dBSea Benchmark Testing

Testing dBSea's solvers in multiple comparisons with well-known benchmark problems.

We here present solutions to a range of well-defined underwater sound propagation calculation problems for the comparison of dBSea's algorithms to the open source method based on the same modelling approach.

Many of the examples will link to "UWA" files. These are dBSea scenario files that can be viewed in dBSea BASIC (freely available from: http://www.dbsea.co.uk/media/30273/dBSea-Basic-220.zip).

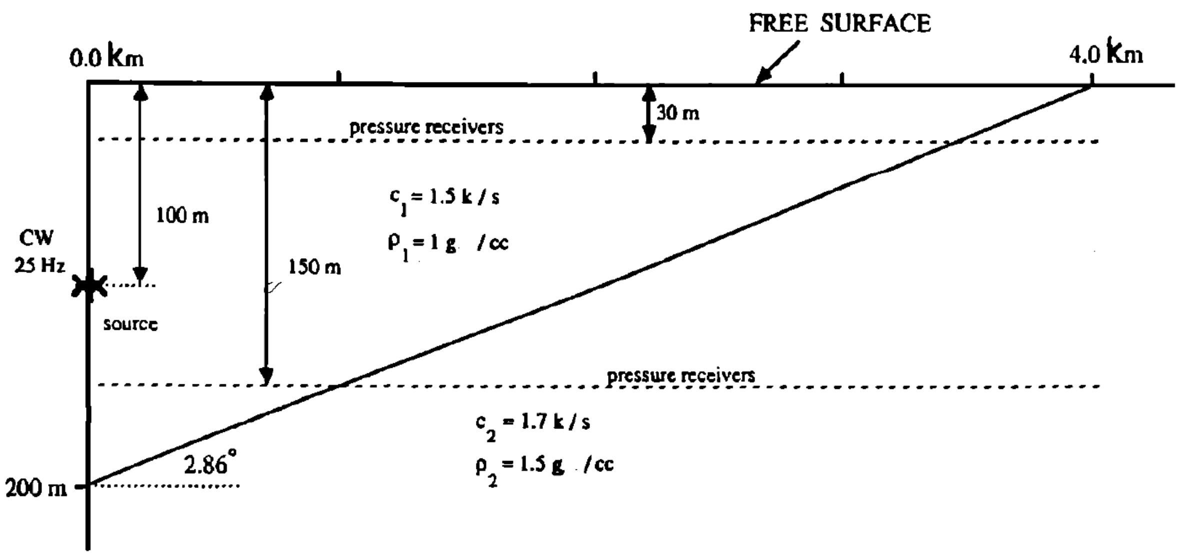
Please not that while raytracing methods have been included in this document for the sake of completeness, they are generally not suitable for low frequency problems (wavelength > 1-3 % of depth).

1 UPSLOPE WEDGE

1.1 ASA BENCHMARK

The ASA Benchmark problems (Jensen & Ferla, 1989) represent a classic base for comparison of propagation modelling.
The UWA file for this scenario is available from:
https://drive.google.com/open?id=0B7cNj3oy6fp0TFg0ZXhrMTZucEU

Figure 1. Schematic of scenario for wedge problem



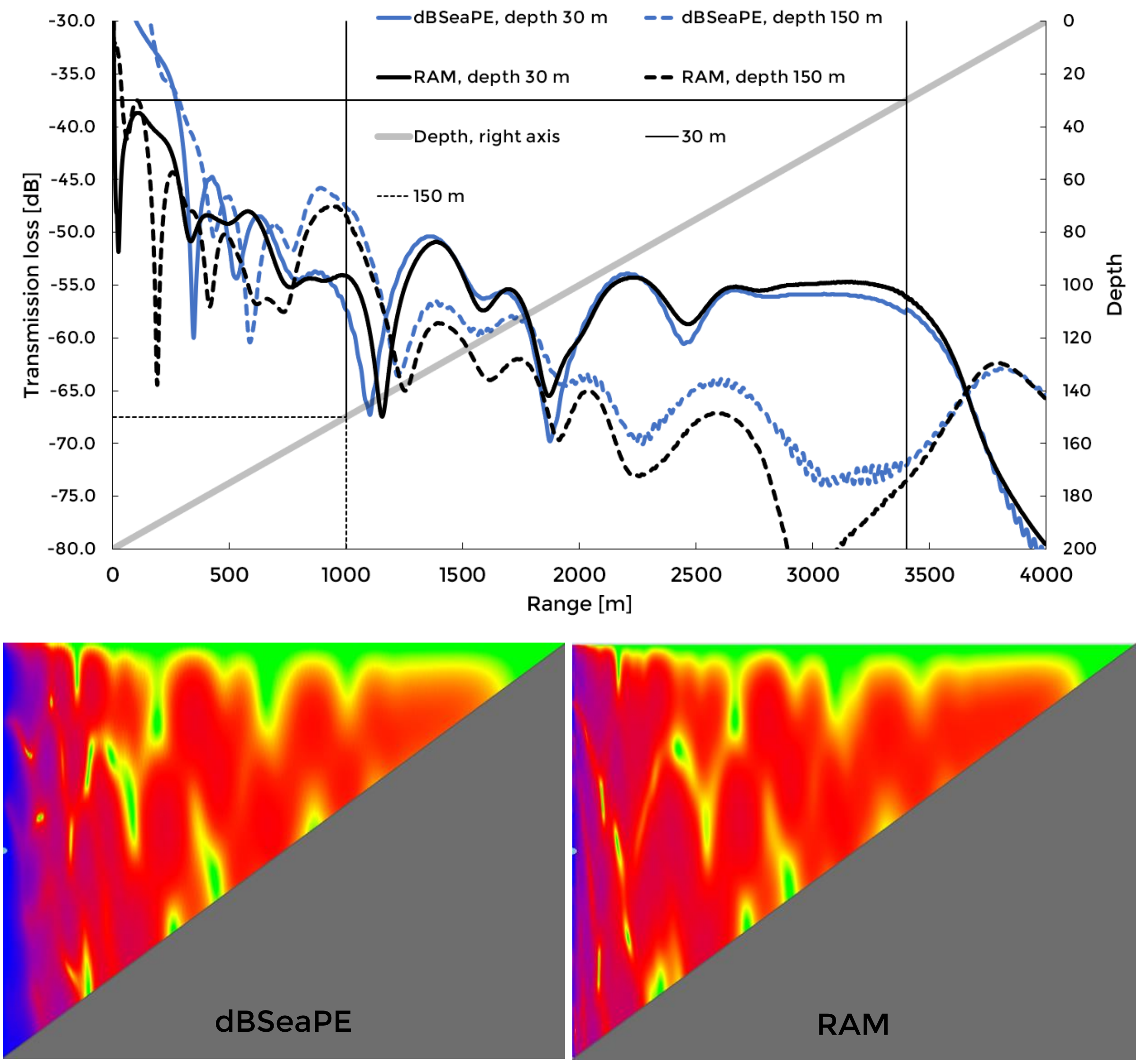
The following results are based on a comparison of dBSea’s solvers with solvers from the [AcTUP tool-box](http://cmst.curtin.edu.au/products/underwater/)[1], covering the three most popular methods of calculating the sound field, namely:

