INTEGRATION INTO HYDROGRAPHIC SURVEY PROGRAMMES

Acoustic Seabed Classification

Acoustic seabed classification is rapidly gaining acceptance as a useful tool amongst the world's ocean community. Commercial classification products can measure acoustic diversity in the surficial seafloor zone and produce thematic maps of the resulting acoustic classes. Hydrographic services throughout the world routinely conduct bathymetric surveys using single beam sounders and multibeam sonar. These operations are ideal candidates to serve as 'surveys of opportunity' for acquisition of acoustic classification information.

The hydrographic office itself gains significantly better seafloor information for charting purposes, with the added benefit that the ocean community outside hydrography gains a new capability to manage the delicate demersal environment more effectively. Of course, a suite of new classification-based data products and previously unknown applications for seabed information comes from this endeavour. However, the Hydrographic Office must integrate this new technology into its programmes very carefully.

Grayscale Tune
Mariners and fishers of years past observed the echo sounder for hours and days on end playing a grayscale Ã”tuneÃ• on the paper roll. These seafarers knew that what was presented on the paper was a measure of the seafloor in more than simply depth. These early researchers correlated the incidental bottom material brought up in their trawl gear with the distinctive patterns they observed on the echogram and thus were the first to use acoustic seabed discrimination as a tool; the subtle echo patterns identified the best benthic fishing zones.

A Perfect Fit
Today, this type of seabed information is achievable on any vessel in a systematic, objective and repeatable way. The total investment required to survey the worldÃ•s oceans specifically for bottom typing
is prohibitive unless this technology can incrementally tag along with other operations that are compatible with classification survey needs. Most hydrographic bathymetric surveys fit this role perfectly. Therefore, Hydrographic Offices (HO) are now presented with an opportunity to acquire a new data type that, for technological reasons, was unattainable only a few years ago. The issue of whether remote acoustic seabed classification is a useful and cost-effective means to map seabed type for purposes of charting is a question each HO must address. It must do so within the context of its survey capability, its need for continuous seabed mapping and the very real cost in time and physical resources.

Survey Design
Acoustic seabed diversity is mapped effectively at those survey scales normally used for acquisition of single beam bathymetry, providing sediment variations are not too great when line spacing is large. In contrast to single beam, multibeam technology demands a dynamic survey design such that line separation is now driven by the need to achieve 100 per cent bathymetric coverage of the seafloor. In shallow water, sonar geometry requires multibeam track lines to be relatively close. This practice matches both single beam and multibeam acoustical seabed classification needs very well, since seafloor geomorphology tends to be more complex in shallow regions; they need to be sampled at a tighter line density to avoid spatial Ã”aliasingÃ• (undersampling) of the geological diversity. Basic, and more subtle, bottom types can be delineated and equally important, boundaries between types can be accurately located. The improvement here is analogous to the significant step forward that the HO made in going from leadline sounding to continuous electronic acoustic sounding.

Groundtruthing
Results from an acoustic seabed classification survey consist of measurements of acoustic diversity expressed in discrete numerical Ã”classesÃ• of the seafloor. Usually, this clustered measurement corresponds directly to unambiguous geology. To verify this correlation, physical and/or visual samples of the seafloor need to be taken then this sampling program assigns (groundtruths) acoustic classes to seabed types. Groundtruthing methods include traditional leadlines (with tallow to capture a small sediment sample), grabs, corers, photographs, and less traditional methods such as video. However, scales of these sampling methods are very different, as detailed in Figure 1. Here the maximum depth of seafloor penetration versus the areal coverage of the acoustic system and the sampled/imaged groundtruthing is presented. The groundtruthing does not generally match the acoustic footprint or penetration for a 38kHz 17Â¼ beamwidth and a 200kHz 9Â¼ system at 100m depth as in this example. Consider also that, when acoustic diversity does not actually reflect the local groundtruthed geology, maps generated will be incorrect, so that some care must be taken in using physical samples to calibrate the classifications.
Even so, after conducting the classification survey, bottom groundtruthing still is required, except now sampling is designed with a more efficient pattern since a priori knowledge of the areal distribution of acoustic diversity guides the positioning and spatial density of the physical and visual samples. Experience has shown that improved results can be obtained with only about 20 per cent of conventional sampling by using acoustic classification as a guide to design the bottom sampling programme at 2 Ã 4 stations per class. Figure 2 demonstrates how to choose suitable sample sites to define the previously surveyed seafloor. The codes are Ã”bottom qualityÃ• values that reflect seafloor geology from a hydrographic perspective. Here, SD is sand, RC is rock, SI is silt, etc.

Operational Restraints

Seabed classification places more stringent engineering requirements on the sounder or sonar transducer installation than those needed for bathymetry alone. Since analysis of fine structure of the acoustic seafloor echo is fundamental to classification processing, it is imperative to preserve the quality of this signal at the source: the transducer installation. Propeller cavitation injects noise into the echo at lower sounder frequencies but aeration caused by bubble drawdown along the hull also has a significant impact on signal quality at all frequencies. This reduction in signal-to-noise is a consequence of flush-mounting transducers in the hull to maintain operational speeds. Therefore, to improve acoustic quality of the echo, sounder transducers should be installed in a fairing, which will both help to divert bubbles and to place the transducer below the bubble layer into a more optimal acoustic environment. In extreme cases a bubble diversion fence can be installed. Both classification and bathymetric results will be improved.

Costs versus Benefits

In addition to equipment purchase and maintenance, there is a time and data management cost associated with integration of classification programmes into hydrographic surveys. The additional field time needed to implement data collection for classification has been estimated to be 10 per cent of that required for conventional bathymetric surveys. Data management requirements increase such that single beam dual frequency and multibeam backscatter each add 1 - 4 GB/week to archiving needs. However, the largest real cost comes from post-processing the data, where 20 per cent Ã 30 per cent of survey field time is needed to produce cleaned digital classification files, metadata and visualisation outputs. On the plus side, computer technology and software automation is rapidly driving down the labour cost of processing. While these estimates are rough, they serve to highlight the factors to be considered by an HO before pursuing classification technology.

Notwithstanding the real costs in resources and time, there is a concrete benefit to be gained from integrating acoustic seabed classification technologies into hydrographic survey programmes. Hydrographic chart construction quality is significantly improved, since bottom material and boundaries of the geological zones are clearly delineated. This new comprehensive seabed information may well induce modifications in the future format by which navigational charts are presented. Of course, a suite of new markets will naturally be opened up for seabed classification products with respect to geology, habitat mapping, stock assessment, and dramatic seafloor posters useful for public information campaigns such as qualification of marine protected areas.

Summary

TodayÃ•s hydrographic office is presented with an opportunity to improve information about the seafloor by applying acoustical classification technologies to map acoustic diversity of the seabed. While this information can be used to improve the quality of navigational charts, the true intrinsic value of seabed classification is to provide habitat and environmental health information for a myriad of applications. The hydrographic survey vessel is an ideal platform from which to conduct acoustic classification operations. Care must be taken to ensure high quality acoustic signals are acquired for classification purposes. The HO should be cognisant of the investment in time and resources required for the successful integration of acoustic seabed classification into their hydrographic programmes. Technology has now caught up with the skills of the mariners of old, so that any HO can now objectively interpret the seabed with at least the same confidence as those who spent all those years watching the echosounder.

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