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TITLE

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Direct path measurements of bistatic and monostatic scattering in littoral waters in the 2-8 kHz Frequency Band

by
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Direct measurements of acoustic scattering from the seabed at shallow grazing angles presents a considerable challenge in shallow water. Specifically, returns from the air-water interface typically contaminate the signal of interest. To address this issue DREA has developed a pair of sea going research systems for measuring acoustic scatter from the seabed in shallow water environs In this paper the acoustic attributes of both systems will be outlined, the experimental geometry will be described and measurements of acoustic backscatter and forward scatter collected during one such experiment will be presented.

I. Introduction

Defence Research Establishment Atlantic has developed a wide-band sonar (WBS) for collecting environmental acoustic data in the open ocean. This system is highlighted in a companion paper in this Proceedings as well as in [1] The Underwater Acoustic Target (UAT) is a ship-launched echo-repeater with a 15 hydrophone vertical line array (VLA) and a non-acoustic section (NAS) suspended beneath the projectors. Up to 8 hydrophones can be recorded simultaneously but must be selected prior to deployment. with echo-repeat mode disabled, it functions as a remotely controlled source and receiver The UAT can be deployed free-drifting or bottom-tethered Data can be recorded by the UAT directly or can be telemetered back to the tending ship. These systems were situated within 150 m to 300 m of one another and bistatic and monostatic scatter from the seabed were measured at locations on Scotian Shelf and Strataform. Figure 1 shows a schematic of the UAT bottom-tethered and the WBS bottom-mounted as used during these experiments. Following the introduction, the experimental geometry will be described and a sample of the forward and backscatter measurements made with these systems during Boundary 2001 will be presented. Space constraints will limit discussion of the results significantly

II. The deployment

The experimental geometry was a critical factor in this experiment. If the two systems were too close (<100 m) the spatial resolution of the VLA would be too coarse ; it they were to far separated (>300 m) the VLA would span too narrow a vertical beam of angles Noting that both systems weigh over 2000 kg, this was not a trivial concern The UAT was launched first and an initial localization was performed using DREA's FITDS system [2]. The ship would then steam upwind and drift back past the UAT location crossing within about 100 m of the UAT way-point. During this trial run, the ship's drift vector would be monitored. The space frame was readied on the ship's crane and the launch run would commence A delay of approximately a 4 minutes occurred from the time the spaceframe was lifted off the deck to the time it was released into the water. This delay was accounted for during the deployment so that the spaceframe was released at CPA. Immediately after releasing the spaceframe, the weighted cable was rapidly winched into the water to avoid towing the system. Once the cable was deployed the surface float was connected and deployed Once deployed the WBS was localized with FITDS [2] The experiment was performed at two sites with the systems separated by 272 m at Strataform and 164 m at Scotian Shelf.

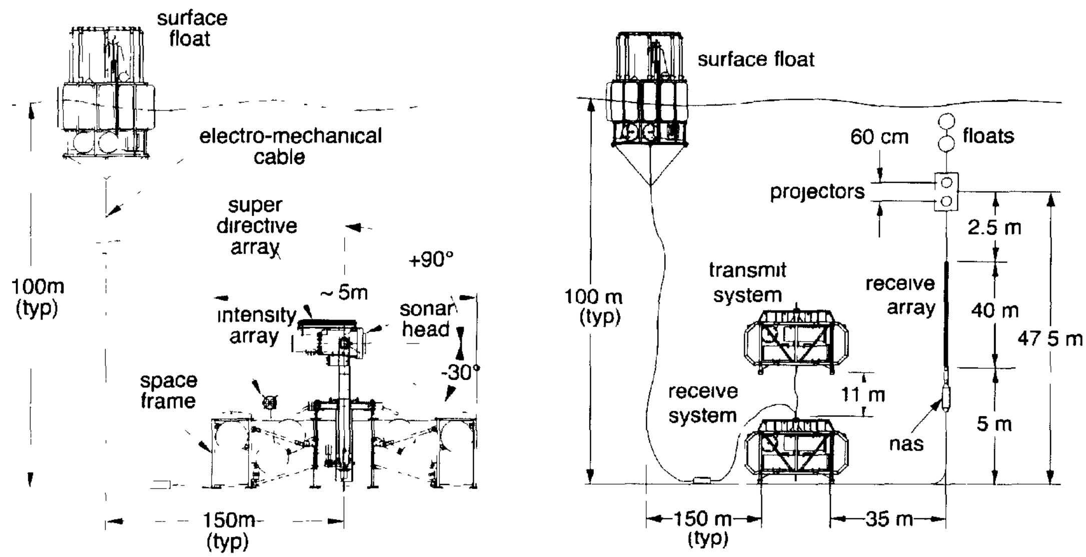

Figure 1. Schematic of WBS (left) and UAT (right) configured for bistatic experiments.

