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Seafloor Characterisation Using Echo Peak Amplitudes of Multibeam Hydrosweep System - A Preliminary Study at Arabian Sea

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ABSTRACT:

In this paper an interface to acquire 59-beams echo peak amplitudes of the Hydrosweep Multibeam system is established. The echo peak amplitude values collected at varying seabed provinces of Arabian sea are presented. The study reveals the importance of echo peak amplitudes for seabottom classification. A qualitative analysis is presented to understand the reason for such variations.

INTRODUCTION:

In order to map the seabed with greater coverage, multibeam systems are a potential instrument. Because of its sidelobe suppressed multinarrow main beams, high resolution bathymetry maps can be generated, which provide varying bottom relief[1]. Apart from this, the multibeam system can also a useful system for seabottom backscattering application. The application of normal incidence echo peak amplitudes are extensively used in the past for the seabottom classifications[2]. But the studies based on the use of the echo peaks for non- vertical angles are limited. Such studies can reveal some indication of topographic variation which can be used as an effective tool for seabottom classification[3].

In this paper, a method to acquire PC(Personal Computer)-based, real-time 59-echopeak amplitudes of the Hydrosweep - multibeam system is discussed.. Here, the histograms of the experimentally collected echo peak amplitude information for different beam directions of three different topographic domains are presented. Based on these, a qualitative analysis is carried out for seafloor classification.

DATA ACQUISITION:

The multibeam echosounder Hydrosweep system is installed on ORV 'Sagarkanya'. The system is manufactured by M/S STN Atlas Elektronik GmbH, Germany. A detail description is available in the publication by Gutberlet and Schenke,1989[4]. The multibeam- Hydrosweep system is operated at 15.5 kHz. In the Hydrosweep system, the received 72 channel signals across the transducers are preamplified, attenuation-corrected and thereafter beams are formed at the output of the beamforming network. The preformed beams are then used for the depth determination at the bottom echo (B.E) module using necessary tracking software based on the centre of mass calculations. The peaks of the waveforms are selected in the tracking algorithm to determine time difference between the transmission and reception of the pulse. These peak informations of the 59 - preformed beams are not stored in the system which has significant importance for the seabottom classification.

In the Hydrosweep system, the performance of the various units can be monitored using different softwares through an additional terminal WY-85[5]. The programs are used through the terminal using VT200 mode, 9600 baud rate, 8 bits and 1 stop bit, which is subsequently communicated through 20mA. serial interface. The echo peak amplitude values of the 59- beams can be logged while selecting a menu 'L' through the terminal. In order to establish a communication with the Hydrosweep system through WY-85, 20 mA. serial interface port (printer) is used. Also an IBM computer is connected through its serial port to the WY- 85 following RS 232 standard[6], using a public domain interface software which is loaded in the PC. The terminal down loads all the incoming data through its printer port to the hard disk of the computer. All the 59 beam peak values are stored along with the beam identification numbers.

STUDY RESULT :

During the cruise on ORV 'Sagarkanya' SK-103, the echo peak amplitude data was collected in three different topographic domains (Echographs of the three areas are shown in Fig.1).These areas are situated at the Arabian sea off Marmugao. The area A (smooth bottom area- water depth in around 1400 mts.) is located at lat 15° 24.81N lon 72°14.01E. Similarly, area B (mixed roughness - water depth of 1000 mts.) and area C (rough bottom - water depth of 2000 mts) are located in lat 15°18.54N, lon 71°48.72E, and lat 15°29.61N, lon 71°29.93E, respectively. Around 300-400 pings were collected for normal incidence beam (beam no.30), beam no. 20- portside (30° beam direction), and beam no. 10-port side (15° beam direction) have been chosen for the present study. The magnitude of the peak value in the different beams

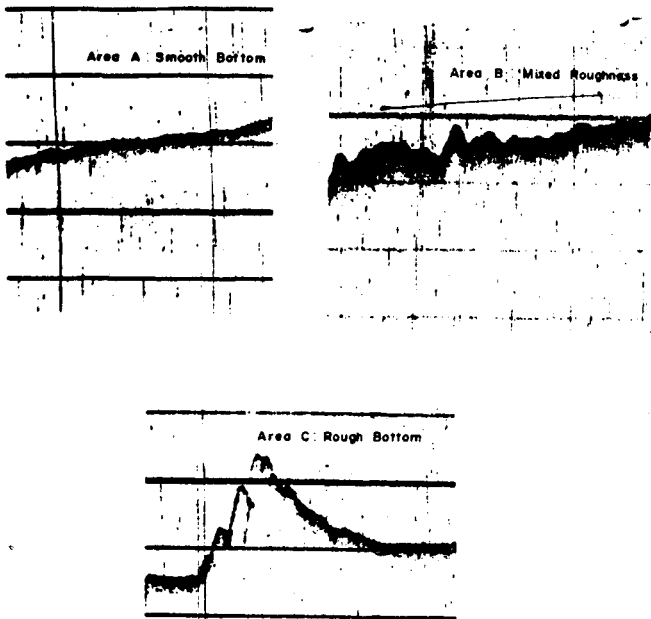


Fig: 1. Echographs of three different seabottom areas.

