Bi-Static Target Scattering Characteristics for Detection and Classification of Buried and Proud Targets

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LONG TERM GOAL

Develop and understand the 3-dimensional target scattering characteristics that will enable optimum search strategies to be developed for multi-static autonomous detection of buried and proud targets.

OBJECTIVE

To measure and develop an understanding of the 3-D scattering and structural response from targets resting on the bottom, and/or partially, or completely buried in the bottom.

Using these scattering results, NRL will work with MIT and NURC to verify the environmental acoustic approximations that have been used in the new hybrid target-modeling framework developed by MIT. This hybrid modeling technique provides an alternative framework for modeling the complex scattering fields observed from elastic targets resting on, or buried in, the ocean sediment.

These results will unlimitedly be used by SWAMSI 08 to develop optimal search strategies for autonomous multi-static detection of buried and proud targets.

APPROACH

NRL has collaborated with MIT and NURC to conduct a series of experiments that measured the 3-dimensional scattering characteristics from mine-like targets. The results will be used to verify MIT's hybrid target modeling, to confirm the bi-static enhancement of energy mono-statically scattered from mine-like targets that is predicted by the models.

The experiments used the NURC TOPAS parametric source mounted on a special telescopic tower. The parametric source insonified several different natural and man

made targets that were resting on the sediment surface, or partially buried. These targets were placed inside the 3-dimensional reconfigurable dome measurement system that is shown in Figure 1. The footprint of the TOPAS beam pattern was centered in the dome measuring system. This hemispherical dome array was developed by NRL-SSC for use in its scattering programs, and is a unique measurement system that can measure the bistatic scattering characteristics from targets placed inside the dome.

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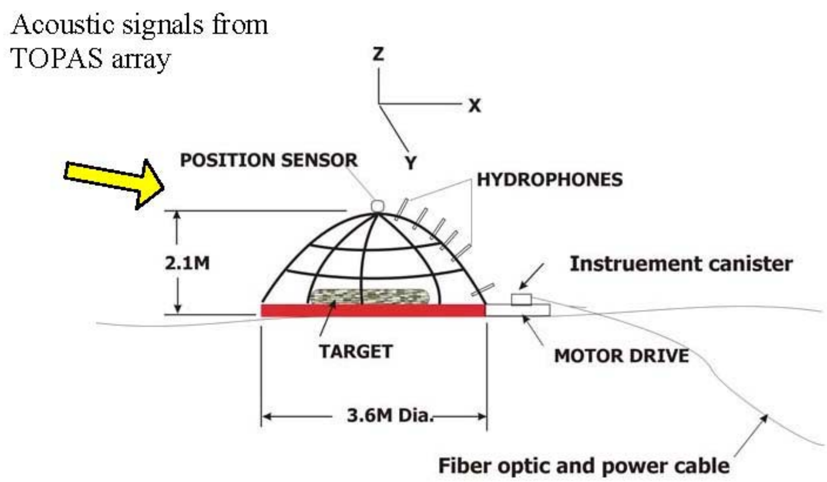

Figure 1: Bistatic dome measurement system

Figure 2 shows the hydrophone positions on the cage. The eight hydrophones had an angular separation of about 8.3 deg.

