PROPAGATION LOSS MEASUREMENTS FOR LOW FREQUENCY SONAR IN EMERALD BASIN AND EXUMA SOUND

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1. INTRODUCTION

Knowledge of the characteristics of sonar propagation in a given environment is essential for the proper employment of a sonar system. A low-frequency hyperbolic frequency modulated signal (HFM) was employed to measure propagation loss in both a deep water environment and in a shallow water surface duct environment. The signal was processed both incoherently, using time-domain energy-detection, and coherently, using a matched filter to determine the degree of coherence loss. The experimental propagation loss results were then compared to computational models, including the Generic Sonar Model (Weinberg, 1985), an eigenray model, and SWAMI (for the shallow water environment), which uses a normal mode model.

2. METHOD

Two locations were chosen for measurement of propagation loss. The first location was Exuma Sound, approximate location latitude 24° 23′N, longitude 76° 9′W. The bottom depth measured at the beginning of the data collection run was 1762 m, with a sound speed profile given in Figure 1. The transmitter was at depth 31 m. A series of three 0.5 second HFMs were transmitted with bandwidth 25 Hz, start frequency 1125 Hz, 1175 Hz, and 1225 Hz, and dwell time 0.1 second. The series was transmitted at one minute intervals.

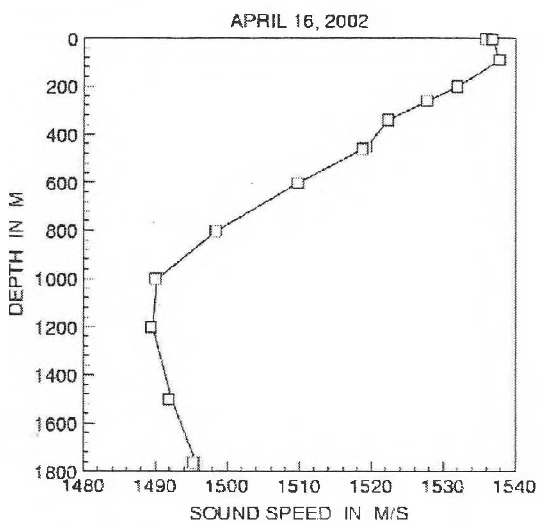

Figure 1. Profile of sound speed vs. depth for Exuma Sound.

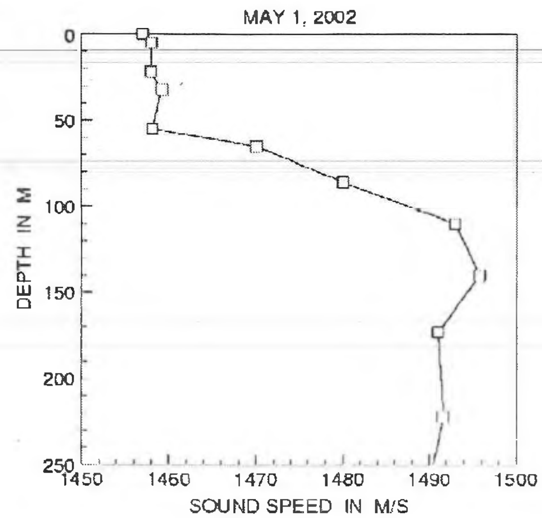

Figure 2. Profile of sound speed vs. depth for Emerald Basin.

The receiver was a Combined Omni Resolved Directional Sensor (CORDS) used in omnidirectional mode, being towed at 50m depth at a speed of 8 knots.

The second location was a comparatively shallow-water site, Emerald Basin, latitude 44° N, longitude 62° 53′W. The bottom depth measured at the beginning of data collection was 260 m and the sound speed profile was as shown in Figure 2. The source in this case was a two-element free flooding ring vertical projector array (VP2) at depth 58 m. The transmit signal was a sequence of one-second HFMs with bandwidth 50 Hz, centre frequency 1150 Hz, 1200 Hz and 1250 Hz and a 30 second dwell time. The receiver was the DRDC Atlantic UAT (Underwater Acoustic Transponder) at a depth of 56 m, using data from one omnidirectional hydrophone.

