MULTIFREQUENCY CLASSIFICATION AND CHARACTERIZATION OF SINGLE BEAM ECHOUSOUNDER DATA COLLECTED FROM OFFSHORE IRELAND

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1. INTRODUCTION

Since 2000, the Irish National Seabed Survey and INFOMAR (INtegrated mapping FOr the sustainable development of Ireland's MArine Resource) have mapped the area from the outer margins of Ireland's territorial seabed to the shelf as well as nearshore areas. Using several research vessels equipped with a variety of instruments, ocean, seabed and sub-seabed properties have been measured.

During this time, INFOMAR has produced regional seabed classification charts using multibeam backscatter data. Multibeam backscatter returns at high frequencies are generally a good indicator of surface seabed properties, but are not suitable for the subsurface discrimination because of minimal sound penetration. Furthermore, multibeam backscatter returns below nadir are not generally a good seabed discriminator, leaving unclassified gaps in most of these charts. Single beam echoes are precisely imaging most of this region, making the two sonar systems complementary in an integrated approach to seabed characterization.

INFOMAR and the Canadian Marine Acoustic Remote Sensing (C-MARS) Facility partnered in 2009 in a pilot project to examine the utility of using both multibeam (MBES) and single beam echosounder (SBES) data in tandem for improved seafloor and shallow seabed classification and characterization. This paper describes the process developed at C-MARS used to analyze SBES data. The results of one case study are shown to demonstrate the potential for seafloor classification and characterization from the INFOMAR SBES data.

2. DATA

INFOMAR uses a range of vessels for geophysical surveys, governed by the water depth of the area to be surveyed. For surveying in deeper waters, the RV Celtic Explorer is equipped with a Simrad EM1002 (95 kHz) multibeam sonar, a SES Probe 5000 subbottom (3.5 kHz) profiler, and a three frequency Simrad EA600 (12, 38, and 200 kHz) hydrographic echosounder. In shallow waters the RV Celtic Voyager is similarly equipped but uses a dual frequency Simrad EA400 (38 and 200 kHz) hydrographic echosounder and has an additional Simrad EM3002 (300 kHz) multibeam sonar.

In addition, at various study sites, grab samples, vibrocores and video footage have been collected, often guided by the seabed classification map derived from the multibeam data. As well, at a few selected sites, a towed Electromagnetic (EM) system was used to measure the electrical conductivity distribution of around 20m below the seafloor.

3. DATA PROCESSING

At C-MARS, research on improved acoustic seafloor classification has focused on the extraction of attributes from SBES echoes. These attributes, in combination with pre-existing features found in QTC IMPACT™, form a feature set that now includes physically based features such as amplitude. As well, integrated moments of the echo amplitudes, modified from van Walree et al. (2005), were calculated. These new features provide additional information useful for classification and potentially characterization.

The following steps were used to extract features from the SBES echoes:

1. The data were loaded into QTC IMPACT™ to convert the raw Simrad data expressed in decibels to a linear scale. 2. Automatic bottom picking was performed, resulting in less than 2% bad picks, and traces with any further bad bottom picks were eliminated.
3. The echo amplitudes were depth compensated for seawater absorption and imprecise spreading law using a process similar to the depth compensation applied to multibeam backscatter values in QTC MULTIVIEW™ (Preston, 2009).
4. After this gain correction, stacks of 5 echoes were assembled to improve the signal to noise ratio.
5. The data were trimmed to *n* standard echo lengths (SEL's) before the pick and *m* SEL's after prior to feature analysis. The standard echo length is defined as the expected duration of an echo from a sand echo for an echosounder with a given frequency and beamwidth. In all cases, *n* and *m* were chosen to prevent truncating echoes from soft sediments in the trimming process (for instance, n=0.5 and m=7.5 for the Malin Sea).
6. The trimmed stacked data were processed with the feature algorithms shown in Table 1. The existing features are primarily related to the shape of the echo. Some of the new features are related to seafloor

properties, such as the seafloor acoustic impedance contrast (amplitude) and seafloor roughness (amplitude variability).

Existing Features in QTC IMPACT™
Cumulative Histogram
Histogram
Quantile
FFT
New Features
Modified van Walree moments
Quantile Cumulative Histogram
Amplitude
Amplitude Variability
Fractal

Table 1. Feature families used in analysis of SBES data in the pilot study.

4. RESULTS

One result of this pilot project is the potential to use SBES features for seafloor characterization. One example of many comes from the analysis of data from a pockmark field in the Malin Sea off the northern coast of Ireland. Figure 1 shows comparisons between the modified van Walree time spread feature derived from 12 kHz SBES data and EM conductivity. From west to east, three regions can be identified.

In region B1, an increase in conductivity is possibly associated with decreases in grain size or compaction, while the time spread feature also increases, consistent with softer or finer sediments and longer echoes. Region B2 is a pockmarked area (as shown in the subbottom profile) with gassy sediments. The EM signature is irregular, with porosity drops and general conductivity values below expected, possibly due to gas related sediment facies.

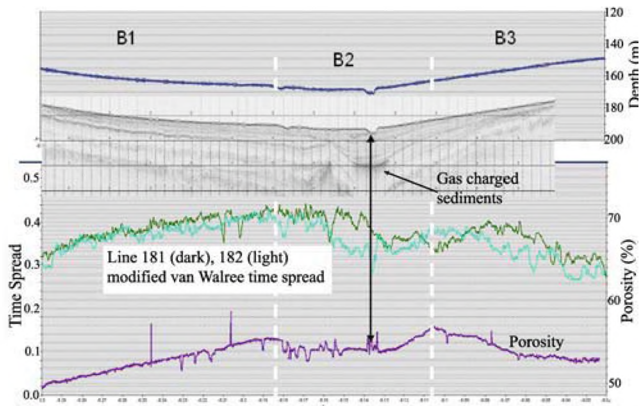

Figure 1. Line 181 and 182 time spread feature (dark and light) correlates well with EM porosity (bottom) in regions B1 and B2, and drops in regions corresponding to gas pockmarks, as shown in the depth and subbottom profiles.

Correspondingly, drops in time spread could be influenced by increased gassy sediment attenuation or gas blanking of the echo return. In region B3, conductivity decreases in a similar way but not reaching the low values of B1. The time spread values show a general negative trend but with more variability and overall lower values than B1, perhaps with coarsening grain size. As with B1, there is fairly good correlation between time spread versus conductivity.

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