3.1. General Overview

In echo sounding it is necessary to make a differentiation between reflection and scattering. The term reflection describes the sound interaction with a nonrandom bottom surface (flat seafloor), in which case the sound is reflected at an angle equal to the angle of the incident sound (specular direction), but with some energy loss. The term scattering is used when the roughness and heterogeneity of the seafloor are important in causing a redistribution of the acoustic energy over angles other than the incoming sound (Jackson, D.R. and Richardson, M.D., 2007).

Another differentiation that it is necessary is the distinction between physical properties of the sediment and geoacoustic properties. Physical properties are those that describe the characteristics of sediments, sediment grains and fluids such as mass density, porosity, permeability. Geoacoustic properties describe how sound behaves into sediments and include speed and attenuation of the wave propagating in the sediment, and acoustic impedance (Jackson, D.R. and Richardson, M.D., 2007).

Early studies in the seafloor acoustics field tried to understand how sound is scattered by the seafloor (Urick, 1954), and also tried to quantify the relationship between geoacoustic properties and physical properties of sediments (Hamilton, et al., 1956). By the 1970’s, field measurements were increasingly generating a large database of the physical and geocoustic relationship that allowed scientists to develop a series of regression equations relating the geoacoustic properties of impedance, reflection, refraction, and attenuation with the physical properties of porosity, density, and grain size of the sediments (Hamilton, 1970; 1972; 1974; 1976; 1978).
With the development of new instruments in the 1980's, more accurate information and better relationships between acoustic waves and physical properties of the seafloor were established in the development of classification models based on attenuation, impedance and volume backscatter (Mayer and LeBlanc, 1983; Shock et al., 1989; Panda, et al., 1994; LeBlanc, et al., 1995). Other approaches examined the coherency of seafloor echoes as an indicator of the seafloor nature, through statistical analysis of fluctuations from ping to ping to find the relationship between the signal and the seafloor roughness and bottom type (Dunsiger, et al., 1981; Stanton and Clay, 1986).

Further improvements in technology led to the development of oblique incident systems, and digital mosaic production led to scientists developing classification systems based on textural analysis (Images are segmented in areas with same statistical properties using the grey level co-occurrence matrix proposed by Reed and Hussong (1989). Other attempts for a classification technique were proposed by Pace and Gao (1988) who used the acoustic signal envelope instead of the image to analyze the power spectra. Stewart et al. (1994) proposed to use the probability density function of the echo amplitude, and Dartnell and Gardner (2004), combined the multibeam bathymetry with the backscatter gathered at same time to segment the seafloor into distinct facies.

During the last two decades many efforts were focused on determining how geomorphological information and physical properties of the seafloor could be extracted using the angular response of the acoustic wave in its interaction with the seafloor.

3.2. Acoustic Scattering

Irregularities in the seafloor cause the acoustic wave to scatter randomly (figure 3). These irregularities could include the roughness of the water-sediment interface, the spatial variation in sediment physical properties, and also discrete inclusions such as shell pieces or bubbles. Although the seafloor is never perfectly flat and homogeneous (scattering is absent), a seafloor perfectly stratified would reveal only reflection (non-random scattering).
However, because all seafloors have substantial irregularities at the scale of the high frequency wavelength, scattering will exist everywhere. Scattering by random boundaries and heterogeneities has been well studied by several researchers, and they usually employ statistical methods to treat the seafloor scattering at high frequencies (Jackson, D.R. and Richardson, M.D., 2007).

**FIGURE 3.-** RANDOM ACOUSTIC SCATTERING (Masetti, G., Sacile, R., and Trucco, A., 2011)

**FIGURE 4.-** SCATTERING PATCH AREA (Jackson, D.R. and Richardson, M.D., 2007).
These studies have demonstrated, backscatter returned to the multibeam sonar is a result of the interaction between the acoustic wave front and the roughness and heterogeneities of the seafloor. The acoustic wave coming from the multibeam sonar typically intersects the seafloor at an angle, which redistributes the incidence acoustic energy in multiple directions; only one portion of the scatter is received by the transducer (backscatter) at certain angle carries important information about the seafloor morphology and physical properties (Fonseca and Mayer, 2007). Hence, the backscatter coefficient of a specific material at a given frequency is an inherent property that only varies with the grazing angle (Hughes Clarke, J., Iwanowska, K., Parrott, R., Duffy, G., Lamplugh, M., and Griffin, J., 2008), and using the inversion of an acoustic model can be estimates some physical properties of the seafloor.

Even thought the scattering strength does not depend on the measurement geometry and measurement system parameters such as source level, and pulse length (Jackson, D.R. and Richardson, M.D., 2007), all those factors play an important role during the backscatter mosaic construction. Greenaway and Weber (2010) suggest that: “In addition to corrections for geometric and radiometric effects, it may also necessary to correct MBES data for non-linear effects in gain, power, and pulse length settings.” Because most backscatter processing tools available at this moment assume linearity in the multibeam echosounder system gain, pulse and pulse length, errors from these effects will impact the quality of the backscatter processing.