- Parabolic equation method - dBSeaPE & RAM
- Normal modes method - dBSeaModes & Kraken
- Ray tracing method - dBSeaRay & Bellhop

Note that the scenario is modelled for 25 Hz. At this frequency we do not expect the two raytracing methods to work well.

1.1.1 Parabolic Equation method

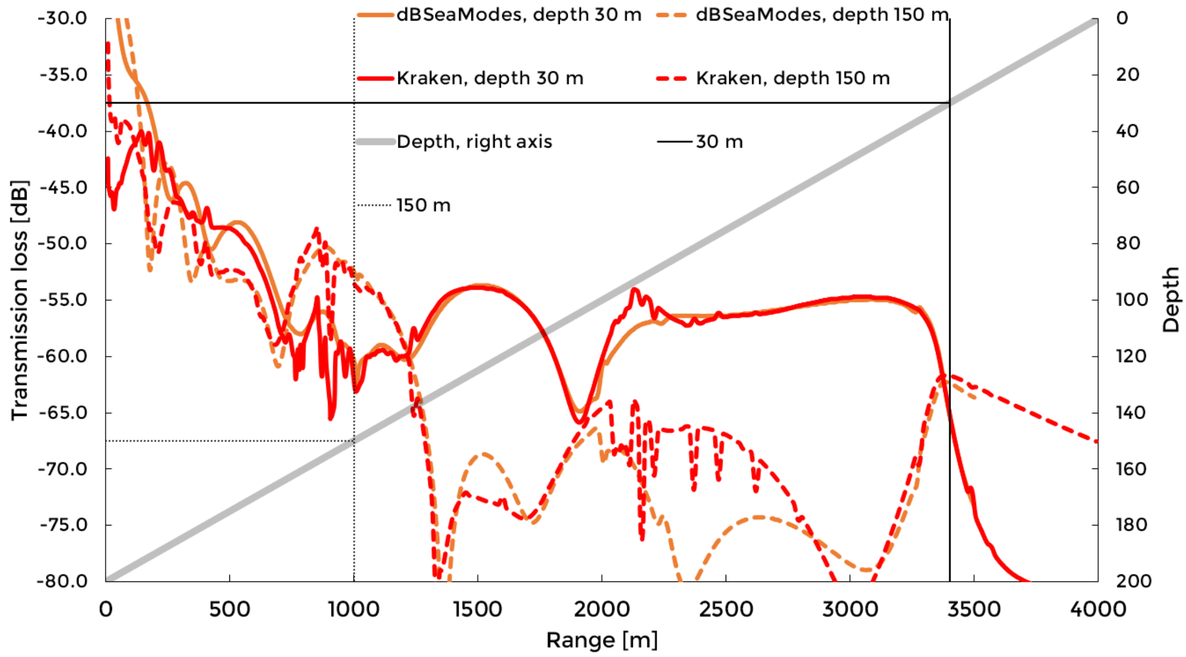
Figure 2. Transmission losses for dBSeaPE and RAM. Depths 30 m and 150 m are shown in chart, while full transects in colour are presented below.

