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Brest | Item **B3**

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B STRATEGIC ASPECTS OF THE WORK OF HOs – TECHNICAL ISSUES

B3 Accepting CUBE surfaces as survey deliverables

Considerations and advantages of accepting CUBE surfaces as survey deliverables

Purpose and scope

This document outlines the considerations and advantages for the UKHO accepting bathymetric surfaces as deliverables from Civil Hydrographic Programme (CHP) contractors for bathymetric swath surveys. The UKHO Bathymetric Data Centre (BDC) is recommending using statistically defined surfaces to clean and verify appropriate bathymetric data.

Swath survey data

CHP contractors currently deliver, cleaned, full density swath bathymetric data to the UKHO for verification. A modern swath system can gather 27 million depths per hour. A typical survey can consist of well over a billion depths. This amount of data is required to ensure that all small navigationally significant features (>=2m^3) on the seabed have been correctly measured. Similar to single beam surveys, swath survey data generally contains noise or 'spikes' that need to be cleaned out before it can be used for a product. Swath surveys contain huge amounts of data and this makes the process of cleaning and verifying very time consuming.

The current process is for BDC to create a shoal biased thinned dataset from the cleaned bathymetric dataset (post verification) for use on UKHO products. This has been adopted directly from single-beam working methods.

Using shoal biased datasets for single-beam surveys is reasonable, as single-beam data is sparse and has no redundancy. Using a shoal biased solution for dense swath data is much less appropriate, as the resulting sounding set will still include some noise. Cleaning noise from swath survey data manually can be very time consuming and subjective. A lot will depend on the particular operator doing the cleaning. Having different operators working on the same data can produce different result and even the same operator can produce different results on different occasions.

Dense swath data is perfectly suited to the use of statistics to determine an accurate and repeatable "most probable" depth using multiple data points.

CUBE surfaces

One statistical method of data processing is called CUBE (Combined Uncertainty Bathymetric Estimator). CUBE processing results in a particular type of grid known as a 'CUBE surface' being formed. The aim of CUBE is to use as much information as possible from the data to determine the most probable depth at any point in the survey area from the many noisy estimates of that depth measured in the same location (i.e. the soundings).

CUBE was developed as a research project within the Center for Coastal and Ocean Mapping and NOAA/UNH Joint Hydrographic Center (CCOM/JHC) at the University of New

Hampshire. NOAA has been successfully using CUBE surfaces for swath surveys for more than 2 years.

Figure 1 shows a 2D slice through some typical swath data. The noise is clearly visible and would need to be removed before a sensible shoal biased depth could be determined. The CUBE surface is shown in green and can be seen to be the more probable depth. A shoal biased solution would be dependent on the quality of the cleaning and is biased by the human operator, as it is difficult to determine where the noise stops and the actual seabed begins. As manual cleaning of swath data is so time consuming, automated cleaning tools have been used to assist with the removal of outliers for some years now, though some manual cleaning is always unavoidable.

CUBE surface depths are typically deeper than shoal biased depths from traditionally cleaned data, but they are a more accurate and repeatable assessment of the true depth.

