# COMPARISON OF MEASURED AND MODELLED TRANSMISSION LOSS IN EMERALD BASIN


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## 1. INTRODUCTION

A key determinant of sonar performance is the propagation of sound in the ocean, which hence remains a subject of applied interest. On 28 July 2007, acoustic data were collected by DRDC Atlantic in Emerald Basin, an open-ocean site near Nova Scotia, for the purpose of measuring the transmission loss (TL) at frequencies relevant to multistatic active sonar. Comparing the measured TL results with theoretical predictions from propagation models was part of the analysis plan. A previous investigation in the same ocean area is described in [1].

## 2. THE EXPERIMENT

The experiment took place in Emerald Basin near 43° 50′N and 63°W. An acoustic projector was towed at 50-m depth by the research ship CFAV *Quest*; the transmitted signal consisted of 11 continuous-wave (CW) tones spaced 100 Hz apart from 1010 to 2010 Hz. As *Quest* steered a straightline course, sonobuoys were periodically launched from the ship's stern. The sonobuoy receivers were set for a depth of either 60 m or 120 m, and the received acoustic signals were relayed to the ship over a radio-frequency (RF) telemetry link. The maximum range was 14 km, as determined by the RF link. Although the bathymetry varied slightly along the ship's track, it will be represented as a flat bottom at 265 m depth. A sound-speed profile from the day of the experiment shows a pronounced duct with an axis close to the source depth (Fig. 1).

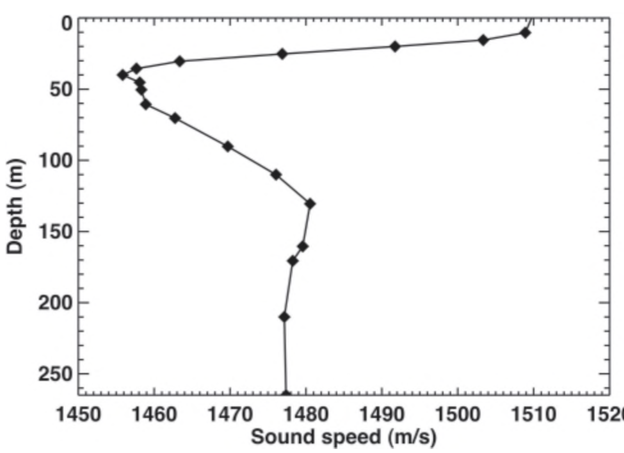


Fig. 1. Sound speed profile taken on 28 July 2007.

## 3. MEASURED TRANSMISSION LOSS

The data collected during the sea trial were later processed to yield estimates of the transmission loss via the equation TL = SL – SPL, where SL is the projector source level and SPL is the sound pressure level at the receiver (both measured in dB re 1 μPa). The main step in the processing was to perform spectral analysis of the acoustic data to obtain the SPL of each tone at the sonobuoys. The projector SL was measured at the Acoustic Calibration Barge, a facility owned and operated by DRDC Atlantic.

The plots in Fig. 2 show measured TL curves versus range for all 11 frequencies; the gaps in the curves are the result of temporary interruptions that occurred in data acquisition. The curves at the different frequencies cluster quite closely together, but the TL is markedly less for the 60-m receiver than for the 120-m receiver. This latter effect is explained by the fact that the sound propagating to the receiver at 60-m depth is almost entirely trapped in the duct, whereas for the deeper receiver the sound interacts with the waveguide boundaries.

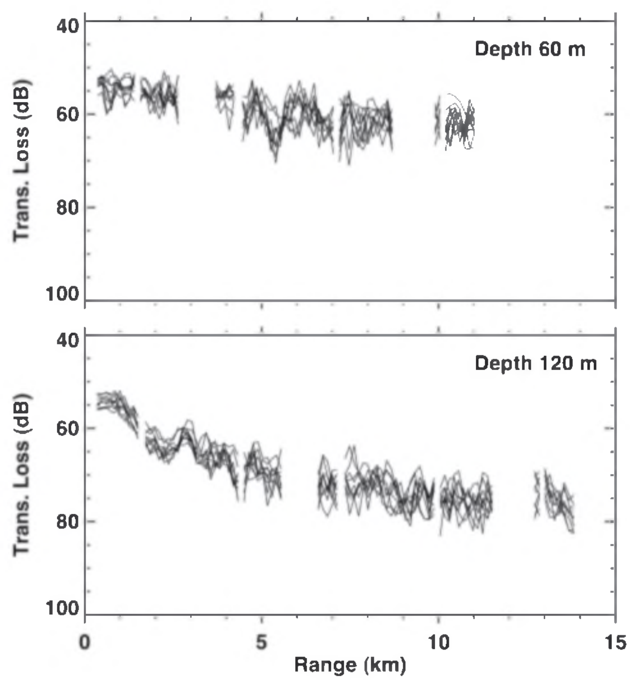


Fig. 2. Measured TL at two receiver depths (60 and 120 m). The results for all eleven frequencies are shown.

