Automatic Construction of Acoustic Themes from Multibeam Backscatter Data

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The final products derived from the interpretation of acoustic backscatter mosaics are normally presented in the form of thematic maps that show the spatial distribution of seafloor facies, grain size, bottom relief, acoustic roughness etc., which are important parameters for geological mapping and in the description of seafloor habitats. Ideally one would like to classify all the pixels in the mosaic independently. It is important to mention that the pixel size in the mosaic is related to the sonar beam footprint on the seafloor, and in that sense is the smallest area with an independent measurement of acoustic properties. However, this classification is only possible when the pixel area is insonified with a sufficient angular coverage, allowing for acoustic seafloor characterization. That requires a survey with an excessive density of coverage, too high to be economically feasible. Another option for seafloor characterization is to use the full sonar swath, which by definition contains a complete angular coverage. But in this case we have to assume that the seafloor is homogenous across the swath, a condition that is frequently violated.

The approach presented in this paper is based on the use of spatial segments of intermediate size (between the pixel and the full swath), which we assume to be homogenous. The assumption of segment homogeneity relies on the information extracted from the backscatter mosaic. Backscatter mosaics depict many boundaries, some related to actual changes in seafloor facies and others are artifacts occurring during acquisition or the mosaicking process. From only the mosaic information, the artifacts can not be distinguished from the real boundaries. We apply an over-segmentation technique to the mosaic, which generates a comprehensive set of the smallest possible segments which preserve spatial similarity, honoring all the boundaries in the mosaic. These small segments have a more complete angular coverage than pixels described above, but still do not have the full angular response required for accurate seafloor characterization. Hence, segments need to be coalesced with similar and/or adjacent segments in order to generate areas on the seafloor with just sufficient angular coverage to allow for seafloor characterization.

In order to perform the coalescence, we first choose a set of seafloor types which are expected to be encountered in the area (base functions). Those base functions are used as references to coalesce the small segments into larger areas on the seafloor - the acoustic themes. The coalescence process is accomplished by a combinatorial optimization technique, which takes into account all available information about the angular response. We then calculate an average angular response per acoustic theme, by reprocessing all acquisition lines and accumulating the sonar samples that are located within the area of the theme. The ARA inversion technique is then applied to this average angular response of the theme, generating estimates of the acoustic impedance, acoustic roughness and mean grain size of the seafloor within the theme.

The output of this automatic procedure is a thematic map with boundaries defined at the pixel resolution. Preliminary investigations showed that these maps are very close to those produced manually by visual interpretation.