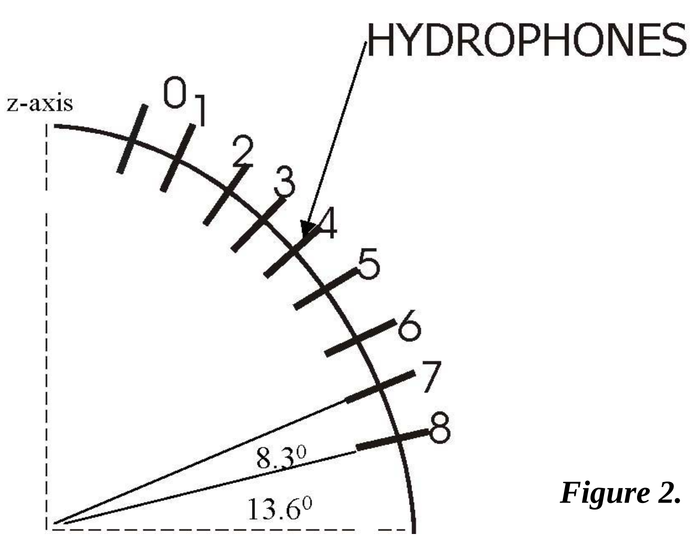

Figure 2. Hydrophone positions

The dome is constructed of solid industrial grade PVC rods that have a ρc close to that of seawater. The dome measured 3.6 m in diameter and about 2.1 m high. Eight omni-directional hydrophones were mounted equally spaced alone one of the arms. The entire dome is rotated around the z-axis using a motor and belt drive configuration. Signals scattered from targets placed in the center of the dome are received by each of the 8 hydrophones as the entire cage is rotated around the z-axis. Signals from the hydrophones, system control signals, cage controls, are sent via cables to the shore station. The 3-week target scattering experiment was conducted jointly with MIT and NURC in an area 50 m off the pier in Marciana Marina, in Elba Italy. A number of different targets types were buried or placed on the bottom. The dome moved from target to target using lift bags. Figure 3 shows the sphere and cylinder type targets inside the measurement cage. The sandy seabed in Marciana Marina is known to be dispersive, and numerous seabed classification measurements were taken for the hybrid model verification. The model validation forms the basis for additional model developments that will address the mutual interaction between the seabed roughness and buried targets.

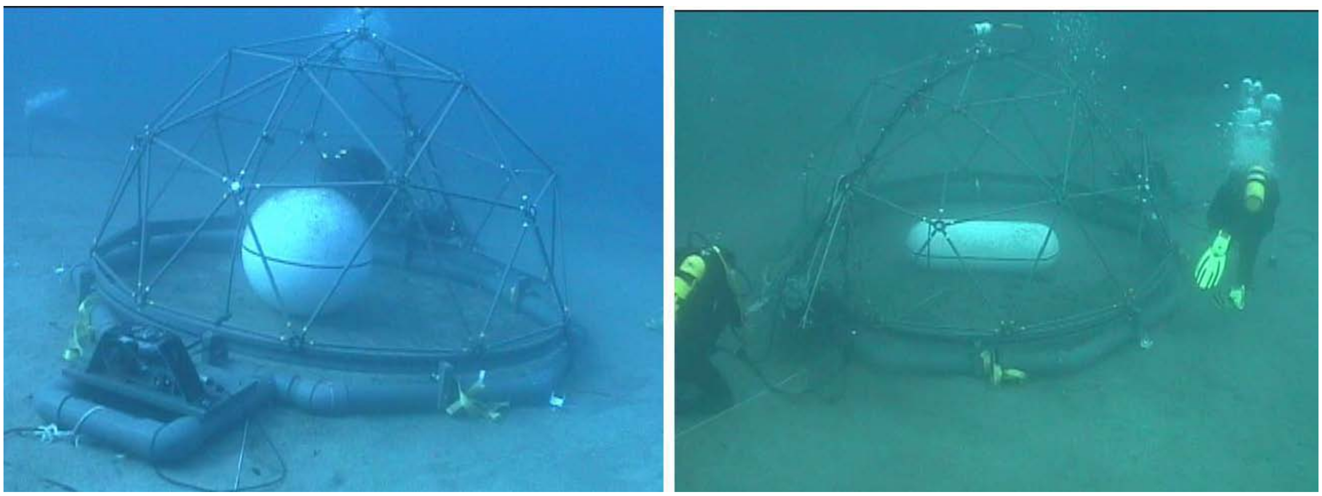

Figure 3. The proud sphere and cylinder resting in the measurement cage

RESULTS

Figures 4-7 show the bistatic time of arrival results for four different target configurations and four hydrophone positions. These include scattering results when there was no target present (Calibration), and when the cage was placed over the partially buried Goats sphere, a proud sphere, and a cylindrical target respectively. The direction of the insonifing pulse is shown by the red arrow. In all cases the initial pulse is the first return seen in all the plots.

