CALCULATION OF *IN SITU* ACOUSTIC WAVE PROPERTIES IN MARINE SEDIMENTS

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The importance of estimating compressional wave properties in saturated marine sediments is well known in geophysics and underwater acoustics. As part of the ONR sponsored Geoclutter program, *in situ* acoustic measurements were obtained using ISSAP (**In** situ **S**ound **S**peed and **A**ttenuation **P**robe), a device developed and built by the Center for Coastal and Ocean Mapping (CCOM). The location of the Geoclutter field area is the mid-outer continental shelf off New Jersey. Over 30 gigabytes of seawater and surficial sediment data was collected at 99 station locations selected to represent a range of seafloor backscatter types. At each station, the ISSAP device recorded waveform data across five acoustic paths with nominal probe spacing of 20 or 30 cm. The transmit/receive probes were arranged in a square pattern and operated at a nominal frequency of 65 kHz. The recorded waveforms were processed for sound speed using two methods, cross-correlation and envelope detection, and compared. The waveforms were also processed for sediment attenuation using the filter-correlation method. Results show considerable variability in the acoustic properties at the same and nearby seafloor locations.

1 Introduction

The earliest published work involving *in situ* measurement of acoustic properties was performed using diver-deployed probes in shallow water [1], a difficult and time-intensive task. During the late 1960's, a deep-diving submersible [2] was used to measure the attenuation of compressional acoustic waves in deep-water, but again divers were left to deploy probes in shallow waters and only a small number of stations were measured. A complete summary of the early research is contained in [3]. Recently, *in situ* measurements have been obtained with sophisticated platforms capable of obtaining multiple, rapid measurements of near surface values of sediment geoacoustic and geotechnical properties [4, 5]. Current propagation models predicting the interaction of acoustic waves with the seafloor are limited by a lack of data correctly depicting the spatial variability of the seafloor. To expand present understanding of acoustic wave propagation mechanisms in marine sediments, it is imperative to obtain abundant and high-resolution measurements in their natural setting.

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2 Experiment description

As part of the ONR Geoclutter program the Center for Coastal and Ocean Mapping designed, built, and deployed ISSAP, a geoacoustic measurement system capable of measuring surficial sediment compressional wave velocity and attenuation. ISSAP was constructed of aluminum and stainless steel, weighed approximately 275 kg, had a height of 1.5 m, and a 9.4 m square footprint. It had two principal parts; an outer frame that acted as a guide for an inner frame assembly. The outer frame consisted of a protective tripod reinforced with a tapered skirt. Articulated tripod feet allowed for vertical probe insertion on slopes up to 20 degrees. Included in the inner frame assembly were a load bearing box beam structure, a 0.36 m square aluminum platform, and a guard ring slightly larger than 1 m in diameter. Mounted on the inner frame platform were two pressure housings for electronics, a color video camera and light, and a Jasco Research UWINSTRU, which measured platform heading, pitch, and roll, depth, and bottom water temperature. The transducer probes were mounted to the underside of the platform with Delrin™ precision machined collars (Fig. 1) designed to minimize travel of the acoustic signal through the ISSAP frame and displacement of the probes during insertion. Multiple locations were available for probe placement. Acoustic path lengths were adjustable in 10 cm increments from 10 to 60 cm.

The ISSAP instrument used four transducer probes arranged in a square pattern giving approximate acoustic path lengths of 30 cm and 20 cm. The active elements were piezoelectric ceramic cylinders with diameter and length of 2.54 cm. Overall probe length was about 30 cm which allowed for up to 20 cm insertion into the sediment. The active zone of the transducer was located at a maximum insertion depth of 15 cm. The transducers were used to transmit and receive, and operated at a frequency of 65 kHz. Sensitivity and response between transducer pairs at different angles was approximately equal.

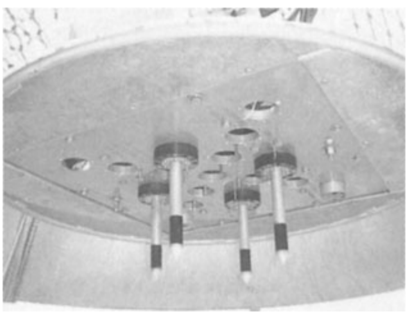

Figure 1. Arrangement of transducer probes on ISSAP and method of mounting.

Five acoustic paths were used to measure compressional speed of sound and attenuation; two long paths (30 cm) and three short paths (20 cm). A 40 μs pulse was generated at a repetition rate of 30 Hz. The acoustic signal detected by the receive transducer was amplified and combined with the transmitter gate pulse to generate a composite signal (see Fig. 2). The gain mode was set to LOW (0 dB) for seawater measurements and HIGH (12 dB) for most sediment measurements. The composite signal was sampled at a frequency of 2 MHz with a National Instruments PCI-6110E A/D data acquisition board. The composite sampled waveform contained all information necessary to calculate the time-of-flight of the acoustic pulse. A distilled water calibration procedure was performed to compensate for fixed system delays. For a complete description of the ISSAP instrument see Mayer *et al.* [6].

Acoustic measurements with ISSAP, and sediment samples from the seafloor (grab and a few slow-core), were collected at 99 station locations over an area approximately 1300 square km. At each location, the ISSAP instrument was lowered to a height ~10 m