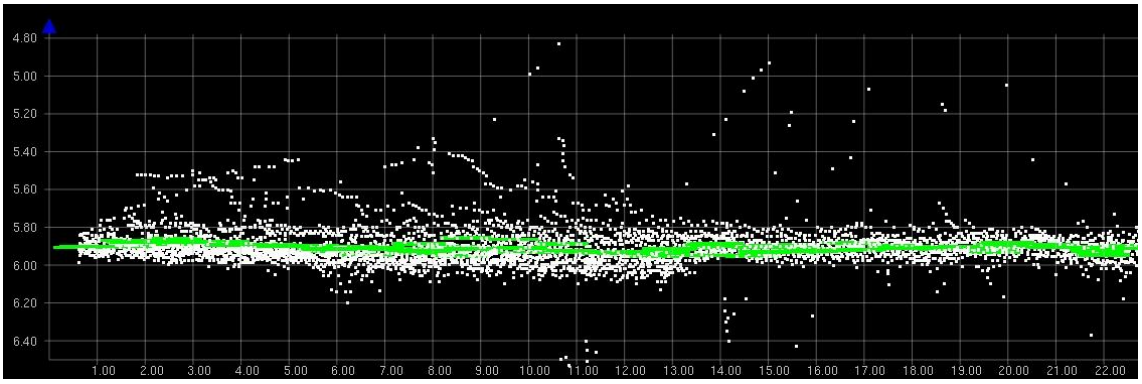

Figure 1 A profile through typical swath data. CUBE surface shown in green.

CUBE not only computes a depth surface, but also gives indications of areas where the algorithm may not have produced credible results. The user is then steered towards these areas and can adjust the CUBE depth surface as appropriate so that the correct depth is selected. This is often the case over ship wrecks or complex seabed features. This ensures that the user spends most of the time examining the important areas of the data and very little time in areas that are not complex and where the data quality is very good.

The deliverable from the contractor to the UKHO would be a final edited CUBE surface and the full density data. BDC can then examine the CUBE surface against the full density data to determine that it is fit for purpose. Further edits can be made by BDC if required, with consultation of the surveyor.

Comparing Shoal biased and CUBE surfaces

Comparisons carried out by BDC show that CUBE surfaces are generally slightly deeper than shoal biased data sets, as demonstrated below. But it must be remembered that this difference is mainly accounted for by the noise in the shoal biased sounding selection. The CUBE surface is the more accurate assessment of the depth. During the study conducted by CCOM/JHC that resulted in the CUBE surface being developed they concluded that over 99% of al soundings on the charts they assessed came from noise and were not the actual seafloor.

BDC examined how this would affect the end products and some comparisons are shown in the images below.

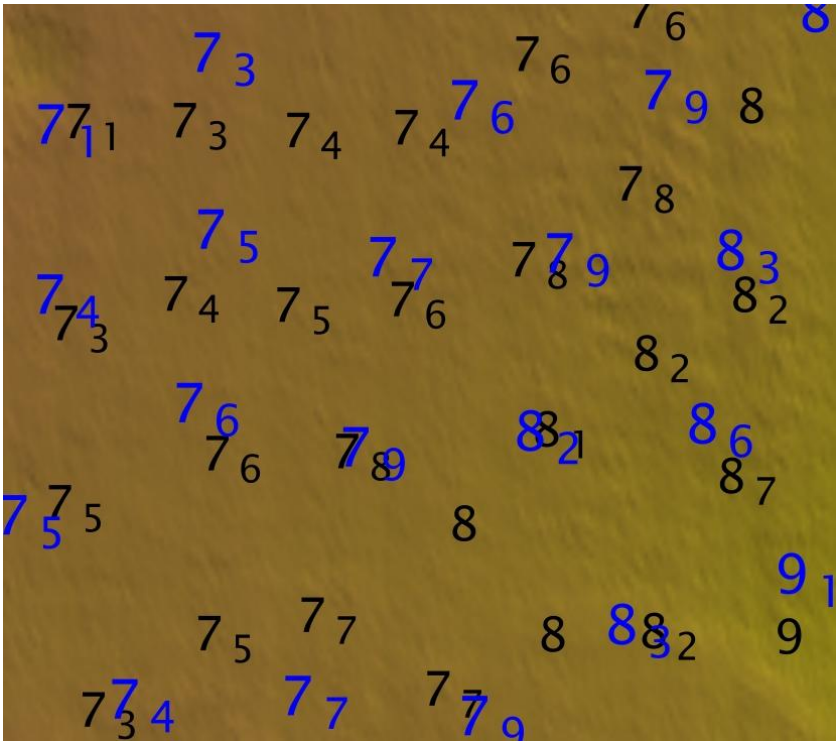

Figure 2 A flat area of seabed shows depths agree to within one decimetre. Traditional sounding selection shown in black and CUBE sounding selection shown in blue

