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14. ABSTRACT

The long term science goals of the project are to understand the nature of the seabed at the geoacoustic meso-scale $O(10^0–10^3)$ m and determine how these structures impact acoustic propagation, diffuse reverberation, and clutter. Several discoveries were made in the course of the project, notably that a) there is a persistent scale, O(0.1) m that controls reverberation in a number of shallow water environments, and b) clutter can be generated by non-discrete, i.e., smoothly and slowly-varying sediment structures (in addition to traditional discrete features, e.g., wrecks). In addition, there were a number of significant advances including: development of measurement techniques/processing to measure meso-scale geoacoustic variability over tens of km with resolution of 0.1 m/7 m in the vertical/lateral dimension; and developing tools to separate frequency-dependent effects so that unbiased estimates of intrinsic attenuation can be made. Even on the mid to outer shelf, substantial lateral variability at the 10 m lateral scale is observed. The underlying processes that lead to that strong variability are not understood at this time.

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Seabed Geoacoustic Structure at the Meso-Scale

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LONG TERM GOALS

The long term science goals are to understand the nature of the seabed at the geoacoustic meso-scale $O(10^0–10^3)$ m and determine how these structures impact acoustic propagation, diffuse reverberation, and clutter.

OBJECTIVES

The objectives are to develop new observational methods to quantify meso-scale seabed variability/ uncertainty and also develop modeling techniques to understand the impact of spatial variability on propagation and reverberation.

RESULTS

The scientific results are contained in 15 peer-reviewed publications. Some of the highlights are briefly described below.

Discoveries

- discovery of a persistent scale that controls reverberation in a number of shallow water environments (Ref[12]). The consistency of the scale, O(0.1)m, suggests an underlying feature or mechanism (as yet unknown) that is consistent across many ostensibly diverse geological settings. This has significant implications for employment of active sonar, and also for seabed database development.
- Discovered that clutter can be generated by non-discrete, i.e., smoothly and slowly-varying sediment structures (Ref [13]). Generally, clutter from the seabed has been associated with discrete features, e.g., wrecks or carbonate mounds. This discovery has implications for sonar systems and for acoustic probing of sediment structures. (with Dale Ellis, DRDC-A)

Significant Advances

- Developed new method (Ref [9]) for estimating dispersion that explicitly includes separating its freqeuncy-dependent effects from the frequency-dependent effects of sediment layering and gradients. The method also has the virtue of determining the attenuation mechanism, i.e., friction or viscous losses (which itself can be a function of frequency). (with Jan Dettmer, U. Victoria)

- Measurements of 1000-3600 Hz attenuation in a muddy sediment fabric using long-range diffuse reverberation (Ref [6]). The importance of this is that
  a) there is a glaring paucity of measurements in the 600 – 4000 Hz band
  b) mud attenuation has historically been very difficult to measure at all freqeuncies due to measurement biases on high frequency samples
  c) uncertainties in the measurements are almost never reported. Our measurements showed quite low uncertainties – average attenuation in a 10 m thick mud layer was 0.009± 0.003 dB/m/kHz. (with Stan Dosso, U. Victoria)
- In collaboration with Gavin Steininger and others at U. Victoria, developed models and methods, Ref [2] to :
  a) determine whether seabed scattering was dominated by interface roughness or sediment volume heterogeneities;
  b) determine the probability of volume heterogeneities as a function of depth in the sediment stack; and
  c) determine the outer scale of the heterogeneities.

  The ability to determine the scattering mechanism (e.g., interface roughness versus volume heterogeneities) from acoustic data is important for both scientific and operational purposes. For the former, it will permit a deeper understanding of the seabed processes that lead to scattering; for the latter, an emerging bottom scattering database will require provincing methods (e.g., is it possible to extrapolate observations in one area to another that has no measurements?). This, and other provincing questions are greatly aided by identification of the dominant scattering mechansim.
- Developed two distinct techniques to measure/analyze meso-scale seabed variability in shallow water using acoustic reflection data from an AUV. One technique (Ref [15]), exploits the high information content of the reflection coefficient versus angle and frequency, estimating all the geoacoustic parameters and their uncertainties with depth and along the track, i.e., a 2D model with a lateral resolution of about 7 m (with Peter Nielsen, CMRE, Jan Dettmer, U. Victoria). The other technique is several orders of magnitude faster computationally and estimates the 2D sound speed profile using the image source method with a lateral resolution of ~50 m. See Ref [4],[8]). (with Samuel Pinson, post-doc).

Incremental advances

- Developed technique to measure low-angle bi-static seabed scattering in shallow water using an AUV (Ref [16]). (with Peter Nielsen, CMRE, and Chad Smith, PSU)
- In collaboration with Gavin Steininger, Stan Dosso and Jan Dettmer (all from U. Vic) estimated roughness parameters from direct path seabed backscatter data (Refs [10],[11]). This represents the first time there has been an objective inverse method applied to seabed acoustic scattering data to provide not only the scattering parameters, but also parameter uncertainties.
- Conducted *in-situ* geoacoustic measurements of sediments possessing a very wide range of grain sizes including very large granules (e.g., shells, pebbles and cobbles), see Ref [1]. This is a sediment type for which no sediment acoustic models currently exist, and very little has been published. However, this kind of sediment may in fact be relatively common. The results are intended to provide geoacoustic data where little exists in the literature and also to motivate development of models that can treat a wide range of grain sizes. (with partners at U. Victoria).

RELATED PROJECTS

ONR shallow water field experiments: the advances in the project described above will motivate and inform experiment design to distentangle effects of sediment dispersion from other frequency dependent effects.

SPAWAR PMW-120 Seabed Bottom Scattering database development. Many aspects of the theoretical and measurements-related research under the ONR research described above have informed this development.

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