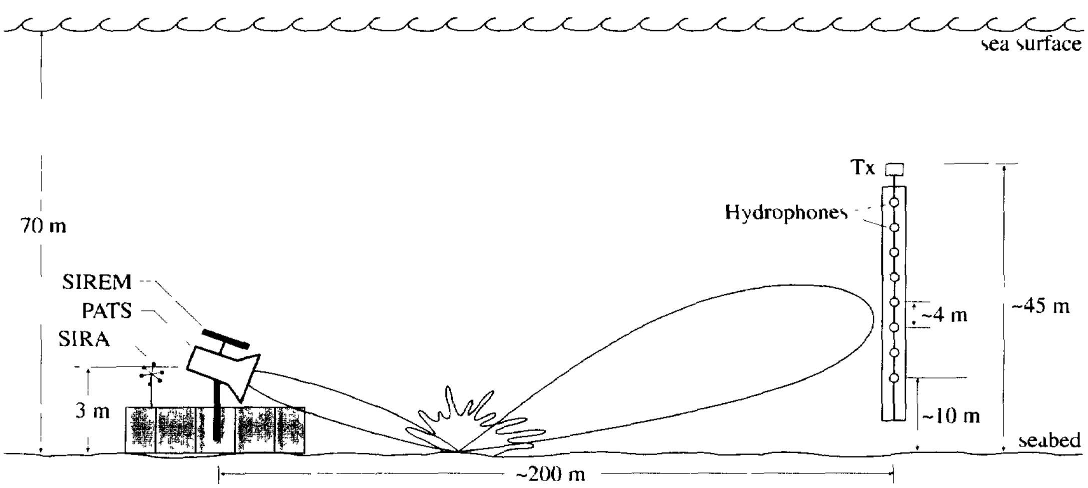

Figure 2. Cross-section schematic of typical geometry for bistatic experiments

III. The experiment

Figure 2 contains a schematic of the bistatic experimental geometry. The WBS was pointed at a grazing angle such that the specular reflection insonified at or near the center of the VLA at an azimuth of -15° relative to the vertical axis of the UAT array This corresponded to 9° grazing at Scotian shelf and 5°grazing at Strataform); A series of 50 pulses were transmitted by the WBS at 2, 4 and 8 kHz with a pulse repetition frequency (PRF) of 4 per second. Forward bistatic scatter was recorded on the UAT and backscatter was recorded on the WBS superdirective array. The parametric array transmitter was rotated 2° in azimuth and the sequence was repeated. This was done from –15° to +15° relative azimuth This experiment resulted in measurements of vertical and horizontal scattering from specular as well as backscatter as a function of azimuth. At various times throughout the experiment, the SIRA intensity array was switched in and the UAT transmitted sets of fifty of 4 kHz tone bursts, 0 5 ms in duration. These pulses were processed to localize the UAT [3] as well as to quantify any motion of the UAT The experiment was repeated for grazing angles approximately ± 3° from specular as measured relative to the midpoint of the VLA.

IV. The measurements

The waterfall display in Figure 3 shows the received energy for all 8 hydrophones as a function of azimuth and grazing angle at 4 kHz. The error bars on the data represent 2 standard deviations about the mean levels shown. The specular reflection occurs at approximately 10°, midway between curves 4 and 5 For reference, the ambient noise level is drawn relative to the lower most solid curve Figure 4 compares the beam pattern of the parametric transmitter measured at sea, to the energy received on a single hydrophone. Spreading of the energy is evidenced by the broadening of the beam relative to the beam pattern. The energy curve flattens off about 14 dB down from the peak due to background noise attributed to the WBS platform.