These data show that, at a grazing angle of 110 , the backscattering levels and number of returns were low compared to the forward results from the smooth sediment features inside the cage. Signal intensities increased with decreasing receiving hydrophone angles. The partially buried Goats sphere showed scattering returns that were similar to those from the smooth surface except at the lowest hydrophone channel (8) where the number of returns appeared to increase. The proud sphere and the cylinder were insonified at 270 and 230 respectively. The number of scattering returns from these targets also increased as the hydrophone number increased.

In all cases, the source of the returns, will be identified using the new hybrid target-modeling framework developed by MIT.

Figures 8-11 shows the same azimuthal scattering plot, but in the frequency domain. In all cases the frequency dependence of the azimuthal scattering is shown. The angles with the highest spectrum levels correspond to the higher signal levels shown in the time of arrival plots (Figures 4-7).

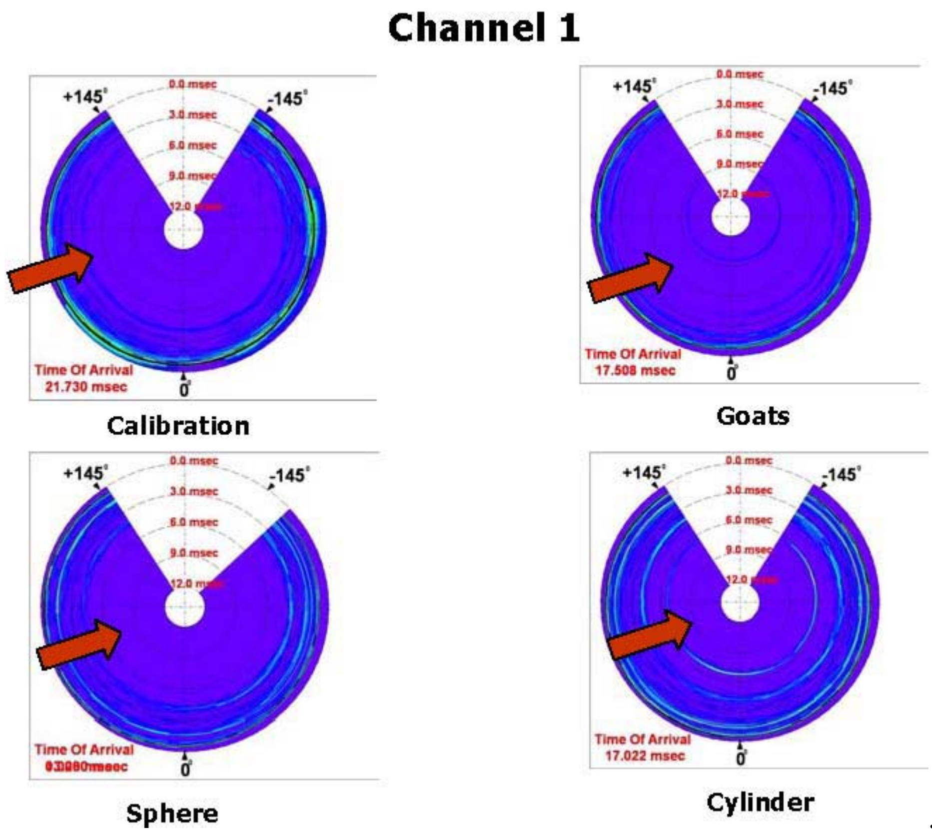

Figure 4. Time of arrival plots for hydrophone channel 1.

