ONR Seabed Characterization Workshop

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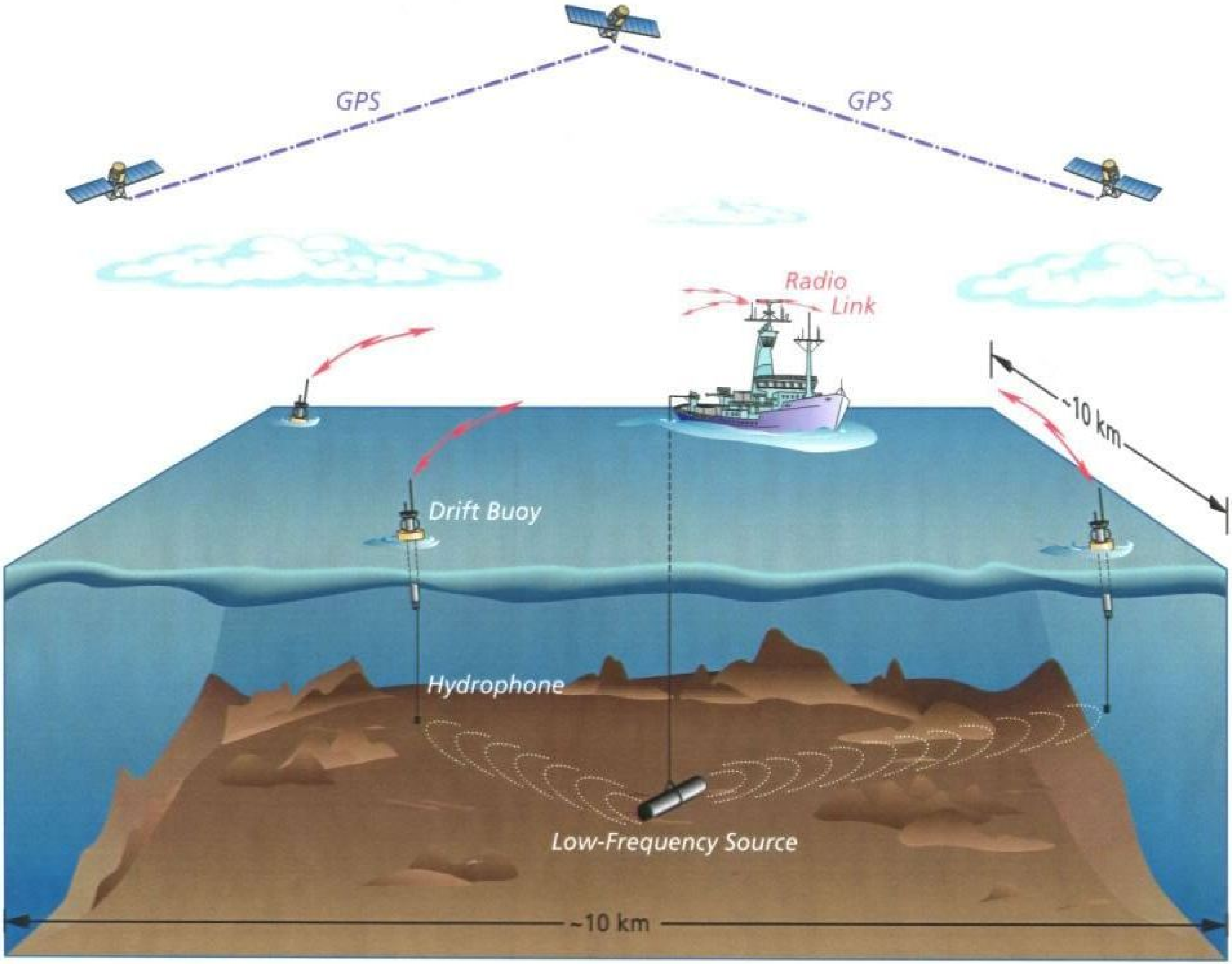
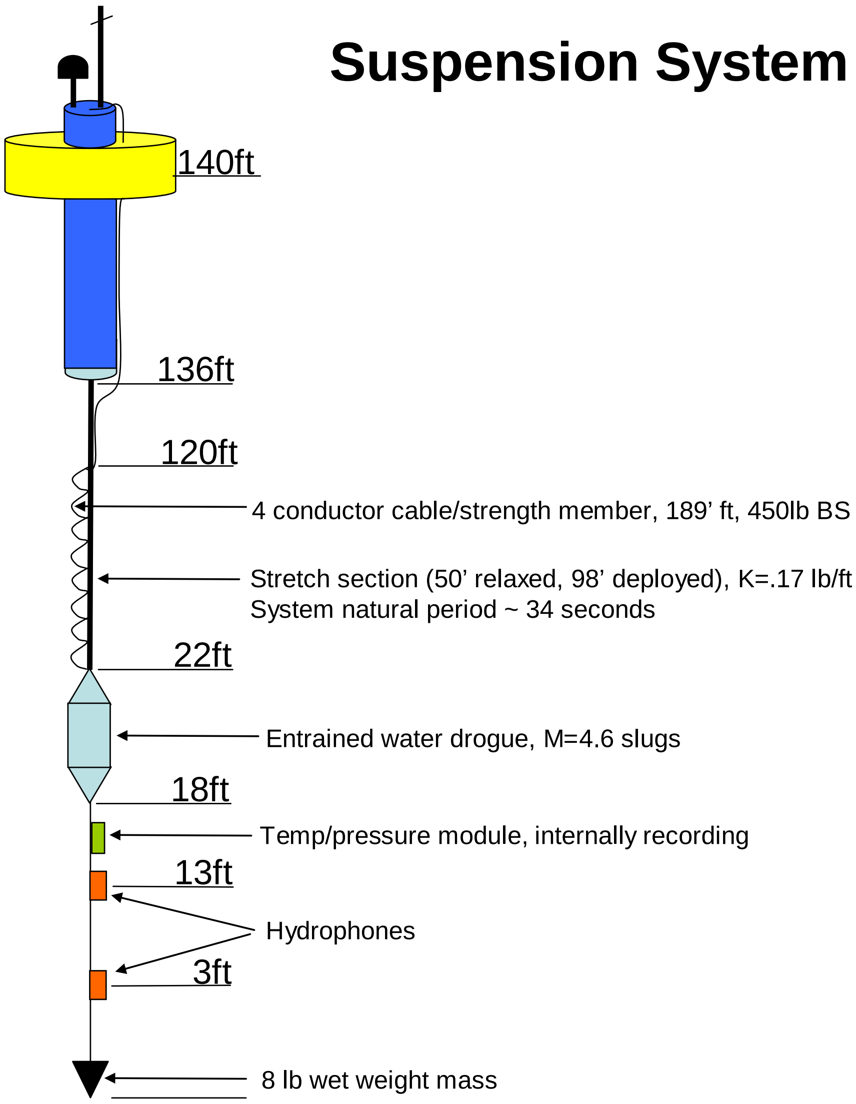