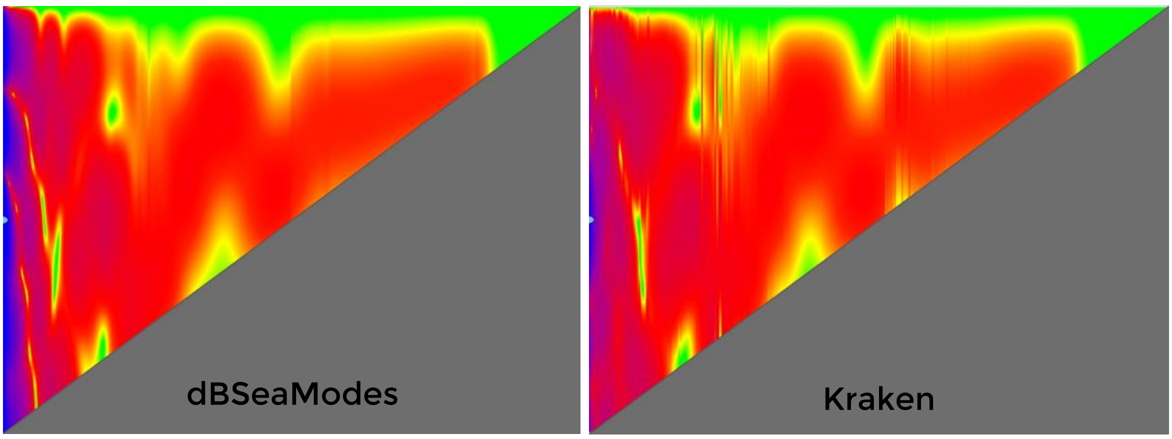


[1] http://cmst.curtin.edu.au/products/underwater/

1.1.2 Normal Modes Method

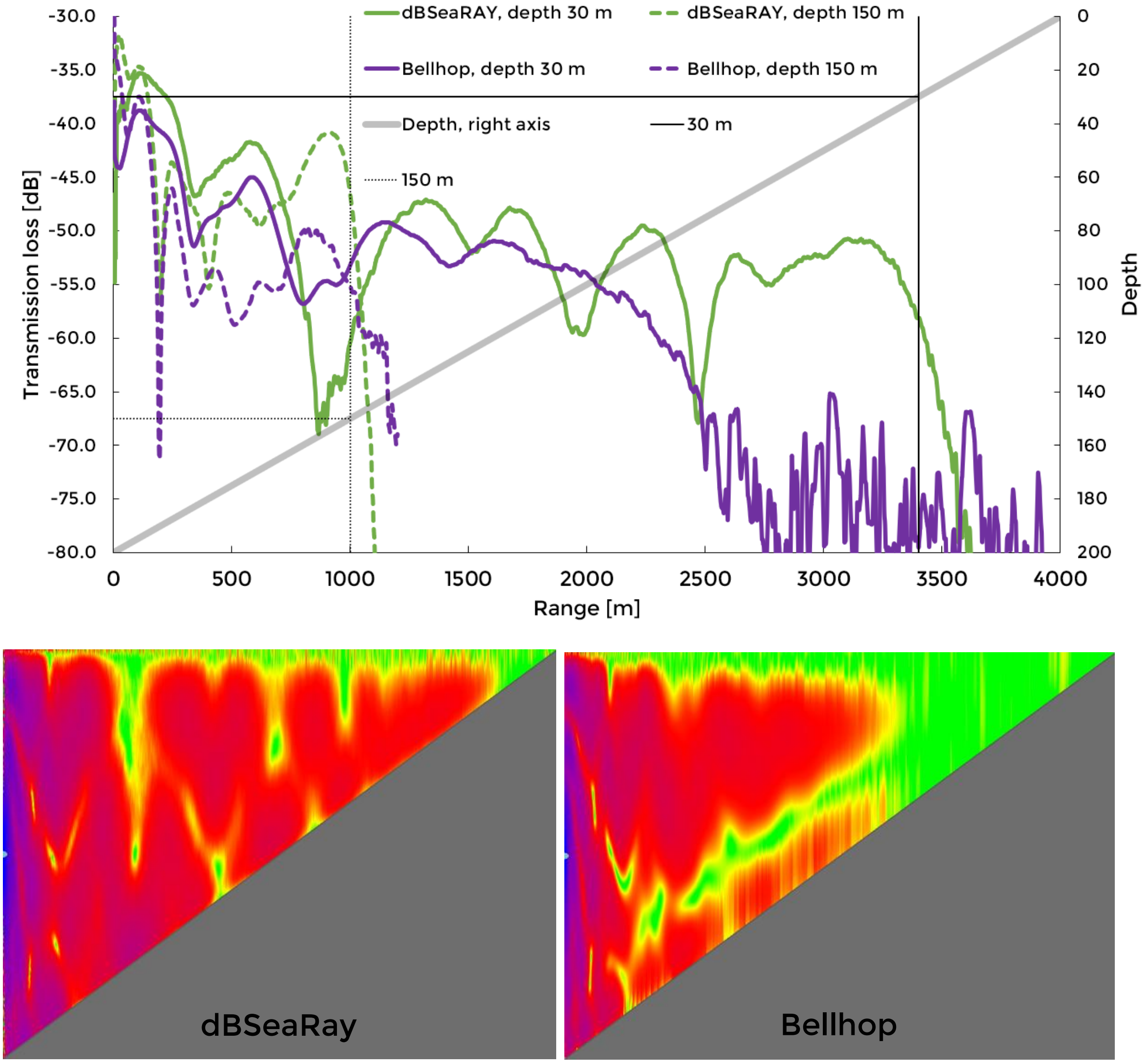
Figure 3. Transmission losses for dBSeaModes and Kraken. Depths 30 m and 150 m are shown in chart, while full transects in colour are presented below.





1.1.3 Ray Tracing Method

Figure 4. Transmission losses for dBSeaRay and Bellhop. Depths 30 m and 150 m are shown in chart, while full transects in colour (-20 dB to -70 dB) are presented below.



Note that neither of the ray tracing methods penetrate the sediment, and so the receiver depth at 150 m terminates shortly after a range of 1000 m. Notice that dBSeaRay reproduces the results well from both the parabolic equation method and the normal modes method, despite being unsuitable for the chosen frequency (25 Hz).

