THE EFFECTS OF AZIMUTHAL VARIABILITY ON MONOSTATIC ACOUSTIC BACKSCATTER FROM THE SEABED

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1 INTRODUCTION

By measuring the effects of azimuthal variability on monostatic acoustic backscatter from the seabed, the accuracy of sonar performance prediction (SPP) models and their detection ranges can be improved. SPP models require a number of inputs including bottom loss, bottom backscatter, surface loss, surface backscatter, ambient noise level and the sound speed profile of the water column. The sea surface loss, sea surface backscatter and the ambient noise level can all be predicted easily using the wind speed [1, 2, 3], whereas the sound speed profile is generally measured using a bathythermograph. Conversely, estimating the seabed properties required for SPP models has remained difficult.

Defence Research and Development Canada (DRDC) – Atlantic (formerly DREA) has addressed these issues by developing a wide band sonar (WBS), to quantify the geoacoustic properties of the seabed. The WBS consists of a parametric transmitter and a superdirective hydrophone line array. Due to the nature of the signal generation of the parametric transmitter, no side lobes are formed and the beam width of the difference frequency is only 3°. These properties, prevent interference from other undesired boundary returns thereby enabling accurate measurements of the azimuthal variability of the backscattering strength.

2 EXPERIMENTAL METHODOLOGY

In June 2002, the WBS was used to measure the azimuthal variability of the backscattering strength. The system collected acoustic backscatter data as a function of azimuth and grazing angle at three shallow water sites - two sites near Sable Island and one site in St. Margaret's Bay, Nova Scotia. The experiments were performed at grazing angles ranging from 7° to 15° and frequencies of 2, 4 and 8 kHz. The experimental geometry is shown in Fig. 1. During the monostatic backscattering measurements the parametric array head was held at a fixed grazing angle while a series of 50 pings were transmitted at a pulse repetition frequency of 4 pings/s. The measurements were repeated in 4° azimuthal increments through 360°. This procedure was repeated at a number of grazing angles.

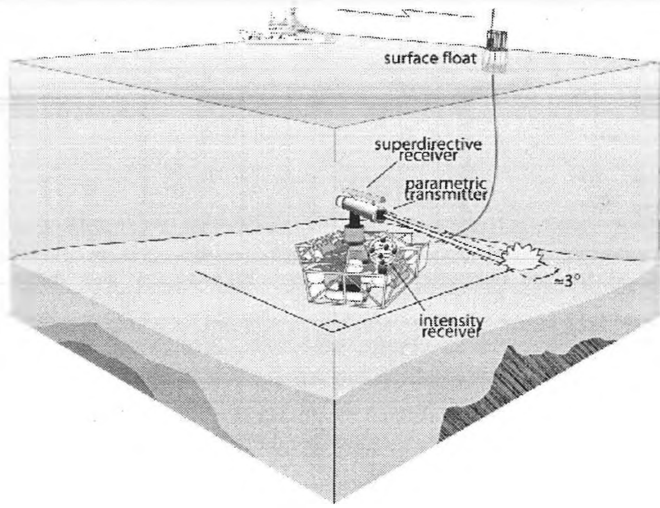

Figure 1 Geometry for backscatter azimuthal variability experiments.

3 RESULTS AND DISCUSSION

Figure 2 shows a color contour image of the azimuthal dependence of the backscattered energy vs. range as measured on a single hydrophone on the superdirective line array. The data are from a site near Sable Island at 8 kHz along 90 different azimuths. The data were taken with the parametric array pointed at a grazing angle of 8.5°. References for ranges corresponding to grazing angles 5°, 8°, 10°, 20° and 30° are shown on Fig 2 and 3. The monostatic return from the center of the beam (yellowish coloured ring between grazing angles 8° and 10°) dominates the energy contour. The monostatic return shows rich structure in the azimuthal dependence of the data as there are many singularities in the seabed structure both inside and outside of the center of the beam. The first 5 ms of the energy time series are discarded because the data are contaminated by signals arising from the structural platform.

From the received levels ($RL(\theta_g)$) of the monostatic arrival, the scattering strength ($BSS(\theta_g)$) may be determined,

$$BSS(\theta_g) = RL(\theta_g) + 40\log[R(\theta_g)] - 10\log(\tau) - 10\log[dA(\phi,\tau)] - BP(\theta_g) - G_{pa}[f, R(\theta_g)] \quad [1]$$

where $R(\theta_g)$ is the one way distance of the monostatic path; τ is the pulse length; dA is the area ensonofied by the 3° beam width ϕ and pulse length τ, $BP(\theta_g)$ is the beam pattern of the source; and $G_{pa}[f,R(\theta_g)]$ is the parametric array gain. The energy data from Fig. 2 were converted to backscattering strength using [1] and are shown in Fig. 3.