GPS
GPS
Radio
Link
~10 km
Drift Buoy
Hydrophone
Low-Frequency Source
~10 km

MOMAX 4 Drifter

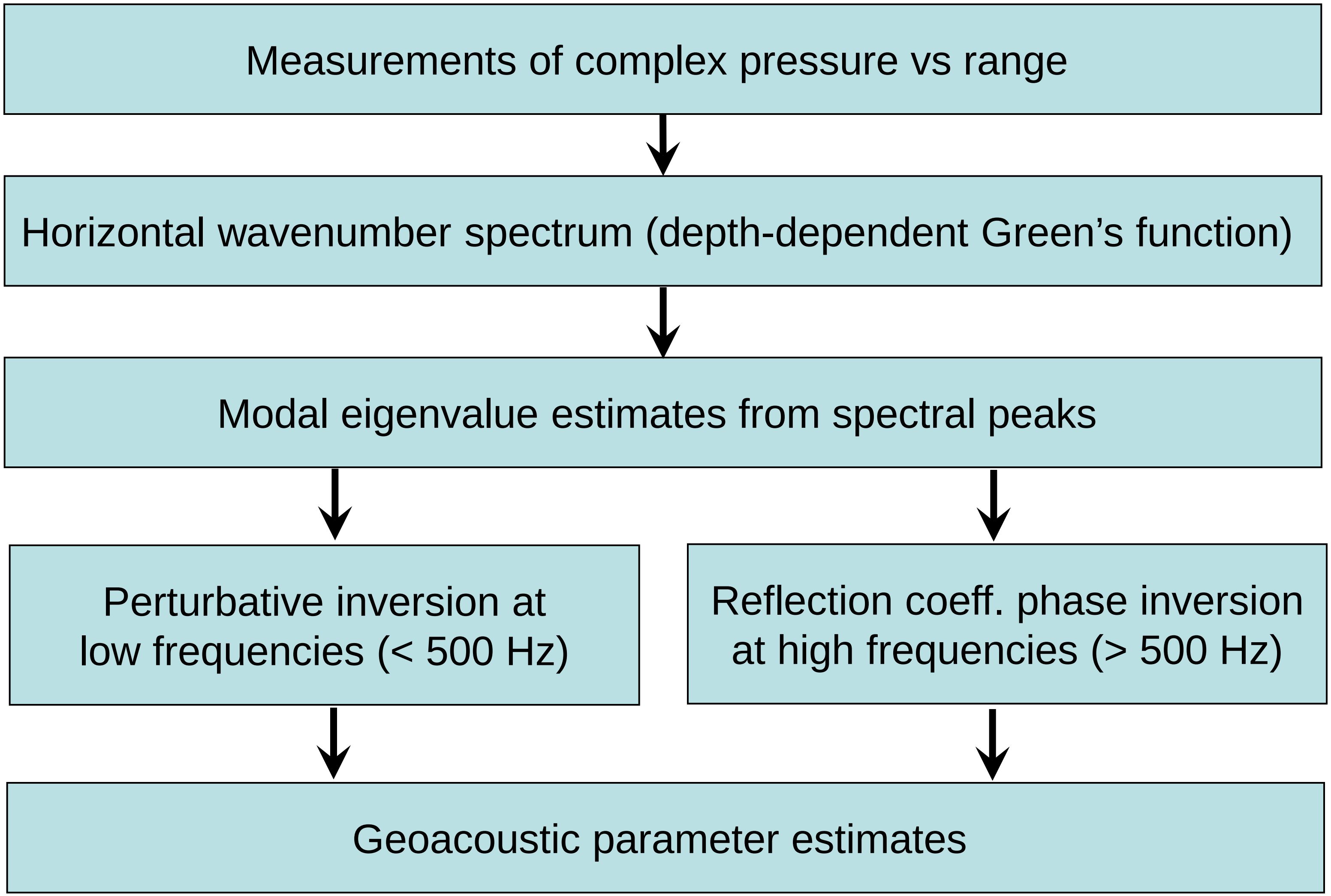
Suspension System



vdH, 2006