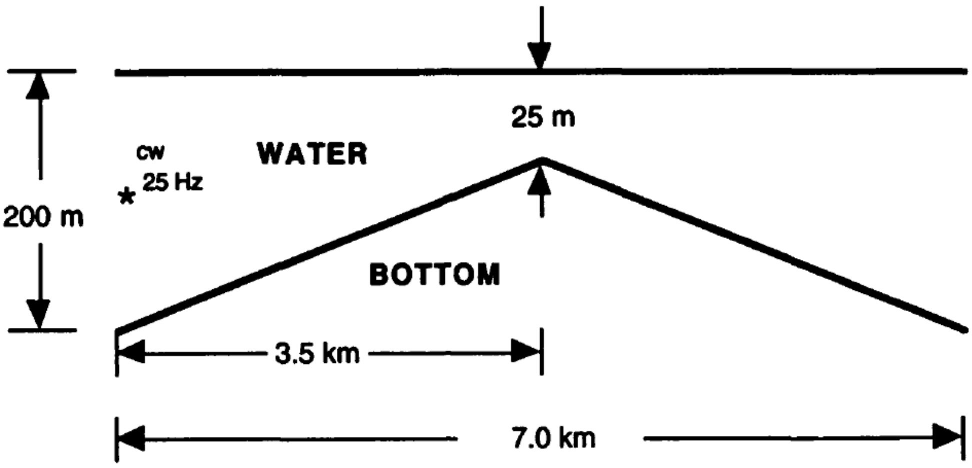
2 Up-Down Energy Conservation problem

2.1 Parabolic Equation Workshop II 1993 – Case II

An upslope-downslope problem formulated to test the energy conservation in strongly range-dependent environments was formulated in (Chin-Bing, et al., 1993).

The UWA file for this scenario is available at:
https://drive.google.com/open?id=0B7cNj3oy6fp0Wi1SdGJGWmhDSHc

Figure 5. Schematic outlining upslope-downslope problem.

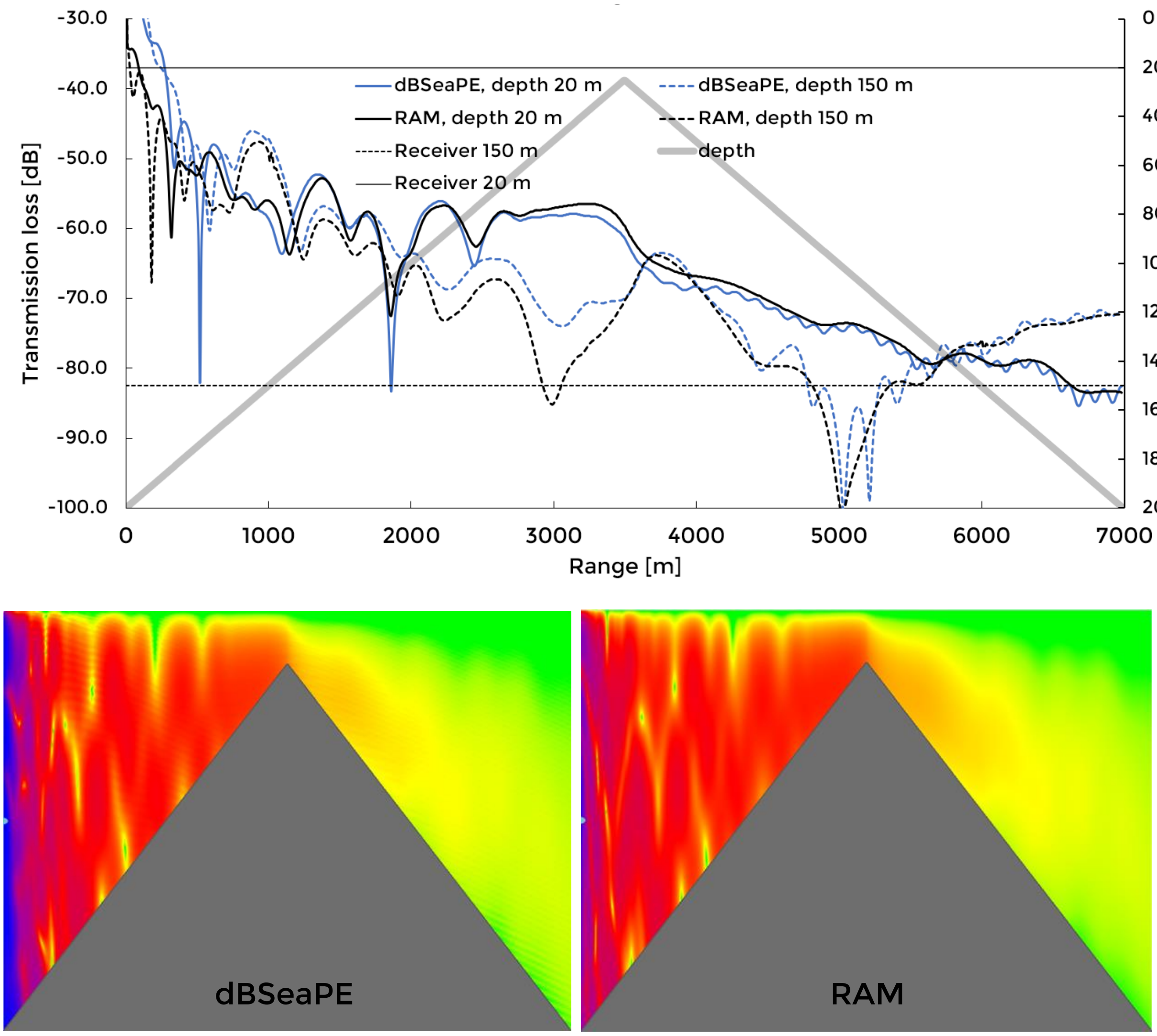


Environmental parameters for Test Case 2.