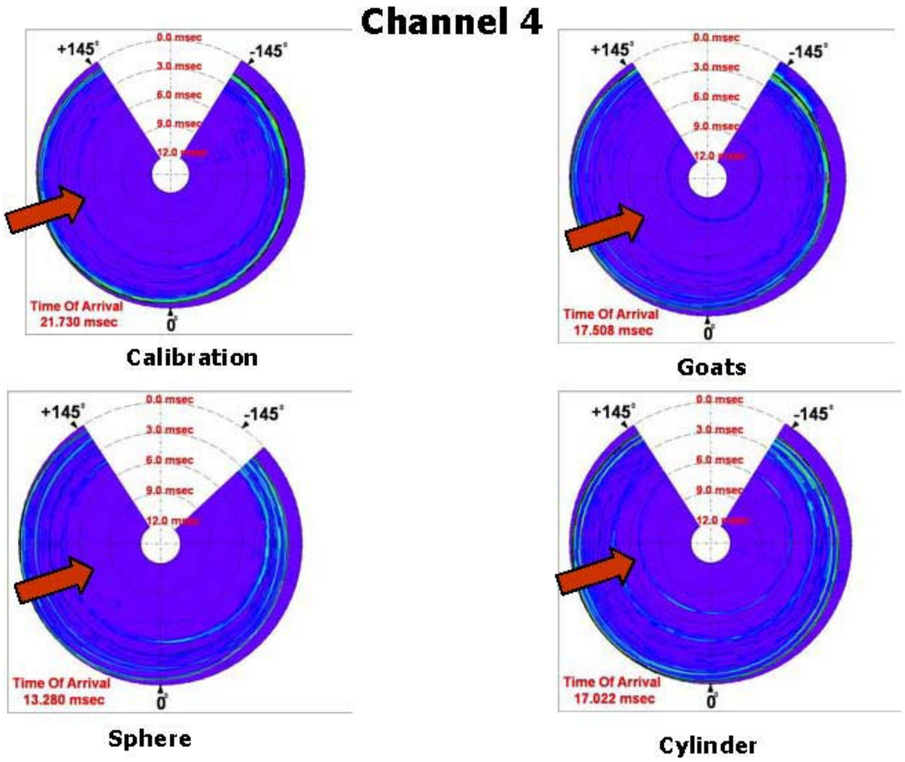

Figure 5. Time of arrival plots for hydrophone channel 4

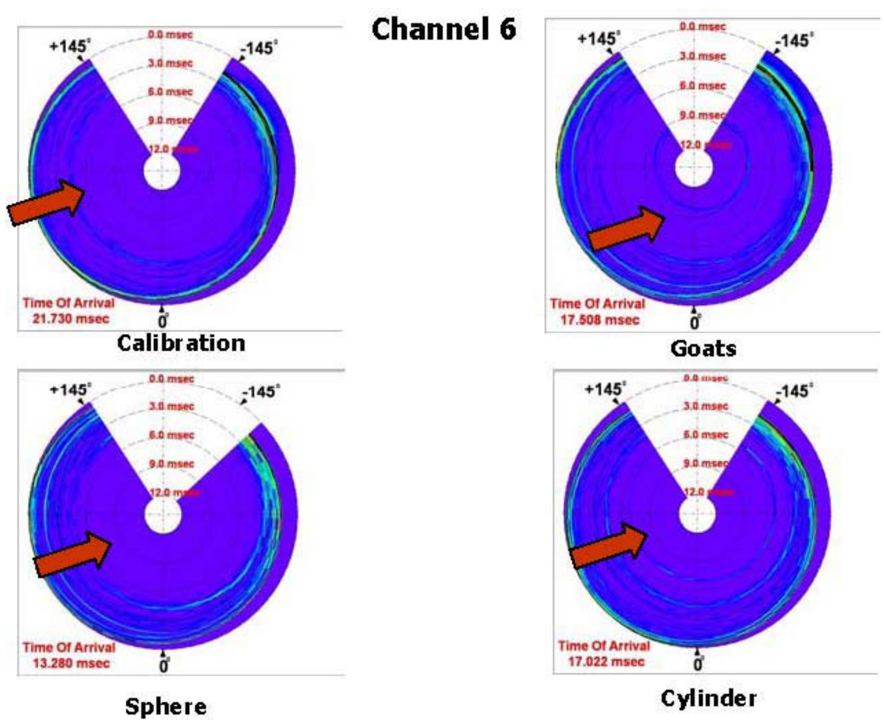

Figure 6. Time of arrival plots for hydrophone channel 6.

