An Empirical Backscatter Normalization Procedure for Bathymetric (Interferometric) Sidescan Sonars.

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The Sonar Equation models the power budget of an active underwater acoustic system as a non-linear combination of statistically stationary and non-stationary signals. Key stationary components are transmission strength, the directivity index of the sonar, many components of propagation loss, and the geometric aspects of target reflection. The non-stationary components of the signal are mostly due to the unpredictable fluid properties of the sea and the non-geometrical reflection and scattering characteristics of the sea floor. Modern acoustic image processing uses sophisticated measured and/or modeled values for each of the stationary components in the Sonar Equation in order to produce a high-quality corrected backscatter image. However, even in the absence of detailed measurements of the sonar system and the ocean environment, it is still possible to achieve high-quality backscatter imagery free of artifacts by taking advantage of the statistically stationary nature of many of the components in the Sonar Equation and remove them from the acoustic signal through a multi-dimensional homomorphic filter.

The USGS has developed software implementing a simple 2D homomorphic filter for our series of pole-mounted bathymetric sidescan sonars. The resulting backscatter imagery is superior to that processed by conventional sidescan packages and is approaching the quality and consistency of fully corrected backscatter images from multibeam.

The first step in our two-step algorithm is to build an empirical table of mean acoustic backscatter as a function of range and angle from the sonar transducers. A brute-force search through the collected data is usually sufficient, although the larger the sample size the more consistent the mean value results. Next, the survey is reprocessed where each raw amplitude digital number (DN) is divided by the appropriate mean value looked up in the table. This step is a simple and effective 2D homomorphic filter and almost completely removes the non-linear but stationary acoustic artifacts associated with sound transmission and beam geometry. The resulting DN for each sample is now effectively a ratio of the acoustic strength of the target relative to a mean value. Over large geographic areas, this produces the desired effect of a consistent DN for a given sea floor type free of systematic artifacts.

This empirical gain normalization approach is uncallibrated and the resulting imagery is relative in nature, but for many applications it is superior to existing TVG-style approaches, particularly for regional studies where ground truthing of the acoustic backscatter can be supplied independently (such as by towed video sled). A key advantage of the approach is that it makes few assumptions about the sonar system employed and it does not require exhaustive environmental knowledge or expensive calibration of equipment. So the technique can be employed widely, even to legacy data sets. A disadvantage of the algorithm is that it assumes the system is consistent from ping-to-ping which is often not the case for manually operated multibeam sonar systems.

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