3. ANALYSIS

3.1 Exuma Sound data

Approximately 4 hours of data was collected in Exuma Sound, translating to about 60 km of range measurement. Figure 3 summarizes the results for the 1125 Hz signal. Both the coherent (matched filter) propagation loss and the propagation loss measured using incoherent processing are very close to those predicted from the model. The model in this case is a range-independent multipath expansion eigenray model. The model results are shown for

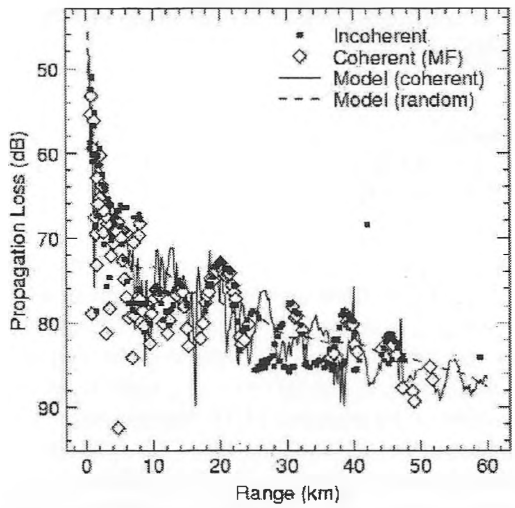

Figure 3. Propagation loss measurements and model for Exuma Sound.

both coherent and random eigenray phase summations. Although the exact nature of the bottom is not known, the model results are quite insensitive to the bottom reflection model used.

There is very good agreement with the data collected and the model; the coherently summed multipath model accurately represents the overall behaviour of the data, although some of the peaks and troughs of propagation loss are not in the same location as they appear in the data, as can be expected from a homogeneous, range-independent model. The difference between the incoherent detector loss and the matched filter loss is fairly small: figure 5 has a comparison for Exuma Sound and Emerald Basin.

3.1 Emerald Basin data

The data from Emerald Basin has measurements over about 55 km of range. The propagation loss data for the 1150 Hz signal and two models are shown in Figure 4.

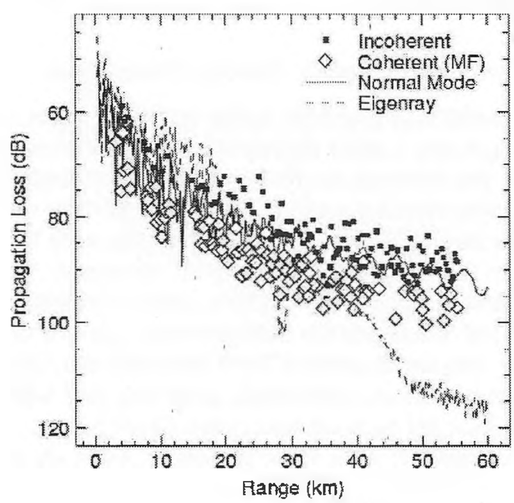

Figure 4. Propagation loss measurements and models for Emerald Basin.

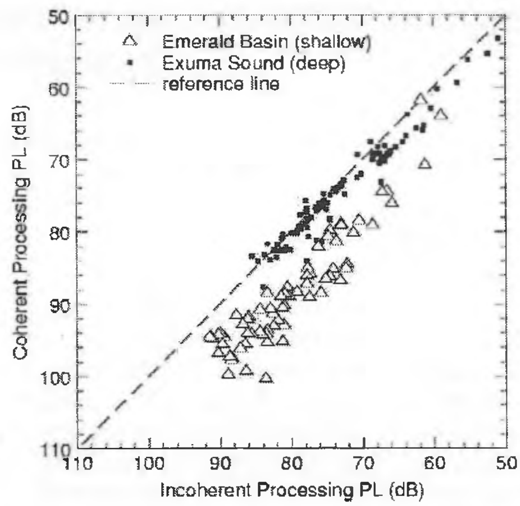

Figure 5. Comparison of propagation loss measured using coherent vs. incoherent processing for deep and shallow water.

In this case, the eigenray model used previously shows a much greater propagation loss occurring at longer ranges than is evidenced by the data. The normal mode model, however, shows a very good agreement with the data. The model used here is a range-independent one. Both the normal mode and eigenray models are very sensitive to surface loss parameters (wave height or sea state).

A comparison of the propagation loss measured using the different types of processing is given in Figure 5. It is evident that the shallow water environment leads to significantly more loss of coherence and thus propagation loss, particularly at extended ranges.

4. CONCLUSIONS

For the data collected here, matched filter coherent processing gives close agreement, to within 2 dB to 3 dB over 60 km of range, to incoherent processing for the Exuma Sound deep water environment. However, the shallow water measurement seems to indicate that loss of signal coherence increases the propagation loss measured, in this case by 5 dB to 10 dB over this range.

The modelling of propagation loss for both coherently and incoherently processed signals also depends on the environment. Here, it is seen that a multipath eigenray model gives excellent agreement to measured propagation loss in a deeper water environment, with little dependence on bottom type. On the other hand, the surface-ducted shallow water environment is more accurately modelled using normal modes, and is quite sensitive to surface conditions. Ideally, the shallow water environment might be modelled using a range-dependent normal mode technique.

5. REFERENCES

Weinberg, H. (1985). "Generic Sonar Model, " NUSC Technical Document 5971D.