FINAL REPORT

ACOUSTIC REVERBERATION IN WEDGE STRUCTURES AT THE TRANSITIONS FROM DEEP TO SHALLOW WATER

N00014-89-J-1515.

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OBJECTIVES

The two objectives pursued in this work are: (1) To investigate acoustic reverberation experimentally and theoretically from a laboratory wedge model of shallow water and (2) To make numerical simulations of acoustic reverberations in multifaceted wedge structures and compare the results with the data obtained from cruise.

GOALS OF THE RESEARCH

The reverberations in a wedge waveguide are complex and reverberation research is best done in the time domain so that the reverberations from different features are separated . Each acoustical arrival will be identified and compared with numerical calculations based on the theoretical model. Our efforts will be finally direct to compare numerical results with the data obtained from a cruise.

RESULTS

We did a sequence of experiments to verify our extensions of the original Biot-Tolstoy theory for a wedge to oceanic examples (1-9). The last paper in the sequence (9) has been accepted for publication. The research also formed the basis of Chapter 11 in the text of Herman Medwin and C, S. Clay, *Fundamentals of Acoustical Oceanography* (Academic Press, October 1997). Bioacoustic studies and scattering from fish and zooplankton are in chapters 9 and 10.

Sound transmissions in wedge structures

Our laboratory models simulate the structure of a continental boundaries such as the east coast of United States. It has a shallow sloping bottom (0^o - 0.5^o) that changes to a steeper slope (6^o - 11^o) at the continental slope. Our laboratory acoustic models, Fig. 1, greatly exaggerate the actual slopes. The acoustic models have (1) a 11^o slope that changes to a 50.5^o slope and (2) a 35^o slope change to a 59^o slope. The surface and bottom of the acoustic models are dry wall construction board. The source is a spark and the receiver is a small microphone. The spark source fires and then a sequence of arrivals are received at R. The first is the direct arrival. Image reflections and the diffraction from A follow. The diffraction arrival also has image reflections. The images then become sources for more diffractions from A. Theoretical computations used the Biot-Tolstoy theory (10) and the kaleidoscopic image constructions in Feuillade and Clay (8).

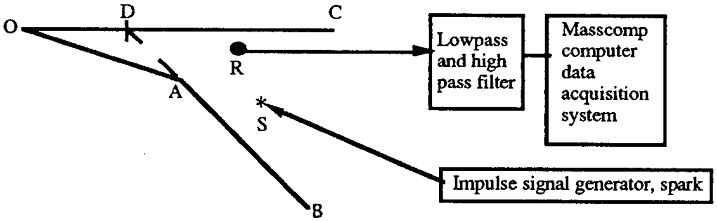

Fig. 1. Shelf and slope geometry.
S and R stand for source and receiver. The lowpass filter was 30 kHz and the highpass filter was 2 kHz. In the computer, 50 signals were stacked, then the mean value was deleted. Here the source S and receiver R are shown at positions beyond the shelf break at A.

The image construction and arrivals for steeper shelf and break (a 35° slope change to a 59° slope) are shown in Fig.2. This example was chosen from reference (9) because the arrivals are simpler than those of the shallower wedges as sketched in Fig. 1. The receiver positions were chosen to be near the diffracting wedge angle at A.

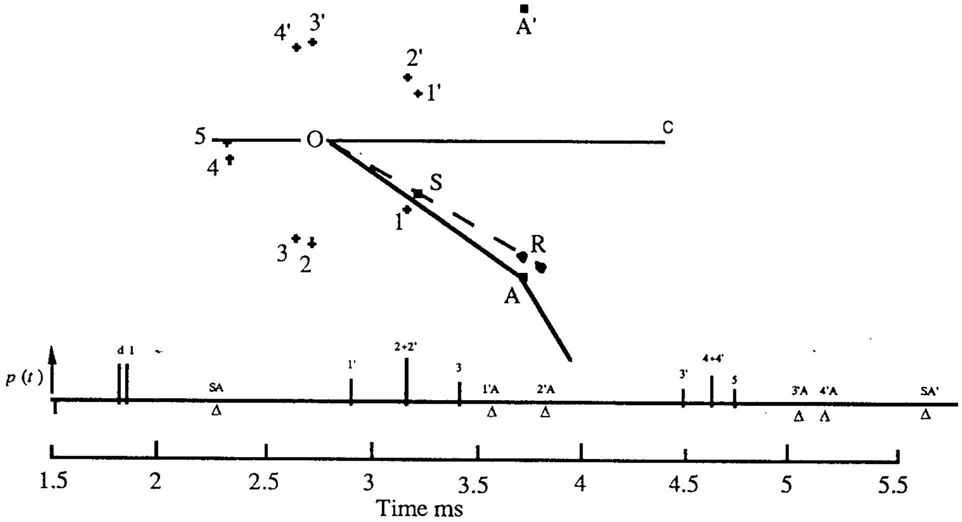

Fig.2 Wedge waveguide and image constructions. The wedge walls are rigid dry wall construction boards. The impulse response is *p*(*t*). R indicates the range of receiver positions. The wedge angles are 35° relative to horizontal and 59° relative to the horizontal interface.From Li and Clay (9).