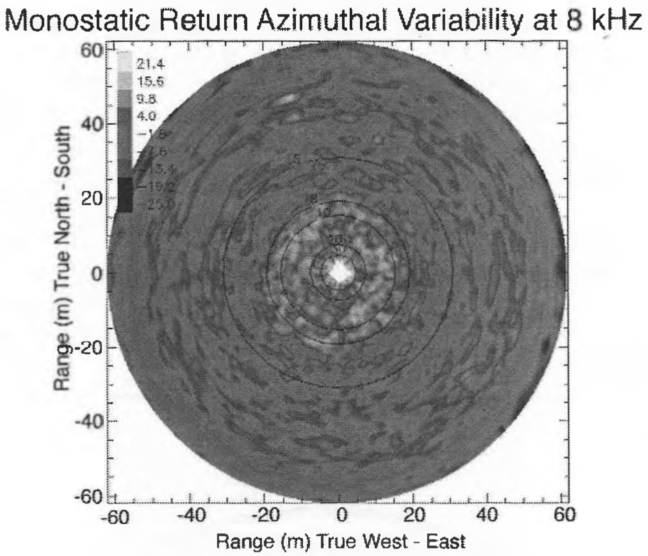

***Figure 2** – Color contour images displaying the azimuthal variability of the energy time series*

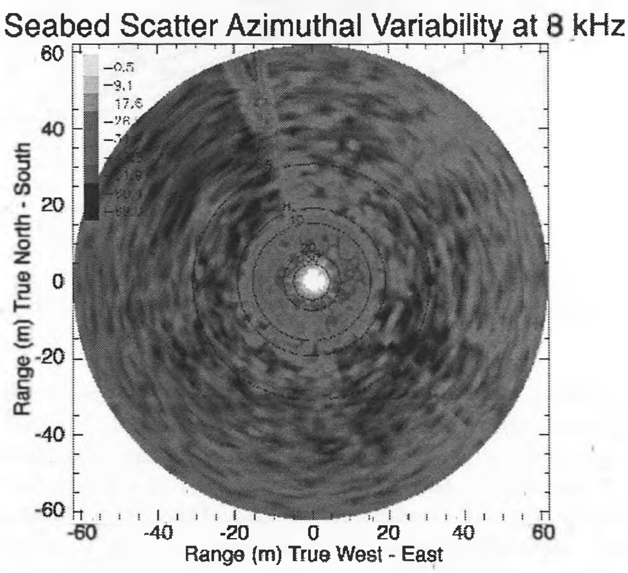

***Figure 3** – Color contour images displaying the azimuthal variability of the seabed scattering strength*

Figure 3 shows considerable variability in the scattering strength of the seabed. At shallow angles, near the center of the beam and further ranges, the monostatic return is calculated using returns obtained solely from the ocean floor and may be used to calculate scattering strength of the seabed provided that there is sufficient signal-to-noise. This experiment was performed at 2, 4 and 8 kHz and at grazing angles of 8°, 12° and 15° to increase the accuracy by extending the range over which the monostatic return is close to the center of the beam. These results (not shown) also have substantial azimuthal variability of seabed backscatter near the center of the beam. Note, at steeper angles, away from the center of the beam, scattering strengths are higher in part due to a larger scattering strength and also due to some ringing of the initial pulse in the frame of the WBS.

4 Conclusion

Accurate measurements of the azimuthal variability of the backscattering strength were obtained during DRDC – Atlantic sea trial Q267 in June 2002. Monostatic backscattering strength measurements were performed as a function of azimuth. The monostatic return shows rich structure in the azimuthal dependence of the data as there are many singularities in the seabed structure both inside and outside of the center of the beam. When converted to scattering strength, the monostatic return shows considerable variability as a function of azimuth. The backscattering strength measurements appear to be independent of frequency within the statistical accuracy of the data.

5 References

1. Michael Nicholas, Peter M. Ogdan, and Fred T. Erskine, "Improved empirical descriptions for acoustic surface backscatter in the ocean", J. Oceanic. Eng. 23, 81-95, (1998).
2. Weinberg, "The Generic Sonar Model," Naval Underwater Systems Center, New London, CT, Technical Document 5971D, (1985).
3. Harold Merklinger and John Stockhausen, "Formulae for estimation of undersea noise spectra", Proc. 50th Meeting of Acoust. Soc. Am., paper HH10, Cambridge MA (1979).