	2.18	2.81	2.93
1A	0.5 / 0.013	0.81	0.72						
1B	0.5 / 0.013	0.81	0.72						
2	1.0 / 0.023	1.31	1.22						

Table 4: computation and validation of S-44 depth accuracy

From Table 2, 3 and 4 we see that a portion of the grid cells do not meet the relevant standard. For each grid size the percentage that meets the quality standard at 21 m depth is computed:

Grid size	ZOC A1	ZOC A2	ZOC B	ZOC C	Order 1A	Order 1B	Order 2
	0.71	1.42	1.42	2.05	0.47	0.72	1.22
2x2	99%	100%	100%	100%	96%	99%	100%
4x4	98%	100%	100%	100%	90%	98%	100%
8x8	90%	99%	99%	100%	59%	91%	98%
16x16	62%	93%	93%	0%	22%	64%	91%
32x32	31%	81%	81%	90%	5%	31%	74%
128x128	0%	0%	0%	50%	0%	0%	0%

Table 5: Percentage of area within limits of ZOC and S-44 – posteriori

When the survey was acquired, all data points matched S-44 order 1A with the TVU online computation. However, a posteriori confidence level computation does not entirely meet S-44 Order 1A. This may be caused by the slope of the terrain having a negative effect on the computed confidence level using the DTM points inside the grid cell.

When changing to a larger grid cell size, the a posteriori computed confidence level drops at 16x16m to unacceptable levels.

When applying the parameters and computation method of S-44, the percentage outside the quality level is greater. At 8x8 grid cell, the value is too low to be classified as order 1A confidence.

Conclusion:

The computed vertical accuracy and associated confidence level has a direct relation to the grid cell size used. It is recommended that the smallest possible grid cell size should be used but the cell size should contain enough samples to compute an appropriate standard deviation. Also note that the slope of terrain is not accounted for in this computation.

To fully meet a standard, the most stringent quality level should be computed as reference, i.e. at the shallowest depth of the survey area. Otherwise for each cell, the computed standard deviation has to be checked at its specific depth against the quality standard using either the existing CATZOC formule or the S-44 formula, pending on the outcome of the discussion of DQWG-13.

Please also note the gridding algorithm may be different between various software packages. This is also a quality issue.