Assessment of the impact of changes in bathymetry on the safety of navigation: The UKHO experience.

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The UK Hydrographic Office (UKHO) has a 200-year history of producing nautical charts and associated publications. Today, as a Trading Fund within the Ministry of Defence (MoD), the mission of the UKHO is to meet national, defence and civil customer's needs for charts and other hydrographic information in support of safe navigation. Navigational charts and associated publications remain the UKHO's core business, with a world wide series of over three thousand charts in paper and electronic form.

Among other responsibilities, the UKHO is tasked with producing reports providing recommendations and advice about the need for routine re-surveys of areas of unstable seabed in UK waters. Re-surveys are carried out as part of the Civil Hydrography Programme which is funded by another Government department called the Department of the Environment, Transport and the Regions (DETR). These reports examine the type, density and draught of shipping transiting an area, the under-keel allowance recommended by the UK Government, the natural depths, seabed mobility (both vertical and horizontal) and provide an assessment of the impact that depth changes may have on shipping in that area. Recommendations are also made about the priorities for the future work programme for analysis of data from routine re-surveys. The limits of these re-survey areas are agreed and reviewed by the Civil Hydrographic Review Committee (CHRC), taking into account the recommendations of the UKHO. This committee is chaired by the UK Maritime and Coastguard Agency and includes representatives from chart users, port authorities and the General Lighthouse Authorities.

Areas where it is considered possible that significant movement of sandwaves on the seabed could jeopardize the safety of surface navigation are re-surveyed periodically. Large portions of the UK continental shelf are covered with sandwaves, especially in the Southern North Sea. They occur in depths from a few to 100 metres and vary in height from 1 to at least 20 metres in height. There are several busy ports on the East coast of the United Kingdom including Hull, Harwich and Lowestoft. The Dover Strait is one of the busiest seaways in the world with in excess of 120,000 transits per year. UK waters include the southwest-bound lane of the Traffic Separation Scheme in the Dover Strait and English Channel. In addition, a recommended track runs through the Dover Strait from offshore Europoort in the north, to offshore Dungeness in the south. This route is used by 'Very Large Crude Carriers' (VLCCs) which draw up to 22.6 metres in depth. With the addition of under-keel allowances, depths of 30 metres or less are generally considered to be potentially significant for safe navigation.

There are presently 58 defined areas, which are periodically re-surveyed. The limits of these Routine Re-survey Areas (RRAs) are carefully defined. They are generally located around Goodwin Sands, the Southern North Sea, Shingle Bank, East Anglia, Bristol Channel, the south-west bound recommended track through the Dover Strait, and the Thames Estuary. They vary in size from approximately 1 to 70 square nautical miles in size. Each RRA has an associated re-survey frequency, which varies from once a year to every 12 years. As knowledge increases, some of these areas have their frequency of survey amended or could be removed from the re-survey programme altogether.

Each of the surveys is planned and specified as part of a Hydrographic Instruction (HI). HIs are produced annually for all surveys funded by the MoD or DETR. A ten-year rolling programme of routine surveys is maintained that shows which areas are due to be surveyed in a particular year. Amendments to the programme are made as a result of any change to the survey frequency or RRA limit recommended by the UKHO and agreed by the CHRC. The HI ensures that the survey is conducted in a manner such that a comparison can be made with the previous survey

allowing an assessment of seafloor changes to be made in a meaningful way. For example, the survey line spacing and track direction are, as far as possible, the same as for the previous survey.

Re-surveys are normally carried out by Naval Party 1016. This team currently embarked in the MV Proud Seahorse, comprises Royal Navy surveyors and a civilian crew working on a civilian ship. Surveys are normally carried out at a scale of 1: 12500 or 1:25 000 with a line spacing of 62.5 metres or 125 metres depending on the depth. They normally use satellite-based differential GPS for positional fixing which is carried out to a specified accuracy of +/- 13 metres (2?). An Atlas Electronics Deso 25 echo sounder is currently used on dual frequency 33/210 kHz. The latter frequency is used for the survey, as the lower frequency tends to interfere with the side scan sonar and has poorer resolution in shallow waters. Soundings produced by the survey are required to have an accuracy of +/-0.5 +/-0.009d metres (2?) (d is the depth). The seafloor is normally insonified to determine its texture using a type-2053 side scan sonar supplied by Ultra Electronics. The bathymetric and positional data are processed onboard by the Kelvin Hughes SIPS-S computer system. The end product, in terms of bathymetry is a graphical plot of depths and a higher density digital data set. All meteorological and oceanographic observations, photographic views, tidal data, geodetic observations, and wreck records are rendered in a Report of Survey.