In the water the sound speed is 1500 m/s, the density is 1 g/cm^3, and there is no attenuation. In the fluid bottom the sound speed is 1700 m/s, the density is 1.5 g/cm^3, and there is an attenuation of 0.5 dB/λ. The frequency is 25 Hz, the fixed point depth (source depth) is 100 m, and the moving point depths (receiver depths) are 20 m and 150 m.

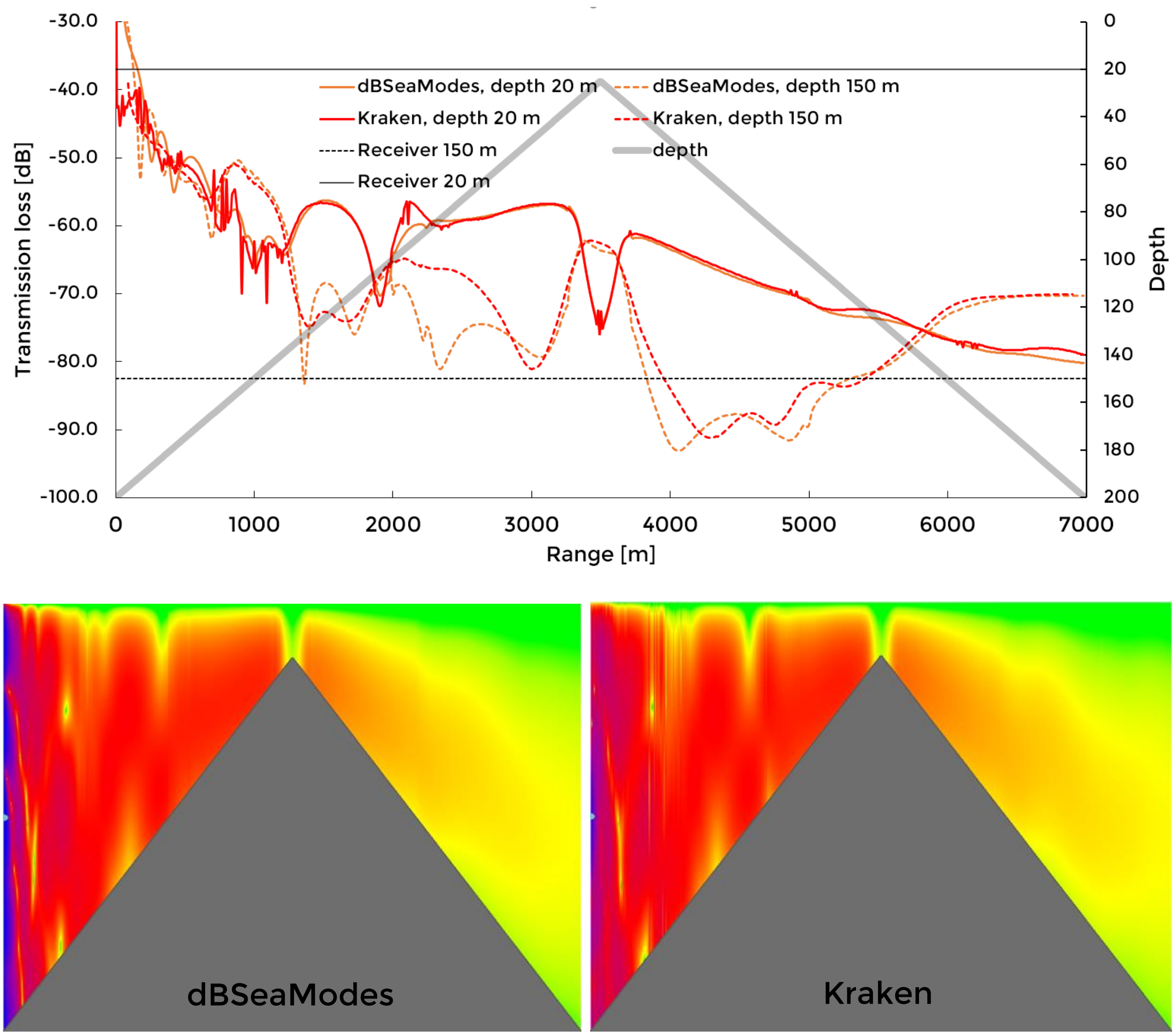
2.1.1 Parabolic Equation Method

Figure 6. Transmission losses for dBSeaPE and RAM. Depths 20 m and 150 m are shown in chart, while full transects in colour are presented below.



2.1.2 Normal Modes Method

Figure 7. Transmission losses for dBSeaModes and Kraken. Depths 20 m and 150 m are shown in chart, while full transects in colour are presented below.