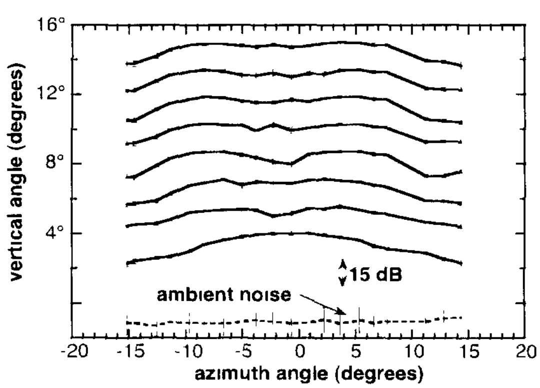

Figure 3: Waterfall display of bistatic scatter measured at Scotian Shelf (4 kHz).

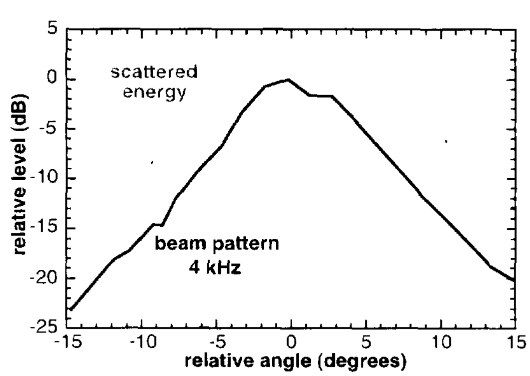

Figure 4. Measured beam pattern compared to bistatic scattered energy.

This experimental geometry provided an opportunity to collect backscatter data as a function of azimuthal angle on the WBS during the bistatic scattering experiment. (It also enabled spatially coincident measurements of forward bottom loss/scatter and backscatter as a function of grazing angle. Analysis of these data have only just begun, preliminary results are contained in Figures 5 and 6. Figure 5 shows the azimuthal dependence of the backscattered energy at 4 kHz that was collected on the WBS while the bistatic data shown in Figure 4 was being collect by the UAT. Figure 6 shows the backscattered energy as a function of grazing angle at 2, 4, and 8 kHz. The three curves in Figure 6 are corrected for the frequency dependence of the source level but not for the grazing angle dependence of the spreading loss.

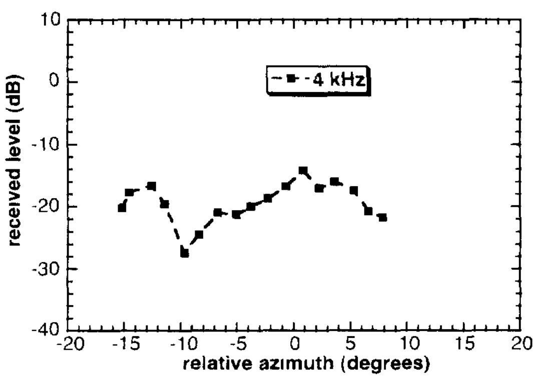

Figure 5 Azimuthal dependence of the backscattered energy.

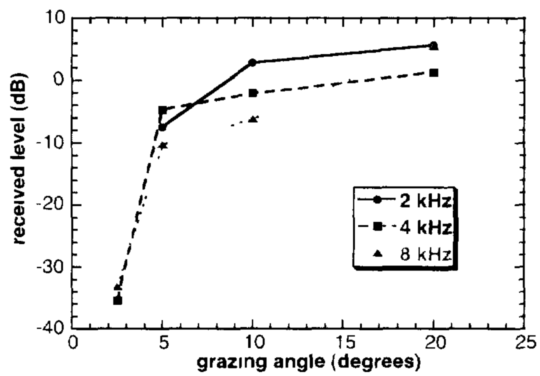

Figure 6: Backscattered energy as a function of grazing angle

V. Concluding remarks

The WBS and UAT were used to gather a unique data set of out of plane bistatic scatter and backscatter as a function of azimuth in the 2-8 kHz range. The experimental geometry also enabled spatially coincident measurements of forward scatter and backscatter – samples of which are contained herein.

VI. References

1 Paul C. Hines, W. Cary Risley, and Martin P O'Connor, "A Wide-Band Sonar for Underwater Acoustics Measurements in Shallow Water," Proceedings· Oceans'98, Nice, France, Sept. 29-Nov. 1, 1998.

2 Osler, J and Beer, J., "Real-time Localization of Multiple Acoustic Transponders Using a Towed Interrogation Transducer", Proceedings of Oceans 2000 MTS/IEEE Conference, Vol 1, 2000, 8 pp 725-732

3 Localization using SIRA provides a more accurate bearing angle than FITDS and can be done without maneuvering the research ship