The UKHO puts considerable effort into the appraisal of surveys rendered, particularly by the Royal Navy. The appraisal process checks the geodetic, oceanographic, tidal, and digital processing aspects of the survey. The Hydrographic Data Centre within the UKHO, uses SIPS platforms to perform detailed checks on rendered digital data sets. These checks ensure the data is complete and free from gross errors, and that the correct sounding selection parameters have been used. Typically this takes between 5 and 10 days effort per survey. If the survey does not meet the standards specified in the HI and defined in hydrographic surveying specifications, the survey is returned to the ship for re-processing. Typically 40 to 45 surveys are received from the Royal Navy every year. The appraisal process is important for survey analysis because a poor quality survey could result in misleading or incorrect recommendations being made.

The Survey Analysis section within the Hydrographic Data Centre has been using Universal Systems Ltd. (USL) CARIS software since April 1999. This software is a chart production and publication system used by many Hydrographic Offices around the world to store, analyse and publish hydrographic information. CARIS is used to undertake several different types of analysis in order to build up a picture of how an area of seafloor has changed with time. The outputs from this analysis are used in the report to support the recommendations. The number of reports produced annually varies between 15 and 25.

To carry out the analysis, CARIS requires bathymetric data from the latest and previous surveys conducted in the Routine Re-survey Area. The first step is to take the older survey and create a Triangulated Irregular Network (TIN). The TIN is automatically compared with the soundings from the newer survey using the ‘comparative surface analysis’ function. A new data set is produced which contains the difference in depth between the two surveys at the same locations as the soundings in the newer of the two surveys. A regular grid of values is generated from this difference data set which is colour banded to more clearly present the magnitude of the change in depth across the area of the survey. This is called a variability plot. Although it shows the change in depth, either shoaling or deepening at a particular location, it does not show the lateral movement of features very well.

A regular grid with a resolution of approximately 30 metres is produced from the most recent survey data set. This is used to create a colour classified 3-d view of the seafloor, which can be displayed from almost any angle. Selected soundings are also plotted from this survey to present a thinned colour-banded plot of bathymetry. This plot shows the area surveyed and gives a feel for the depths generated from the most recent survey.

Seafloor profiles are created from the TIN for each survey. If the southwest-bound recommended track runs through the area surveyed, a profile along its length helps to understand the dangers to vessels following this route. When the profiles from each survey are viewed together, the changes in the shape of the seafloor over time can be seen along this route.

Contour plots are automatically interpolated from the TINs produced from each survey. Using the same contour interval, these can be superimposed to present the change in apparent position of the chosen depth contours. This plot shows the lateral movement of features on the seafloor better than any of the other visualisations produced.

A multibeam hydrographic system is currently being trialled by the Royal Navy and the UKHO. The system being used is the Atlas Fansweep 20. Such systems are likely to be in full operational use by the Royal Navy and commercial contractors within the next few years. Multibeam surveying presents many complex issues for the UKHO. This high-resolution data will, in future, change the way in which surveys are validated, appraised, and archived. The UKHO needs to resolve issues such as how it can be efficiently appraised, and decisions need to be made about the density and format of bathymetry that will be permanently archived.

Multibeam data will also have a significant impact on survey analysis. For example, it will be possible to generate higher resolution grids than has been possible to date. Each square mile of survey area will contain approximately 20 million soundings before processing. The data set rendered is likely to comprise a Digital Terrain Model made up of merged regular grids for the flatter less complex parts of a survey area, and TINs for the more complex, shoaler parts. With each sounding potentially being used as a node for the TIN there is a trade-off between the accuracy and resolution of the data model and the computer processing requirements needed to generate it. The Hydrographic Data Centre will need to trial the use of this new high resolution data model to understand its impact on survey analysis work in the future.

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