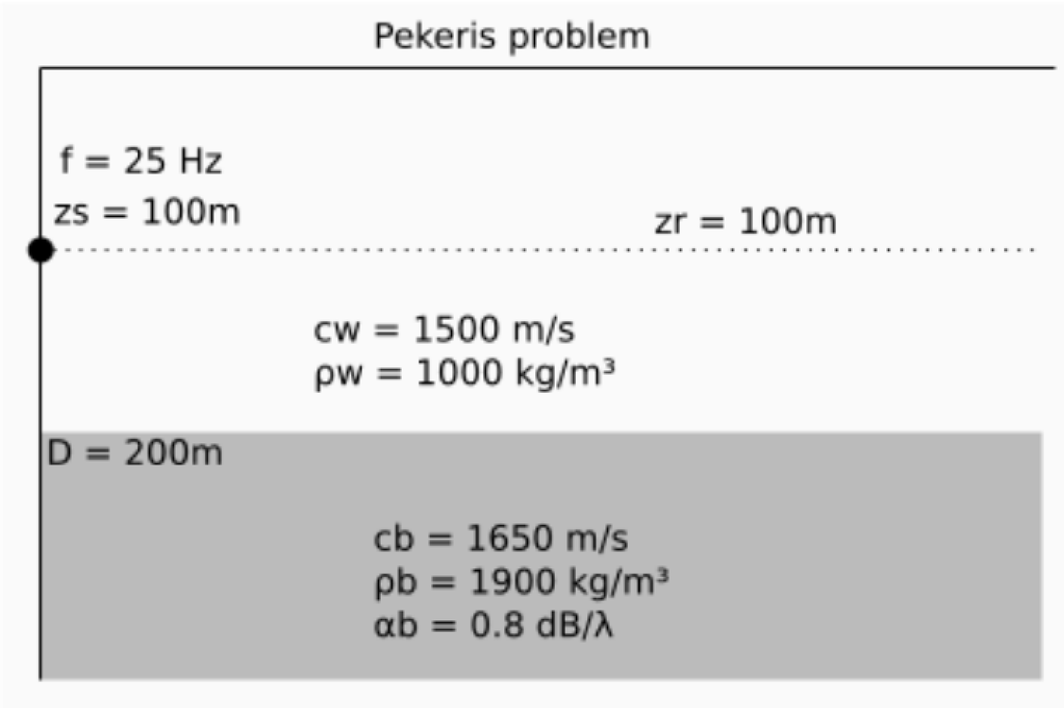


3 Flat-bottomed Waveguide

3.1 Pekeris Problem

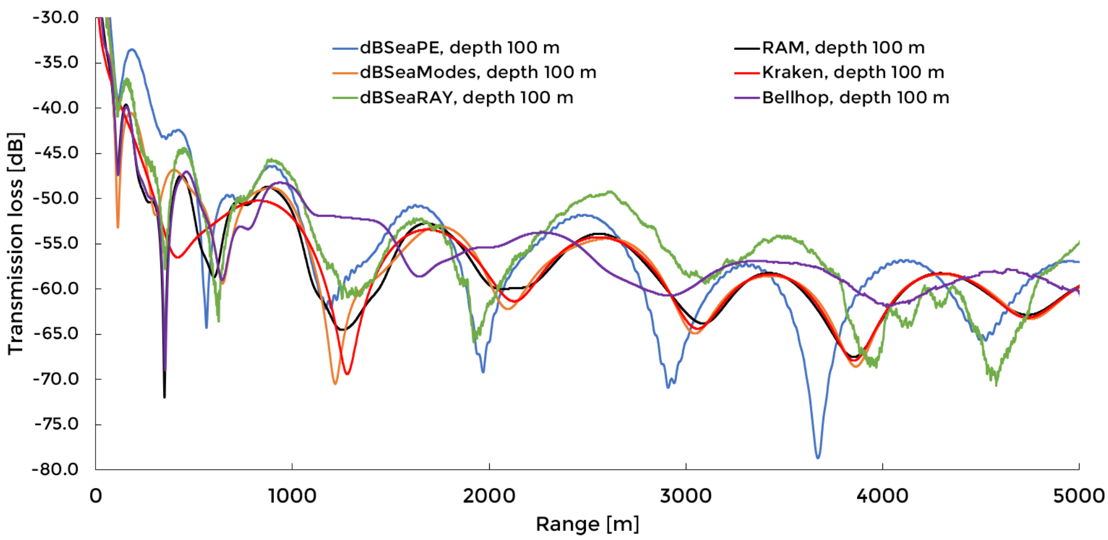
The Pekeris problem is a horizontally flat waveguide, designed to test propagation in an environment with a moderately absorbent sediment

