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7 May, 1997

Dr. Jeff Simmen
Program Manager
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Dear Jeff:

This is my final letter for Grant No: N00014-93-1-1352 entitled "Finite difference modeling of bottom reverberation". The period of this grant was from 01 September, 1993 to 28 February, 1997. Total amount of the grant was $93,000. The purpose of this grant was to apply finite difference synthetic seismogram techniques to modeling of low-grazing angle seafloor scattering and reverberation; to continue forward-modeling of ARSRP Natural Laboratory environments; and to determine the accuracy of facet and finite difference models in reproducing scattered fields when realistic geoacoustic properties are assumed. Research was carried out in accordance with the following Grantee proposal:

Date	Proposal Number	Amount
17 May 93	8286.1	$93,000

This grant supported, in part, Chris Bradley to complete his Ph.D. Thesis in the MIT-WHOI Joint Program in Oceanography (Bradley, 1994). Chris used 3-D finite difference modeling to compare scattering from volume and interface heterogeneities at the seafloor (Bradley and Stephen, 1996). 2-D and 3-D models for flat seafloors with sub-bottom heterogeneities, single facets, and statistically rough seafloors were compared. Chris observed significant secondary and tertiary scattering from rough, hard bottoms representative of basaltic seafloors. The results indicate that two-dimensional techniques may be appropriate for modeling sub-bottom volume heterogeneities with velocity contrasts less than 10% and that they may underestimate scattering from rough seafloors. The discrepancy between 2-D and 3-D models is partly attributed to sub-surface conversion to horizontally polarized shear waves on 3-D models. This is significant for both volume and interface heterogeneities. The results of the 3-D modeling were used in part to explain observations of ambient noise below the seafloor (Bradley et al, in press).

The grant has also supported Robert Greaves in his Ph.D. research. Bob has completed an analysis of the ARSRP acoustic backscatter data from Site A (Greaves and Stephen, 1997). He

studied the correlation between backscattered signals from "inside corner" and "outside corner" crust and the observed hydrosweep bathymetry. He concluded that the seafloor dip, on the scale of a few hundreds of meters, influences but does not determine scattering strength. The observed variations in scattering strength too large to be explained by data error or seafloor dip. Other characteristics of steeply dipping areas, such as subsurface properties or smaller scale surface features, strongly affect backscattered signals.

Greaves is continuing his thesis research. He has a chapter in preparation giving a detailed geological description of Site A at a range of scales He is using these results as the basis for 2-D finite difference modeling of actual backscattered signals from the ARSRP experiment. Greaves is targeting Fall '97 for his thesis defence.

If you have any other questions or need more information please let me know. We appreciate your support. Thanks.

Yours sincerely,

Ralph Stephen

cc: Roy Smith, WHOI

Papers published under ONR support on Grant No: N00014-93-1-1352 (1993-1997)

Refereed Journals:

Bradley, C.R. and Stephen, R.A., 1996. Modeling of seafloor wave propagation and acoustic scattering in 3-D heterogeneous media. J.acoust. Soc. Am., 100, 225-236.

Bradley, C.R., Stephen, R.A. and Dorman, L.M., in press. Very low-frequency (0.2-10Hz) seismoacoustic noise below the seafloor. J.geophys.Res.

Greaves, R.J. and Stephen, R.A., 1997. Seafloor acoustic backscattering from different geological provinces in the Atlantic Natural Laboratory. J.acoust.Soc.Am., 101, 193-208.

Theses:

Bradley, C.R. (**1994**). *Very low frequency seismo-acoustic noise below the sea floor (0.2-10Hz)* Ph.D. Thesis, Massachusetts Institute of Technology and Woods Hole Oceanographic Institution.

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13. ABSTRACT *(Maximum 200 words)*

Finite difference modeling was used to compare scattering from volume and interface heterogeneities at the seafloor. Two-dimensional and three-dimensional models for flat seafloors with sub-bottom heterogeneities, single facets, and statistically rough seafloors were compared. Significant secondary and tertiary scattering from rough, hard bottoms representative of basaltic seafloors was observed. The results indicate that two-dimensional techniques may be appropriate for modeling sub-bottom volume heterogeneities with velocity contrasts less than 10%. The discrepancy between two-dimensional and three-dimensional models is partly attributed to sub-surface conversion to horizontally polarized shear waves on 3-D models for both volume and interface heterogeneities. The results of the 3-D modeling were used, in part, to explain observations of ambient noise below the seafloor. Analysis of the ARSRP acoustic backscatter data from Site A was completed. The correlation between backscattered signals from "inside corner" and "outside corner" crust and the observed hydrosweep bathymetry was studied. It was concluded that the seafloor dip, on the scale of a few hundreds of meters, influences but does not determine scattering strength. Other characteristics of steeply dipping areas, such as subsurface properties or smaller scale surface features, strongly affect backscattered signals.

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