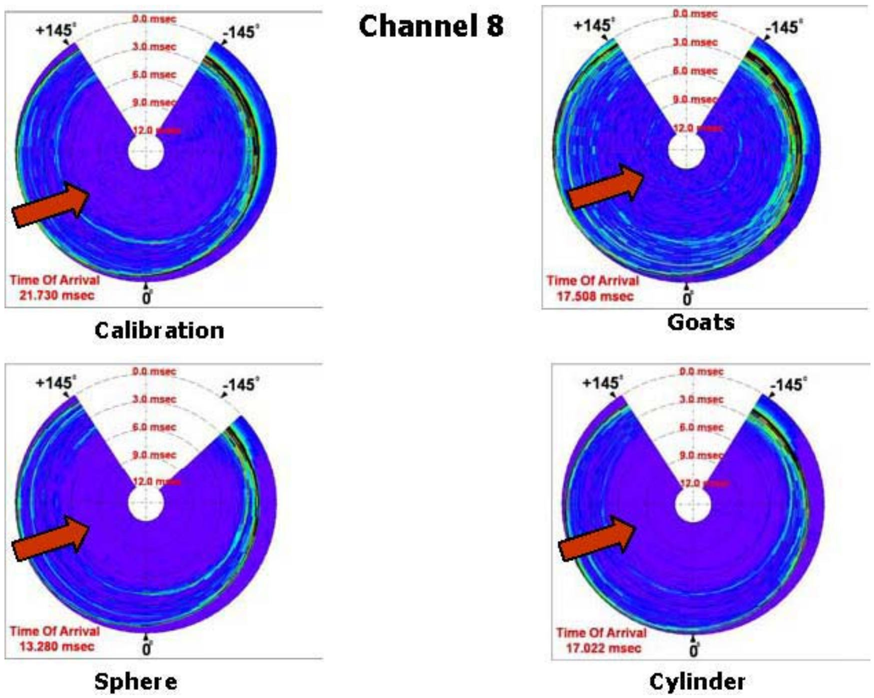

Figure 7. Time of arrival plots for hydrophone channel 8.