Link:
https://drive.google.com/open?id=0B7cNj3oy6fp0WmJ1eW1jNjNzQTA



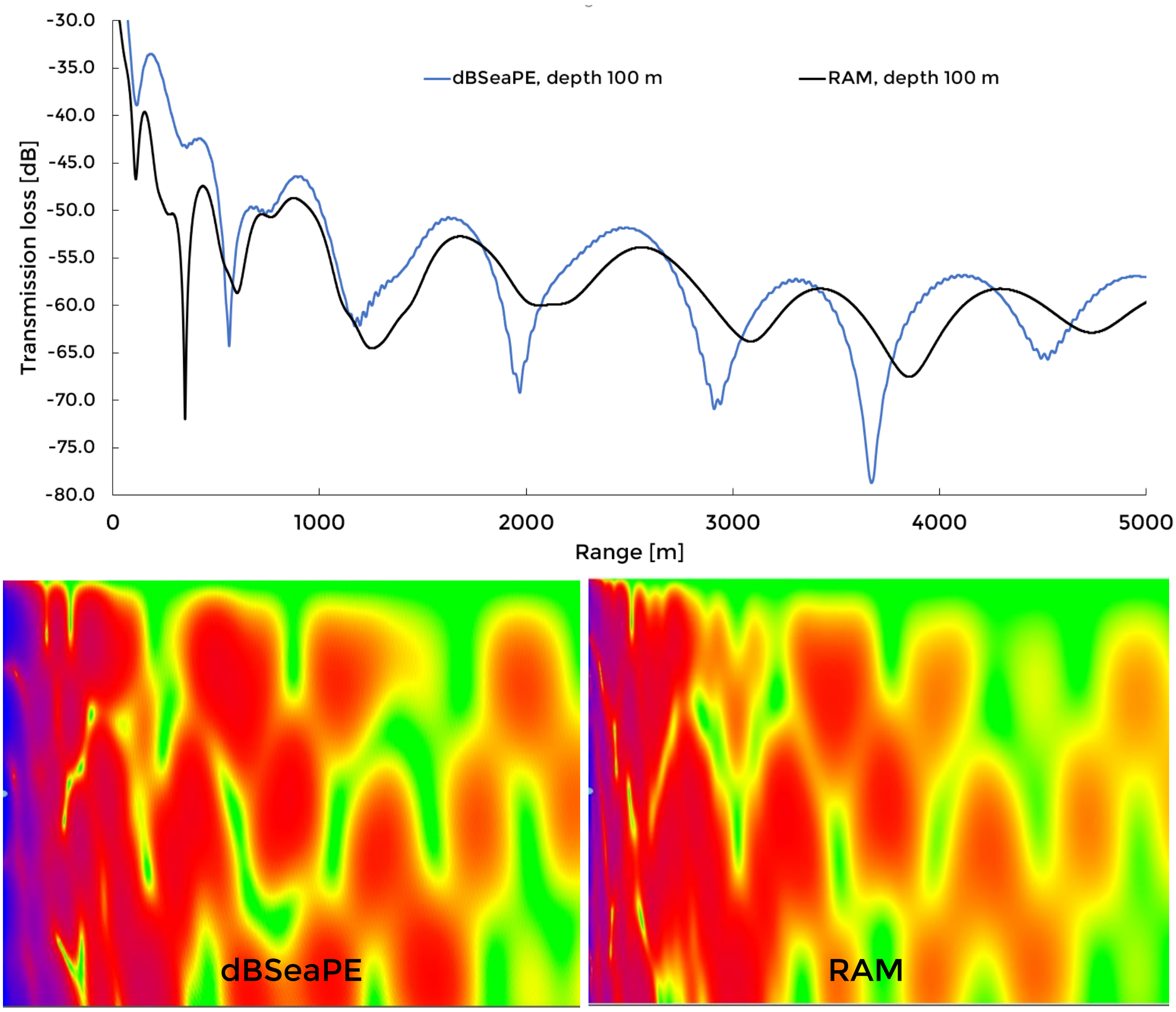
3.1.1 Summary of all Methods

Figure 8. Transmission losses for all three methods in the flat waveguide.



