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Analysis of Grazing Angle and Frequency Dependence on Acoustic Backscattering Pattern

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Abstract

This study aims to investigate the underwater acoustic backscattering pattern with respect to grazing angles and frequency. The narrowband impulses signal was generated from 8500 to 9500 Hz with 250 Hz increment, and the grazing angles were 10^o, 20^o, 30^o, 40^o, and 50^o, respectively. The measurement was carried out in a 9m-width, 5m-wide and 0.5 m- water deep pond with muddy bottom with spatial-aliasing free hydrophone array placed at depth 15 cm and 35 cm. The experiment used ray tracing method for sensor placement. The measurement results showed that bottom backscattering pattern was observed at grazing angle 10^o to 30^o, and whilst from 40^o to 50^o the surface backscattering pattern was appeared on the loudness contour. The results also showed the intensity was higher at grazing angle 10^o-30^o at depth 35 cm, whilst from 40^o to 50^o was higher at depth 15 cm. It was confirmed from the measurements that the intensity has an exponential decay at grazing angle 10^o, 30^o, and 50^o. Intensity as function of grazing angle was found to fit Lambert's rule at grazing angle 10^o-40^o at depth 15 cm and grazing angle 10^o-30^o at depth 35 cm. The results suggest that the acoustic backscattering pattern depends at grazing angle only. The intensity increased as the acoustic waves were backscattered because of reflection as well as interference with walls of the pond, rough bottom, and water surface.

Keywords: underwater, backscattering, intensity, grazing angle, frequency

1. Introduction

Using acoustic characteristics such as reflection and scattering acoustic wave can be used as SONAR (Sound Navigation and Ranging) technology. SONAR usually used as a communication system in submarines, additionally SONAR can be used in fishing, mapping seabed, and made a strategy of pipe placement or sea building. Mostly all the research about underwater acoustic was done in sea water, such as Kunz and Gauss bottom backscattering strength measured at 2-5 kHz in the shallow water west of Scotland [1]. Because of the complexity of sea layer, the backscattering strength measurement became complex so multiple measurement in various condition needs to be done. For this reason many people done the same research in different locations, several comprehensive reviews have been published which include bottom backscattering strength versus grazing angle in the 20-100 kHz frequency range [2, 3, 4]. The most notable of these by McKinney and Anderson [2] and by Shultz [3], a few measurements as grazing angles below 10^o are included. The review by Bunchuk and Zhitkovskii [4] includes information at low grazing angles. These reviews generally agree that bottom backscattering can be broadly categorized according to bottom composition, such as mud or silt, sand, and rock or gravel.

Research in open sea had many physics variables that made the measurement process became complex, because of that N. Cochard [5] offer solution by building anechoic tank as sea miniature. Before Some research about underwater in Engineering Physics department ITS had done in a semi anechoic tank that used sponge as absorber [6]. The sponge absorption coefficient went down drastically in water, so there was many scattering that happened that made result less accurate [7]. Wisely, we try to do research in a bigger pond with muddy bottoms. Hopefully the muddy bottom would absorb and reflect the sound like the seabed. Although the pond had muddy bottom, the wall surrounds the pond was made of concrete. The measurement was carried out in a 9m-width, 5m-wide and 0.5 m- water deep pond. A spatial-aliasing free hydrophone array placed at depth 15 cm and 35

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cm so the scattering near bottom and surface could be observed. So practically we investigate about the underwater acoustic backscattering pattern with respect to grazing angles and frequency.

2. Methods

2.1. Tools Calibration

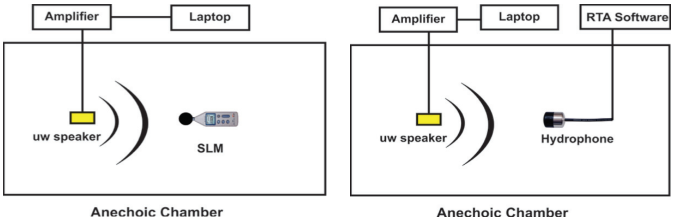

Figure 1. Tools configuration on speaker calibration (left) and hydrophone calibration (right)

Speaker and hydrophone were calibrated using configuration in the figure, it is based on Yuwono calibration configuration [6]. The SLM (sound level meter) was calibrated using sound calibrator before being used. The SLM was used to measure background noise in an anechoic chamber. To determine the power of speaker that will be used, the speaker gain was set so that the SLM measurement slightest change than background noise, the SLM was placed in most far of measurement points. SPL (Sound Pressure Level) was measured using SLM in 0^0-180^0, with 20^0 increments at distance 10, 15, 20, 30 cm. The SLM was replaced with hydrophone that connected to Realtime Analyzer (Yoshimasa) software to calibrat all hydrophones. Measurement was done for all frequency signal that will be used, that were 8500- 9500 Hz with 2500 Hz increments.

2.2. Sound Velocity Measurement

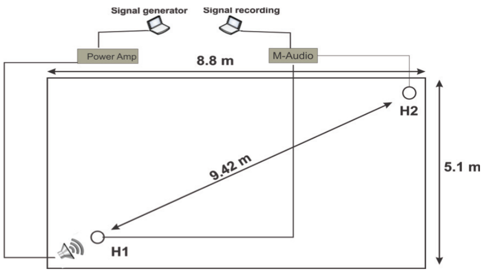

Figure 2. Sound velocity measurement configuration.

Sound velocity measurement was done by determined time delay between two hydrophone that was separated as far as possible in the pond. The configuration was done like in the figure 2. H1 was hydrophone that placed near the speaker and H2 was hydrophone that placed far from the speaker. The equation that used to calculated the sound velocity was:

$$v = s/t \quad (1)$$

where : v = velocity (m/s) s = range between hydrophone (s) t = time delay (s)

2.3. Measurement Point Determination

Measurement points were gotten from ray tracing simulation using software EASE 4.3 with grazing angle variation 10^o, 20^o, 30^o, 40^o, and 50^o. The simulation was set with two basic criteria, ten rays that were out of the speaker and maximum reflection that happened was 30 times. The sample result of ray tracing simulation can be seen figure 3. The scattering that happened indicated by the area where some rays gathered, all of it were marked as measurement point.

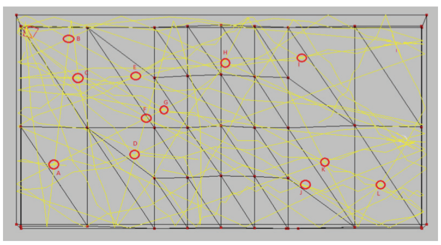

Figure 3. Measurement point for grazing angle 30^o.