Shallow-water Reverberation:
Measurement Technique, Initial Reference Level and Geoacoustic Inversion

Ji-Xun Zhou
School of Mechanical Engineering, Georgia Institute of Technology
Atlanta, GA 30332-0405
phone: (404) 894-6793 fax: (404) 894-7790 email: jixun.zhou@me.gatech.edu

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LONG-TERM GOALS

The long-term goals of this work are: to develop a practical model for predicting reverberation level (RL), echo-reverberation ratio and reverberation vertical coherence (RVC) in shallow water; to characterize seabottom geoacoustic parameters (sound speed and attenuation) and scattering function from high quality reverberation data in a frequency range of 100-3000Hz, and to reveal the physics of bottom scattering from the "window' of shallow-water reverberation.

OBJECTIVES

The scientific objectives of this year's research include:

(1) To develop a method for accurately measuring absolute reverberation level (ARL) in shallow water, normalized to a source level (SL).

(2) To analyze the characteristics of the RL as a function of time and frequency, and to understand the physics of the observation.

(3) To continue the RVC-based inversion of seabottom acoustic parameters.

APPROACH

A quality database of reverberation is absolutely essential if one is to understand the shallow-water reverberation problem. However, to get wideband reverberation levels (RL) simultaneously for both short and long ranges in 100 – 3000 Hz frequency range is a delicate task that can be subject to errors. Wideband reverberation measurements were conducted at the center of the ASAEX site in the East China Sea, and at the center of Yellow Sea '96 site in the Yellow Sea, using 38-g and 1000-g explosive sources and a vertical hydrophone array. We introduce a simple method to get RL at low- and mid-frequencies. Special attention is paid to the measurements of the RL at short- and mid-ranges. With this method, one does not need to accurately calibrate hydrophones and measurement systems, or to measure absolute source level (SL). It can avoid signal overflow and saturation problems caused by powerful sound sources. The method is based on a physical fact: for a given experimental location the reverberation level as a function of time, i.e., the curve shape of RL (t), is unique, independent of source level (by which it was normalized) or measurement method.

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14. ABSTRACT
The long-term goals of this work are: to develop a practical model for predicting reverberation level (RL), echo-reverberation ratio and reverberation vertical coherence (RVC) in shallow water; to characterize seabottom geoacoustic parameters (sound speed and attenuation) and scattering function from high quality reverberation data in a frequency range of 100-3000Hz, and to reveal the physics of bottom scattering from the ?window? of shallow-water reverberation.

15. SUBJECT TERMS

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The methodology is as follows:

(1) Use an identical measurement system to record both source direct signal (without any reflection from surface or bottom) and reverberation signal and then normalize reverberation to the source signal in the data processing.

(2) Use larger charges (1000-g) and a hydrophone with a pre-amplifier to get the long-range relative reverberation level (RL_L) with a higher reverberation to noise ratio.

(3) Use smaller charges (38-g) and the hydrophone with pre-amplifier to get the mid-range relative reverberation level (RL_M).

(4) Use smaller charges (38-g) and an un-amplified hydrophone to get the relative source level and short-range reverberation level (RLs). Normalizing the uncalibrated value of RLs to the uncalibrated SL gives the short-range absolute reverberation level ARLs;

(5) scaling RL_L and RL_M to match each other between 1s-2s and to match ARLs in the range of 200-500ms gives the complete ARL curve from short-range to long-range.

RESULTS

(1) A simple method to measure the reverberation level in shallow water is developed. We joined short-, mid- and long-range reverberation level curves obtained from different sources and receivers at two time intervals where all of the reverberation levels were at least 10 dB higher than ambient noise.

(2) A nonlinear gain problem in the measurement system caused by powerful sound sources was observed and discussed. Our method can avoid this kind of measurement error.

(3) Results show that when t >1 s, the RL exhibits a strong frequency dependence. Low-frequency RL curves decay much faster than the high-frequency RL curves.

(4) The reverberation level at 1 second after an explosive source is detonated was defined as the Initial Reference Reverberation Level (IRRL, relative SL=0 dB). The IRRLs from deferent sites with different sediments and different water depths (average depth=60m) have been determined as a function of frequency in the 150-3150 Hz range (see Figure 1). The resultant IRRLs from four sandy bottom sites are close to each other. The IRRL increases with frequency in 300-2000 Hz frequency range. The IRRL from a site with a softer bottom (silty clay) is about 10 dB lower than the IRRLs from sandy bottom areas. It might partially be caused by larger two-way propagation loss at the softer bottom area. It seems display no (or weak) frequency dependence for f >400 Hz.

(5) The measured IRRL values have been explained by a mathematical model of SW reverberation. (See dashed lines in Fig.1) The weak waveguide depth dependence of the measured IRRL data also has a physical explanation in this model.

(6) Sound velocity and attenuation in the sea bottom at the ASIAEX site in the East China Sea have been inverted from the RVC data, collected on June 3 and June 5, 2001. Figure 2 show the RVC inverted sound speed in the bottom.