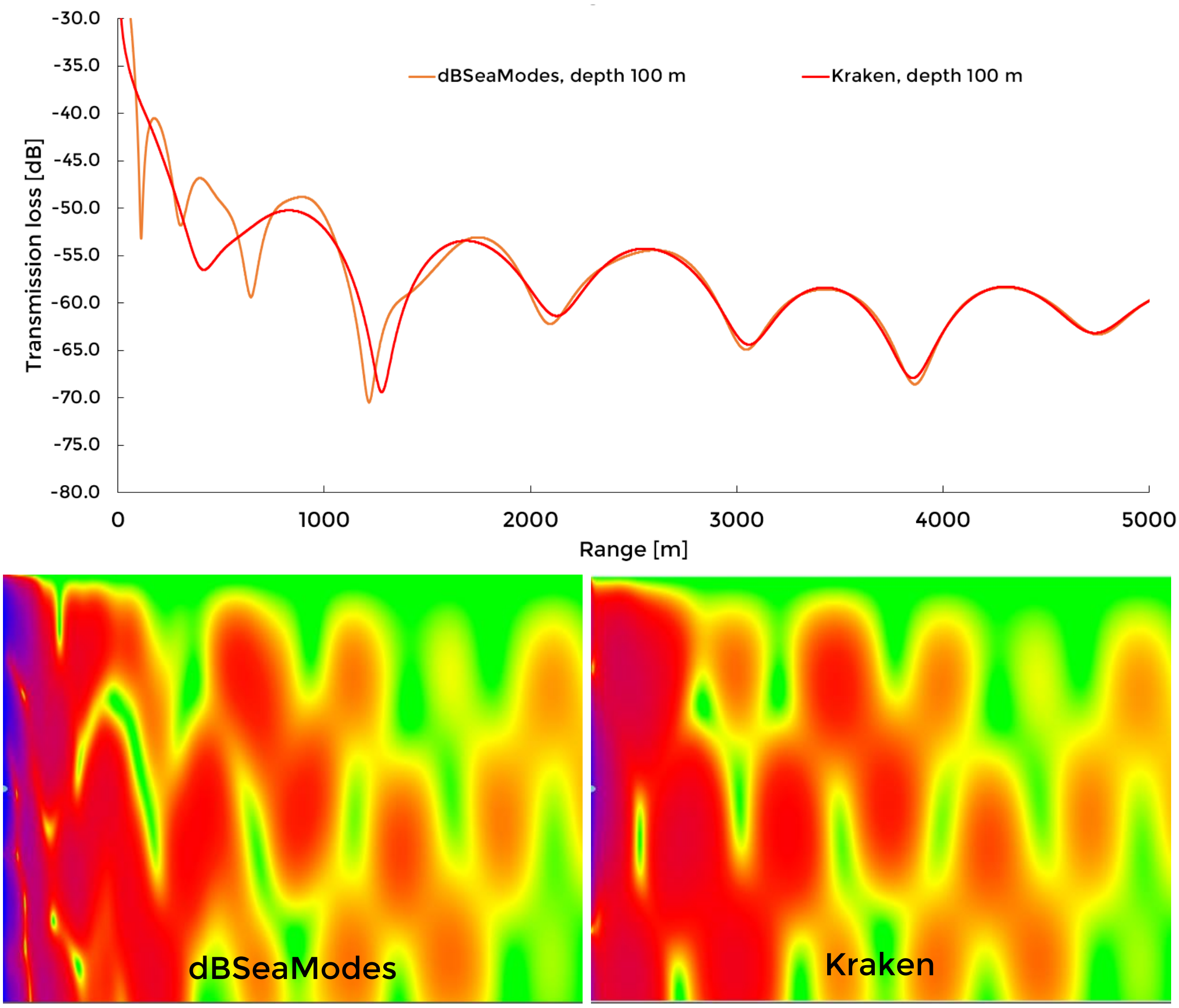
3.1.2 Parabolic Equation Method

Figure 9. Transmission losses for dBSeaPE and RAM. Depth 100 m is shown in chart, while full transects in colour are presented below.



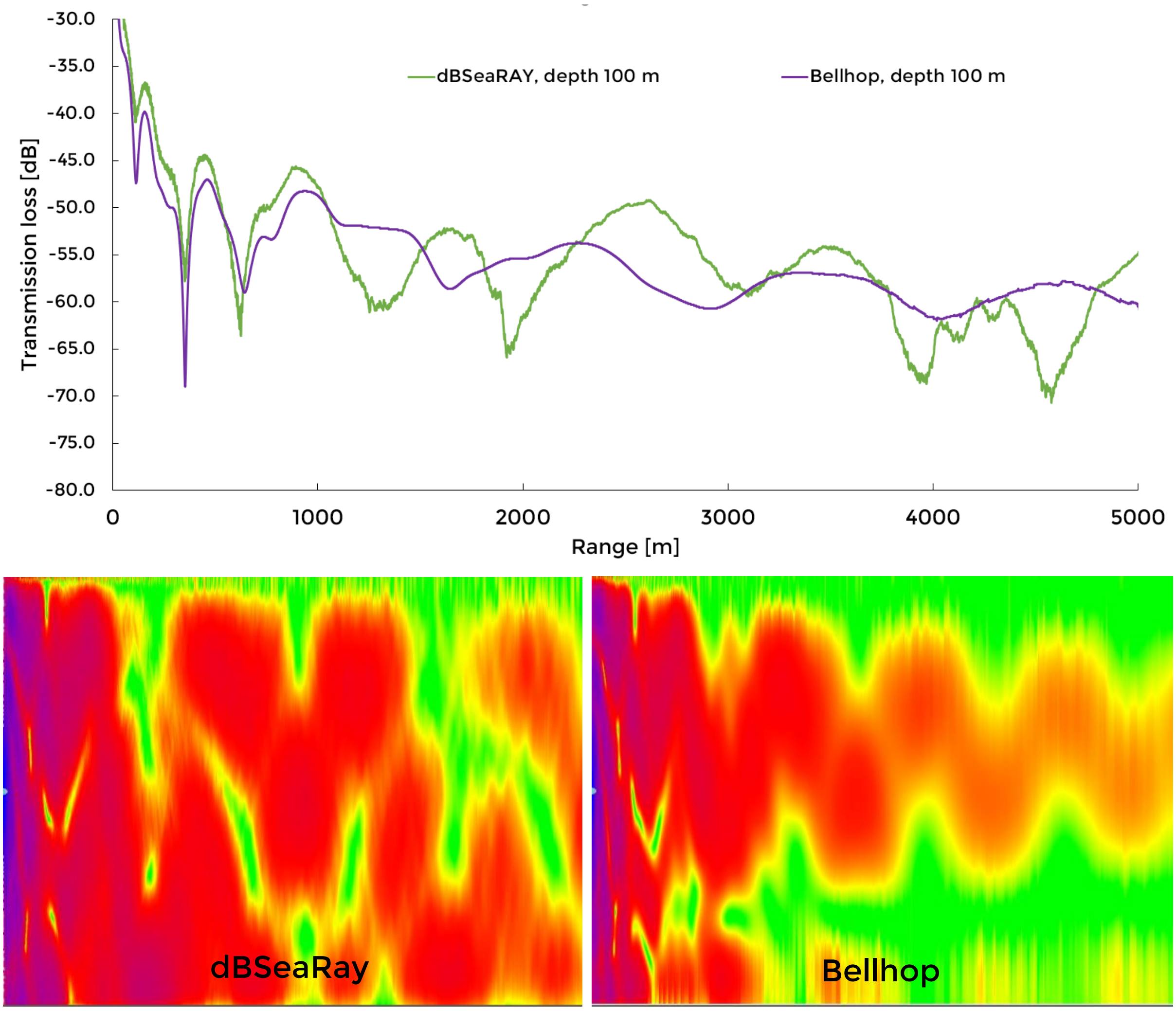
3.1.3 Normal Modes Method

Figure 10. Transmission losses for dBSeaModes and Kraken. Depth 100 m is shown in chart, while full transects in colour are presented below.



3.1.4 Ray Tracing Method

Figure 11. Transmission losses for dBSeaRay and Bellhop. Depth 100 m is shown in chart, while full transects in colour are presented below.



4 References

Chin-Bing, S. A., King, D. B., Davis, J. A. & Evans, R. B., 1993. *PE Workshop II,* Stennis: Naval Research Laboratory.

Jensen, F. B. & Ferla, C. M., 1989. Numerical solutions of range-dependent benchmark problems in ocean acoustics. 4(87).