vary over wide ranges. In order to obtain comparable distribution, root mean square (rms) values of the peak amplitudes of each beam is used as a scaling factor. The normalized histograms in all the three different areas are presented in Fig. 2. The histograms show three distinct variations in Probability Density Functions.(PDF) The nature of the PDFs are found to be spread for smooth bottom (area A) than the area B (mixed roughness) and area C(rough bottom). However for rough bottom area _ the PDF is seen to be more tightly centred around the unit amplitude. The medium roughness area (B) shows intermediate behaviour. When analyzing centre beam (beam no. 30) data of the three topographic domains, the nature of the PDFs are almost similar. The highest value of the PDF is much shifted towards the lower value of the normalized echo peak. (i.e., away from the unity). The PDFs are generally Rayleigh type. According to Stanton[7], echo peak distribution for normal incidence angles (collected from echosounders) can be used to estimate the roughness parameters like micro- or macrotopographic variation of the seabed. The theory proposed by Stanton has the limitations which mentions that $4k^2 \sigma^2 \ll 1$ i.e., for a particular sonar operating wavenumber (k) the σ (rms relief height) should not be much higher. The Rayleigh-like PDF for centre beam peak data of the smooth bottom area (A) reveals that this area consists of small scale relief, but at 15.5 kHz of Hydrosweep's operating frequency, the relief heights of these areas may sufficiently be higher to provide Rayleigh-like distributions.

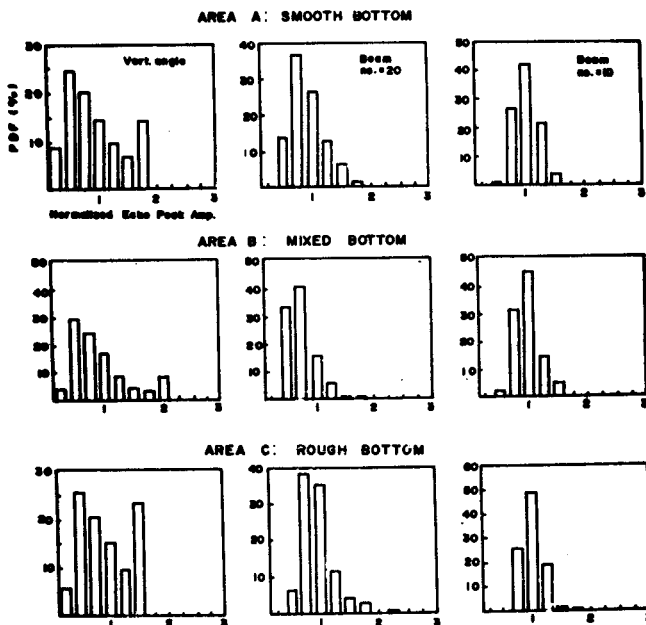


Fig. 2. Echo peak PDF's of the three different areas.

In order to qualitatively analyse the outer beam data of these areas (Fig. 2), we observe that for 15° beam direction (beam no. 20), the higher echo peak value shifts from the unity. The shift is *prominent* for smooth bottom area (A) than the area (B) of mixed roughness. The level of the PDF is also lower for smooth bottom area (A). The PDF of beam 20 for rough bottom area - shows a minimum shift towards a lower peak value, but the level of the PDF's are highest. Similar observation for beam number 10 (beam direction of 15°) reveal that the PDFs follow extremal distribution (the distribution which is functional of number of statistically independent events; for lowermost value of this parameter the PDF is Rayleigh type. As PDF parameter becomes higher, the curve takes the bell shaped pattern.). A critical look of the PDF for rough bottom area-confirms the highest level of PDF. On the whole, it can be mentioned that for areas (A and B), beam no. 20 echopeak distributions are the Rayleigh like, whereas for area C (rough bottom), it

is extremal type. Though the distributions are extremal for all the topographic domains at beam no. 10 (port side- 30° beam direction), the PDF is becoming bell shaped (the parameter which determines nature of the curves, i.e. number of statistically independent values become higher) for beam no. 10. while compared with the others.

The understanding of the above event may be made based upon the Stanton's proposal of biological volume scattering. Stanton [7] had used extremal statistics which shows more than one independent event, each having a random amplitude with a Rayleigh distribution. The echo peak PDF is governed by the number of independent events. The study of the plankton layers show significant deviation of the distribution curves from the Rayleigh PDF. The extremal PDF obtained in the outer beams for rough bottom area, are due to the variation of the large scale features which will tilt the scattering planes to different angles, and act as an independent event, produce the observed PDF. Similarly, for smooth bottom and intermediate roughness areas (A and B), the PDF curves are either Rayleigh or extremal of the lower value- which characterize the degree of independent event, and may be due to the presence of large number of scatterers at the same time.

The Rayleigh behaviour for centre beam peak values of three areas are due to the spherical wavefront of the pulse. Since it will be seen for a short interval of time at the vertical angle than the outer beam i.e., the echoes are less overlapping or less independent.

CONCLUSIONS:

A study of echo peak PDF for the outer beams of the Hydrosweep system from the three different topographic domains indicates a significant shift from the Rayleigh PDF to extremal PDF. The amount of variation depends on topographic characteristics. It is necessary to model the above histograms for exact determination of the degree of variation in the distributions. A study is continuing in this direction to provide a useful model for topographic variations.

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