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

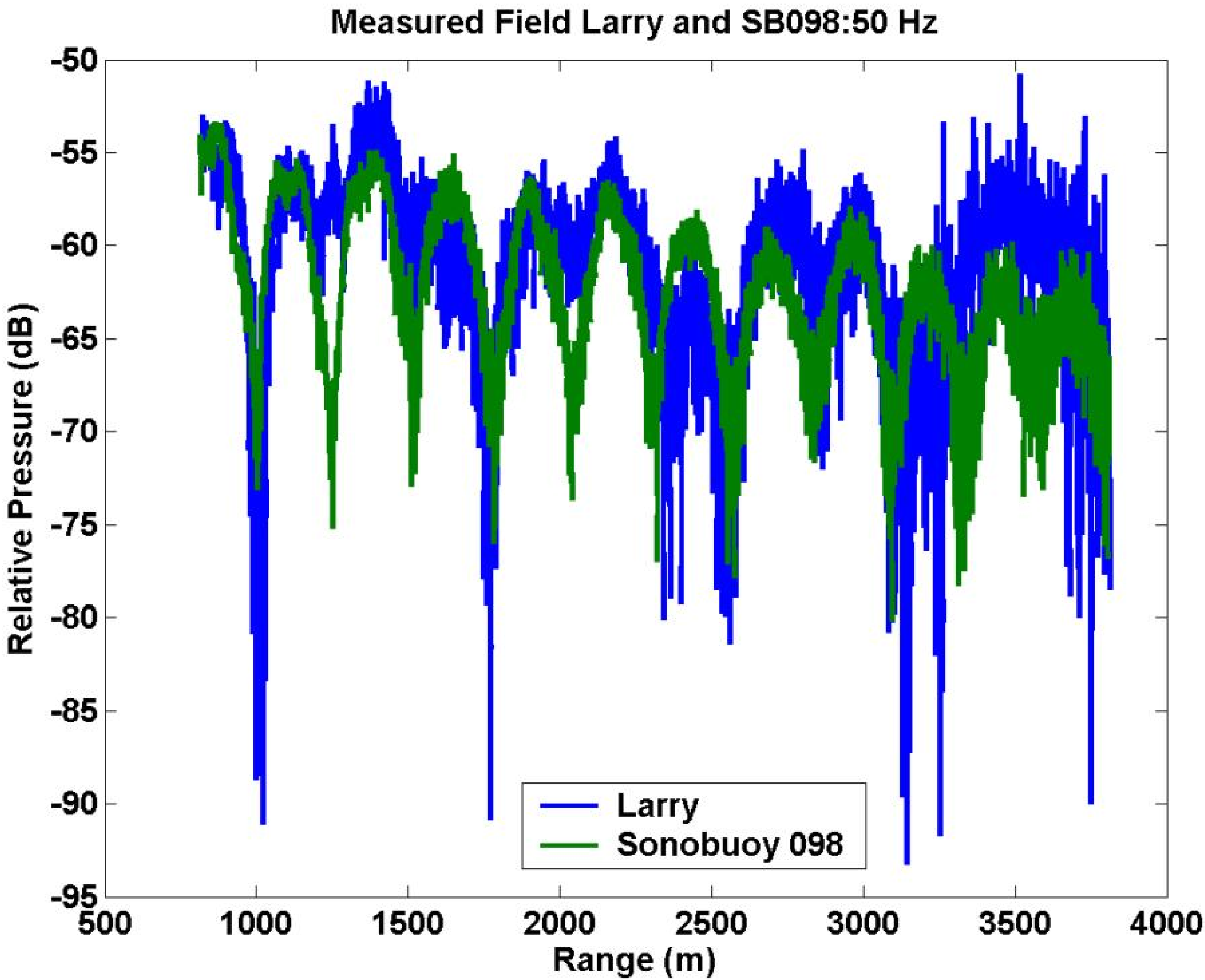
Inversion flow chart

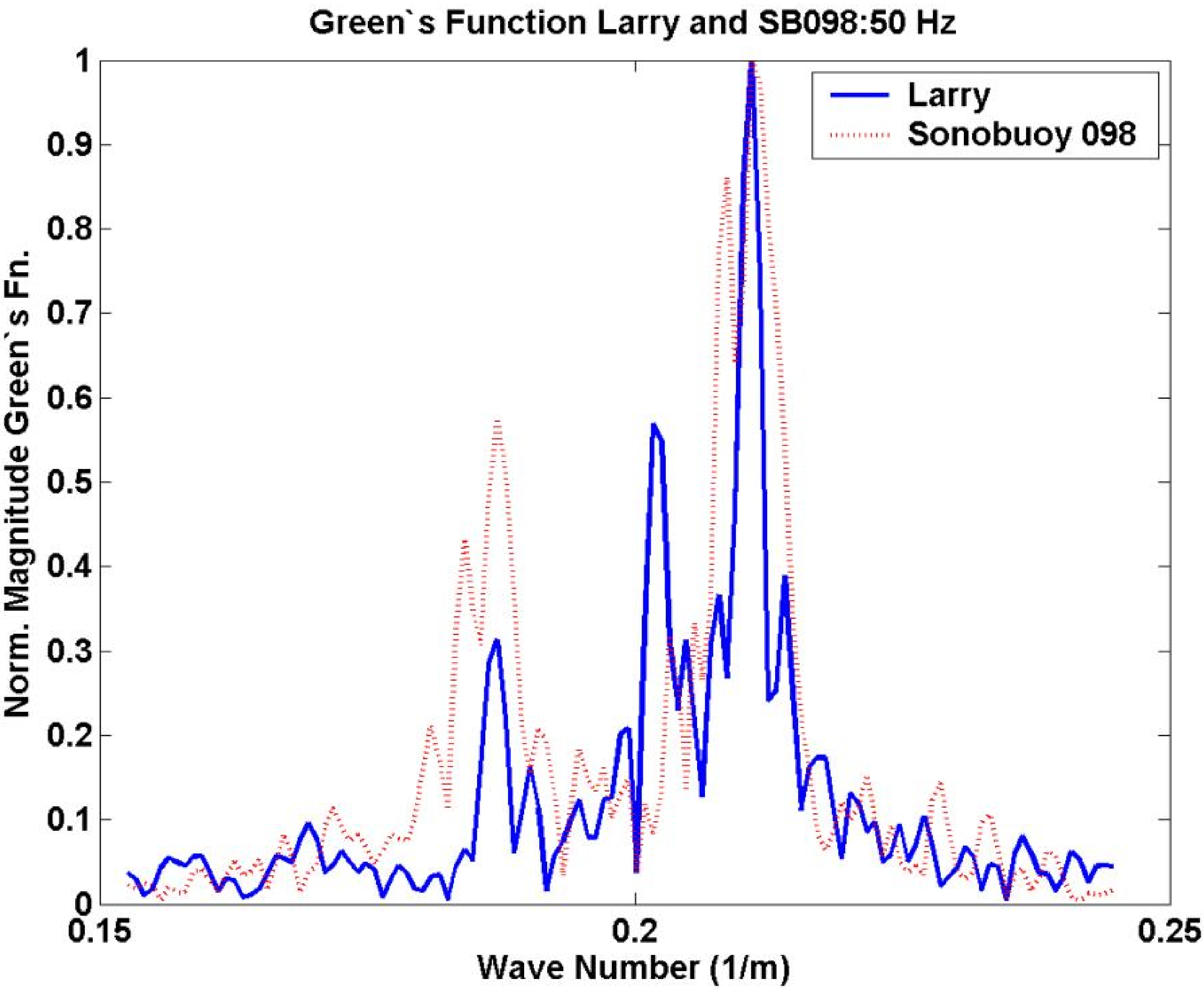