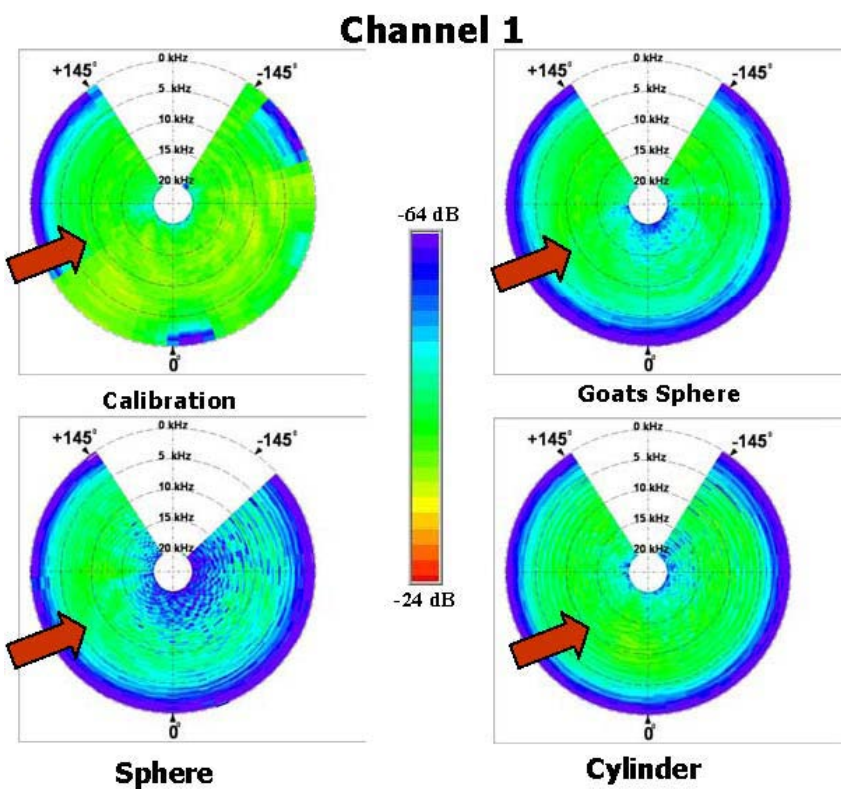

Figure 8. Frequency domain results for hydrophone channel 1

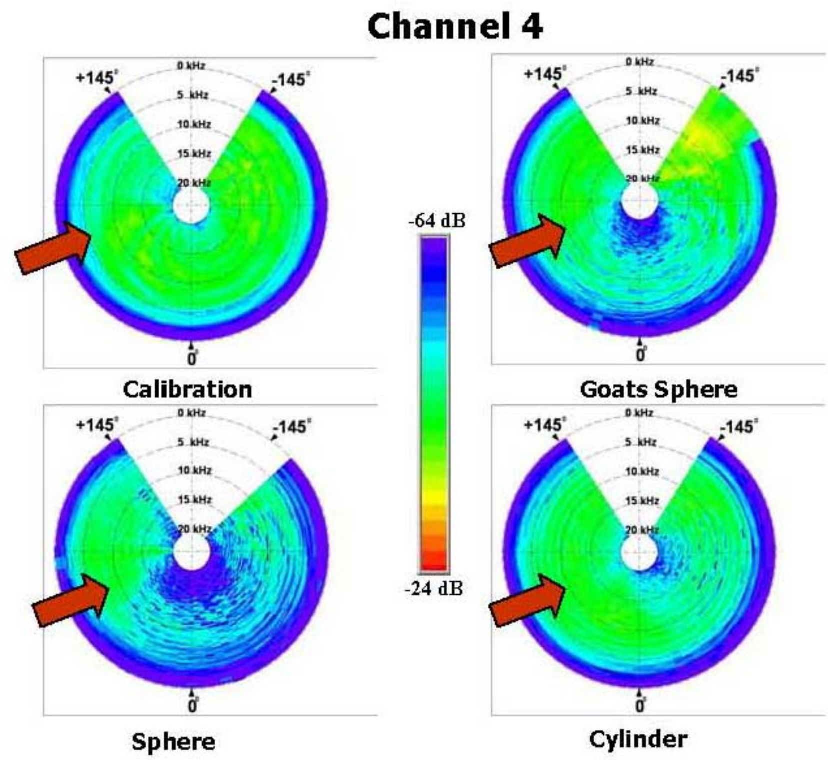

Figure 9. Frequency domain results for hydrophone channel 4

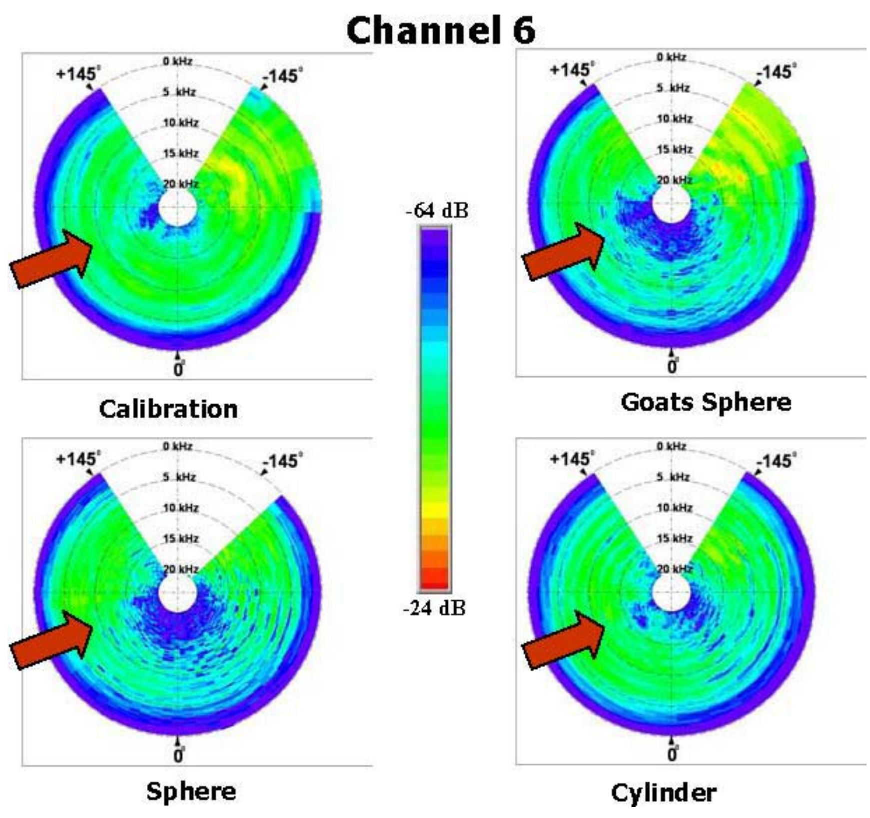

Figure 10. Frequency domain results for hydrophone channel 6

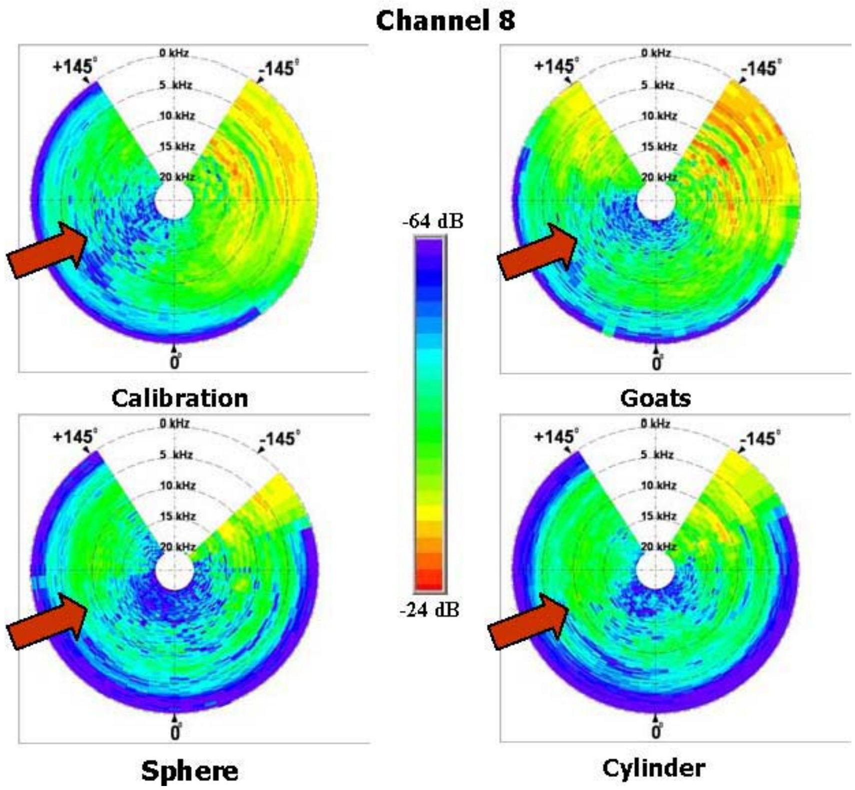

Figure 11. Frequency domain results for hydrophone channel 8

SUMMARY

NRL deployed its cage measurement system to measure the azimuthal scattering characteristics of a partially buried Goats sphere, a proud sphere, and a specially designed cylinder. The scattered signals were recorded by eight hydrophones distributed along the spherical wall of the cage. The-time-of arrival plots showed the various scattered signals and the angles at which they were received. Likewise, the spectrum plots also showed the frequency distributions of the scattered signals.

The new hybrid target-modeling framework developed by MIT will be used to identify the scattering returns as a function of frequency and azimuthal angles.