A set of theoretical impulse transmissions were convolved with the sound transmission from the spark source. Theoretical transmissions to a set of receiver positions are shown in Fig. 3. The arrival are identified as 1) direct, d1; 2) source-wedge at A, SA; 3) arrival from image 1, 1; 3) image arrival from 1', 1'; 4) the next images are 2 and 2'; 5) image arrival from 3, 3; 6) the image-diffraction arrivals, 1'A and 2'A; and so forth. The amplitudes of the theoretical diffraction arrivals are much smaller than the reflections or image arrivals.

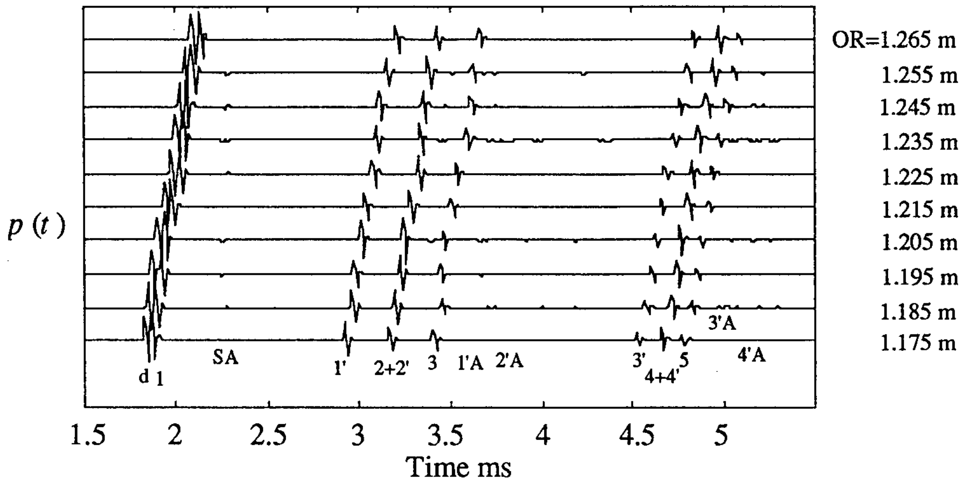

Fig. 4 Theoretical sound transmissions for the wedge and image constructions shown in Fig. 3. From Li and Clay (9)

Experimental sound transmissions are shown in Fig. 5. The theoretical and experimental sound transmissions match.

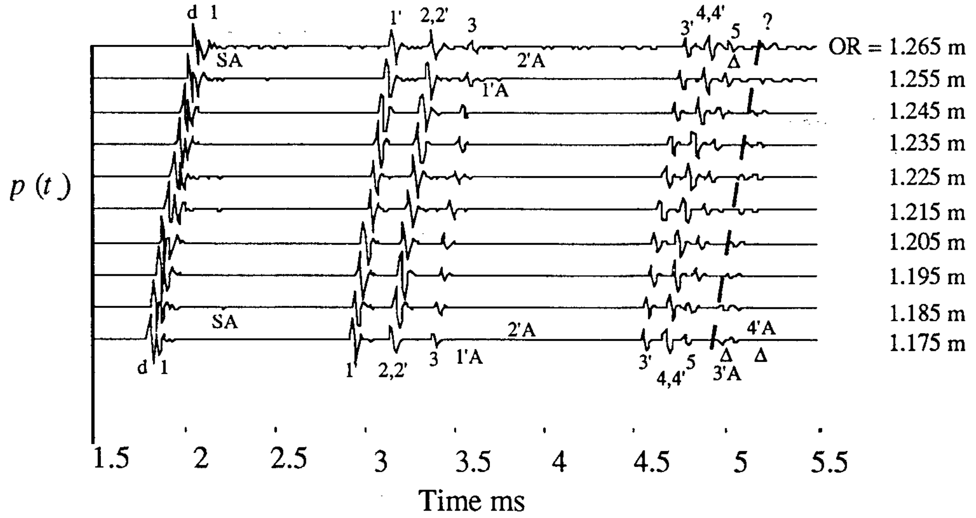

Fig. 5 Experimental transmissions.
The identifications of arrivals are the same as shown in Fig. 4. From Li and Clay (9).

The conclusions are quite simple. The raytrace or image arrivals account for practically all of the acoustic energy. As given in the Biot-Tolstoy theory, one gets a finite number of image arrivals. The number of arrivals depends on the wedge angle, source angle, and receiver angle. Diffraction arrivals were small and usually below the background noise. The image-raypath constructions gave an impulse responses and the convolutions of these impulse responses gave a set of theoretical transmissions. Within small amplitude differences, the theoretical and experimental transmissions matched.

The sound transmissions for such a simple model, Fig. 3-5, are very complex. Without using too much imagination, the reverberations shown in Preston and Kinney (11) can be accounted for with relatively simple ocean bottom structures.

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