ONR Seabed Characterization Workshop

10-11 April 2012

George V. Frisk
Department of Ocean and Mechanical Engineering
Florida Atlantic University
Dania Beach, Florida 33004

Collaborators:
Kyle M. Becker (NURC)
Cynthia J. Sellers (WHOI)
Subramaniam D. Rajan (Scientific Solutions, Inc.)
MOMAX 4 Drifter Suspension System

4 conductor cable/strength member, 189’ ft, 450lb BS

Stretch section (50’ relaxed, 98’ deployed), K=.17 lb/ft
System natural period ~ 34 seconds

Entrained water drogue, M=4.6 slugs

Temp/pressure module, internally recording

Hydrophones

8 lb wet weight mass

vdH, 2006
Geoacoustic Inversion in Shallow Water Using Through-the-Sensor AEER Signals

Inversion flow chart

Measurements of complex pressure vs range

Horizontal wavenumber spectrum (depth-dependent Green’s function)

Modal eigenvalue estimates from spectral peaks

Perturbative inversion at low frequencies (< 500 Hz)
Reflection coeff. phase inversion at high frequencies (> 500 Hz)

Geoacoustic parameter estimates
Narrowband and broadband transmissions: 50-1000 Hz
- Drifting and towed NUWC J15-3 source at 53 m depth
- Drifting and towed NUWC G34 source at 8 m depth
- Data received on 4 drifting MOMAX buoys, each having hydrophones at 61 m and 64 m depths
- Data received on several GPS-capable 53F sonobuoys with hydrophone at 61 m depth, in some cases co-located with MOMAX buoys

CTD and XBT measurements indicate benign water column in SW06 experimental area
125 Hz Pressure Magnitude and Phase
125 Hz Horizontal Wavenumber Spectrogram (Cross-Shelf)
125 Hz Horizontal Wavenumber Spectrogram (Along-Shelf)
140 Hz Inversion – Ohta & Frisk (IEEE JOE 1997)
Pole Method

\[
g(k_r; z) = \frac{i\{e^{ik_z|z-z_0|} + R_S e^{ik_z(z+z_0)} + R_B e^{2ik_zh}\left[e^{-ik_z(z+z_0)} + R_S e^{-ik_z|z-z_0|}\right]\}}{k_z[1 - R_S R_B e^{2ik_zh}]}\]

\[
R_B(k_r) = |R_B| e^{i\phi(k_z)}
\]

\[
|R_B| e^{2i\left[k_z h + \frac{\phi(k_z)}{2}\right]} = -1 = e^{i(2n-1)\pi}
\]

\[
2i \left[k_z h + \frac{\phi(k_z)}{2}\right] = i(2n - 1)\pi
\]

\[
\phi(k_z) = (2n - 1)\pi - 2k_z h
\]

(Becker 2007, Shang 1996)
950 Hz

Actual:
\[ c_B = 1800 \text{ m/s} \]
\[ \rho_B = 1.5 \text{ g/cm}^3 \]

Estimated:
\[ c_B = 1795 \text{ m/s} \]
\[ \rho_B = 1.54 \text{ g/cm}^3 \]
Key Features of Modal Inversion Methods

High resolution estimates of lateral variation in geoacoustic properties (20-1000 Hz)

- Focus on compressional wave speed profiles in sediments
  - Variance in sound speed estimate ~10 m/s
  - Depth resolution ~1 m

Estimates of horizontal wavenumber spectrum (depth-dependent Green’s function) can be used in several inversion techniques

- Perturbative inversion
- Pole method
- Ratio method uses Green’s function estimate at two receiver depths
- Genetic algorithms

Modal inversion methods can include additional geoacoustic parameters

- Absorption (affects modal peak widths and amplitudes)
- Shear waves (e.g., Scholte wave peak in wavenumber spectrum)
Conduct MOMAX experiment with large number of sonobuoys (e.g., 15-20)

- This approach will provide a 3D characterization of the normal mode field as well as an opportunity to invert for the 3D geoacoustic parameters.

Incorporate the use of COTS sensors used by the operational Navy (e.g., sonobuoys)

- This approach offers the opportunity for the development of geoacoustic survey methods that can be applied to large geographical areas in an operational Navy context.

Perform experiment in late winter/early spring to ensure a homogeneous water column

- This strategy avoids the negative effects of water column variability on the solution of the geoacoustic inverse problem.