IMPACT/APPLICATIONS

The resultant RL and IRRL may offer some reference values for the design of reverberation measurements or numerical simulations of shallow-water reverberation and bottom scattering.

PUBLICATIONS

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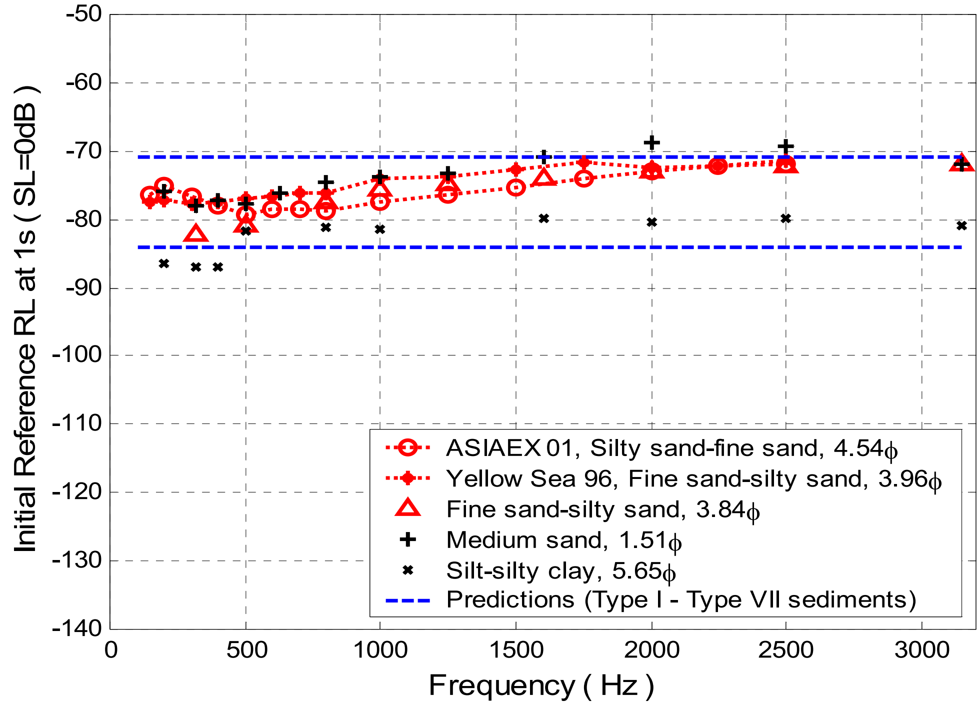

Figure 1.   Measured initial reference reverberation levels and theoretical predictions

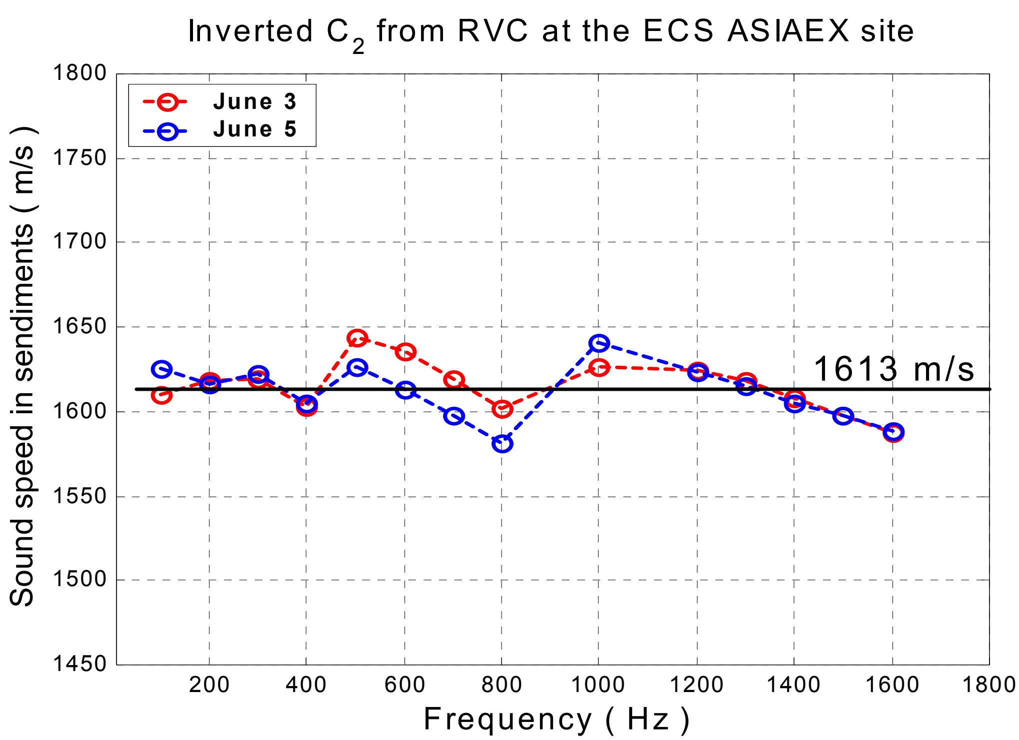

Figure 2. Sound speed in the bottom at the ASIAEX site, inverted from two RVC measurements