Geoacoustic Physical Modeling: Volume-Roughness Interactions

Anatoliy N. Ivakin
Applied Physics Laboratory,
College of Ocean and Fishery Sciences, University of Washington,
1013 NE 40th Street, Seattle, Washington 98105
phone: (206) 616-4808 fax: (206) 543-6785 email: ivakin@apl.washington.edu

Raymond Soukup
Naval Research Laboratory,
4555 Overlook Avenue, Washington D.C. 20375
phone: (202) 404-4833 fax (202) 404-7732 email: soukup@abyss.nrl.navy.mil

Award Number: N00014-07-1-0172

LONG-TERM GOALS

The long-term scientific objective of this research is to develop a geoacoustic model of the seafloor using laboratory studies for better understanding the physics of interaction between sound and marine sediments. The emphasis is on phenomena encountered in the interaction of high-frequency acoustic signals with littoral ocean bottoms.

OBJECTIVES

The specific objective of this research is to investigate the physics of volume-roughness interactions in sea bed scattering using physical models in controlled experiments in NRL tank facilities.

APPROACH

This project is a part of collaboration between APL and NRL, which involves water tank measurements of scattering from various fabricated physical models, such as heterogeneous rough plates, to model scattering from the littoral ocean bottom (e.g., sandy sediments with rough surface and various inclusions such as shells, rocks and gas bubbles) in the 50-300 kHz frequency range. These experiments will take place at the NRL Shallow Water Acoustic Laboratory.

Sediment acoustics experiments at sea (such as the SAX04 shallow water environment) can be extremely (and unpredictably) complicated due to weather effects and the biological activity (fish near the bottom and organisms in the sediment) [1], so there is often ambiguity and uncertainty in performing scattering model/data comparisons in an attempt to validate any theory. Therefore, laboratory experiments on scattering in controlled conditions, using fabricated physical models of ocean sediments in controlled conditions, with a simple and unambiguously defined environment, would be very relevant and complementary to experiments at sea.

The goal of this laboratory study is experimental testing of several interesting effects which should be observed in acoustic scattering from rough heterogeneous natural media, such as marine sediments. These effects are caused by volume-roughness interactions and should be very pronounced at near- and

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 2007	**Annual**	**00-00-2007 to 00-00-2007**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Geoacoustic Physical Modeling: Volume-Roughness Interactions	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of Washington,College of Ocean and Fishery Sciences,1013 NE 40th Street,Seattle,WA,98105**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
code 1 only

14. ABSTRACT
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15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**3**	

sub-critical grazing angles [2]. For example, the very first theoretical considerations by Ivakin [3] predicted the dramatic enhancement of volume scattering at these angles because of enhanced penetration due to interface roughness (which is a major issue in the SAX99 and SAX04 experiments).

In this project, we propose investigating volume-roughness interaction effects in underwater acoustic scattering using an approach which is based on tank experiments. As a whole, the approach allows the study of these effects through a series of steps whereby the physical processes are first observed separately and then as interacting phenomena.

WORK COMPLETED AND RESULTS

This first year of the three year project included mostly preparations for experiments which are to be performed during next year. Various materials and fabricated models were considered and chosen to appropriately accommodate conditions of the scattering experiments so that acoustical properties of the models correspond to those for various types of heterogeneous rough sediments. The experimental planning assumed, in particular, elaborating certain initial requirements and recommendations to fabricate physical models for the experiments with appropriately chosen parameters (e.g., parameters for roughness and inclusions, their shapes, scales and locations) to provide conditions at which, first, the models would be simple enough to provide control over all the important parameters and, secondly, the volume-roughness interaction effects would be mostly pronounced for reliable observations and comprehensive acoustic measurements.

These considerations resulted in a plan for testing the effects of volume-roughness interactions and, particularly, the enhancement of volume scattering, through three steps:

1. Experiments will be conducted using a plate made from a homogeneous material (such as blue wax) with a rough surface. The roughness will be the only mechanism of scattering and will be precisely known.

2. A plate with flat interfaces will be used made from the same material (blue wax) but with known heterogeneity (such as inclusions of glass beads) and thus again with only one mechanism of scattering.

3. The wax plate with the same inclusions and the same roughness, where volume-roughness interactions are involved, will be used.

The experiments corresponding to these three steps will take place in FY2008, and most of the analysis and publication of results is planned for FY2009. These experiments will take place at the NRL Shallow Water Test Facility, and the data acquisition will be performed in a manner analogous to NRL experiments with rough interfaces [4,5]. However, previous NRL experiments have involved only homogenous physical models with no volume scatterers and have used different materials, e.g., PVC, imitating hard types of ocean bottom (for example, limestone).

IMPACT/APPLICATIONS

The results on scattering from sediment models obtained in this research will provide a better understanding of bottom acoustic interaction at high frequencies. The results of this research will be published and widely open to scientific community, and can be used in algorithms for remote geoacoustic characterization of marine sediments (ONR, Code 321CG).

RELATED PROJECTS

This research is closely related to projects involving the study of acoustic interactions with heterogeneous ocean bottoms. NRL, APL/UW, CNRS/MRS and NURC will collaborate under an approved JRP for FY07-09 with a focus on tank experiments with physical models for buried objects and volume scatterers. This JRP is not a funded project, but rather an agreement for international collaboration that is included in the NURC Program of work, involving funded projects from these various organizations. The time frames of the JRP and this project are intended to correspond with the NRL base project by Soukup "Acoustic Interactions with Heterogeneous Media".

This research is also related to Ivakin's FY06-FY07 project "High frequency scattering from water saturated sandy sediments: Laboratory study" sponsored by ONR Ocean Acoustics and conducted in collaboration with Dr. Sessarego of CNRS/Marseille, France. That project also involves a laboratory study approach, however, it includes experiments with natural sand sediments, preliminary degassed and flattened, to focus on effects of the granular structure of sediments with different mean grain size (e.g., medium vs coarse sands).

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