# 4. MODEL RESULTS

The next step was to compare the measured TL curves with theoretical predictions made using the propagation model PECan (Canadian Parabolic Equation model) [2] and Bellhop [3], a model developed by Michael Porter. PECan is based on a finite-difference solution of the parabolic approximation to the wave equation, whereas Bellhop uses Gaussian beams [4]. The geo-acoustic bottom was modelled as a 20-m layer of sediment (density 1.6 g/cm$^3$, speed 1521.7 m/s, absorption 0.5 dB/ $\lambda$) overlying an infinite half-space (density 2.1 g/cm$^3$, speed 1846.7 m/s, absorption 0.5 dB/ $\lambda$).

PECan and Bellhop were used to calculate theoretical TL values on a 5-m range grid. However, the experimental TL values were in effect averaged over 120 m in range due to source motion during the analysis intervals. The model results were therefore averaged in range using a 120-m-long boxcar window. The PECan results for all 11 frequencies are shown in Fig. 3. The TL curves for the 60-m receiver display the expected low loss, without much range structure. There is much greater loss for the 120-m receiver, and an interference pattern is evident. The same general pattern appears in the Bellhop results (not shown).

# 5. COMPARISON

The experimental and modelled TL results are compared at a single frequency in Fig. 4. The experimental results, earlier plotted as lines in Fig. 2, are now plotted as discrete points superimposed on the theoretical curves. First comparing PECan and Bellhop between themselves, we find reasonable agreement, particularly for the 120-m receiver, although Bellhop shows greater attenuation with range. (Volume attenuation and surface scattering were omitted from the PECan model runs.) Next comparing the model predictions with the measured TL results, we observe good agreement at the frequency shown (1010 Hz). The agreement at the other frequencies is usually as good as in the case shown here; where systematic discrepancies exist, buoy-to-buoy comparisons suggest the presence of frequency-dependent gain errors in the buoy receivers, which are not intended for the accurate measurement of acoustic level. In conclusion, the results of this paper clearly support the use of the two numerical models as tools for predicting sonar performance in the 1 – 2 kHz band.

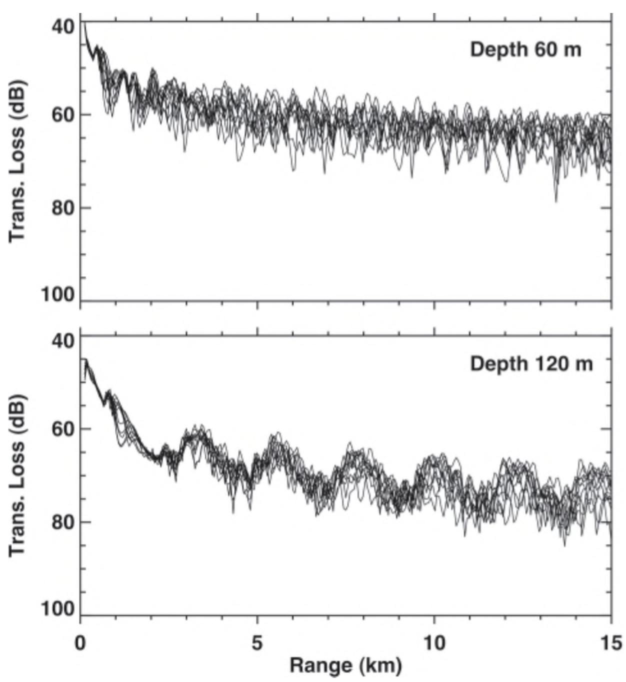


Fig. 3. TL at all 11 frequencies as modelled by PECan.

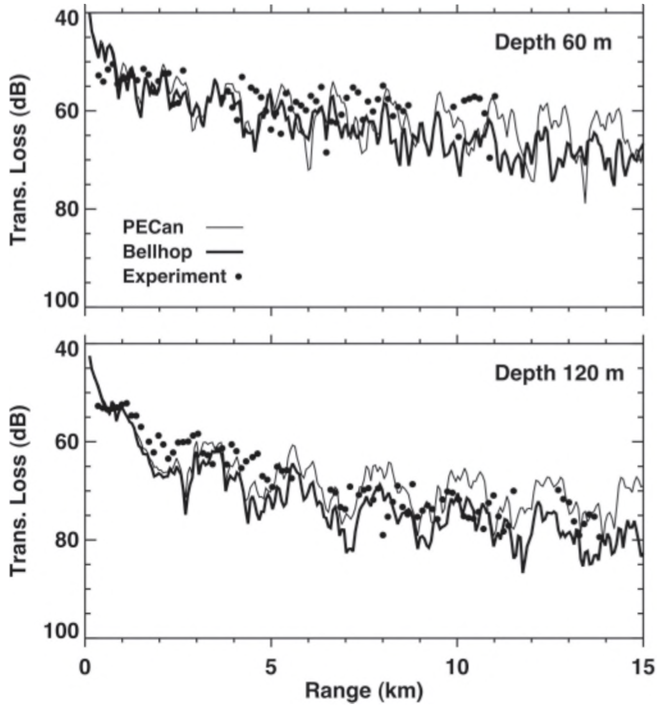


Fig. 4. Comparison of measured and modelled transmission loss at a single frequency (1010 Hz).

# ACKNOWLEDGEMENTS

Sean Pecknold, Gary Brooke, and David Thomson provided advice on propagation modelling, and Mark Radcliffe produced the plots.

# REFERENCES

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