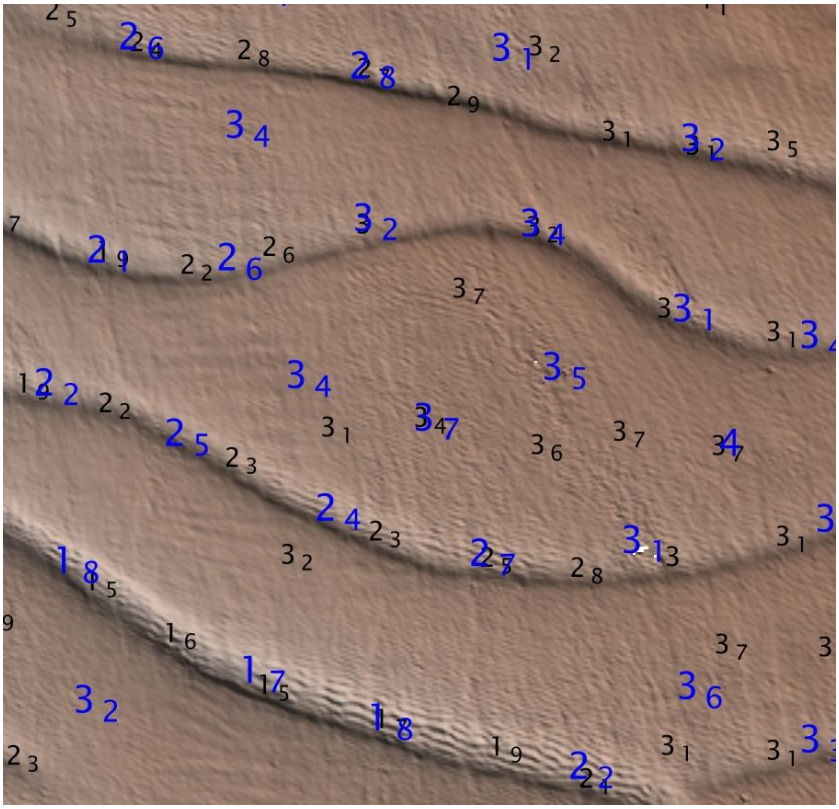

Figure 3 A more complex seabed also shows fairly close agreement. The critical depths agree to within two decimetres. Traditional sounding selection shown in black and CUBE sounding selection shown in blue

It is not expected that the soundings from the 2 processing methods would exactly match, but from these examples it can be seen that using a CUBE surface will not cause a dramatic change in the depth values that would be used on a product.

Conclusions & Recommendations

The results of the study carried out by UKHO BDC show that CUBE surfaces are suitable to be accepted as deliverables from survey contractors. The UKHO BDC is currently waiting for the Maritime and Coastguard Agency to review the study and approve CUBE surface deliverables and then a suitable specification will need to be written that can be used for future CHP contracts.

If the UK Hydrographic Office decides to accept CUBE surfaces as a deliverable from CHP contractors this will:

1. Improve the quality and accuracy of the bathymetric product.
2. Prevent noisy data being used on a product.
3. Reduce contractor processing time and make the process less manually intensive, which will in turn reduce costs and improve safety (as data would be available for products more quickly).
4. Reduce UKHO verification time and make the process less manually intensive, which will in turn reduce costs.
5. Focus effort on examining the important complex areas and features. This should also improve the quality of the data in terms of safety.
6. Ensure that the UKHO is in line with current best practice and is using modern techniques to the full advantage.

For further information or more detail please contact either Chris Howlett or Andy Talbot at the UKHO's Seabed Data Centre (Chris.Howlett@ukho.gov.uk or Andrew.Talbot@ukho.gov.uk).