Narrowband and broadband transmissions: 50-1000 Hz

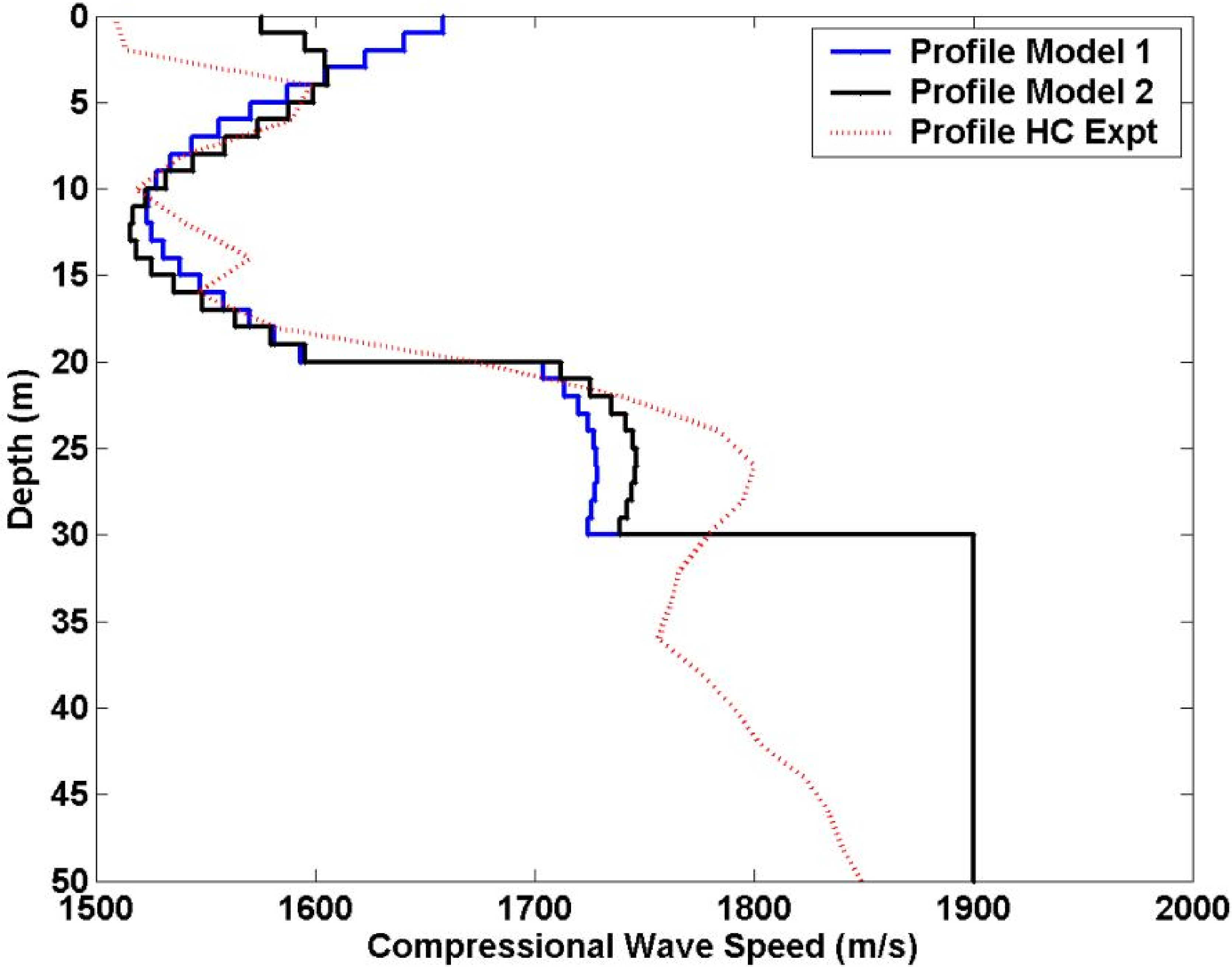
- *Drifting and towed NUWC J15-3 source at 53 m depth*
- *Drifting and towed NUWC G34 source at 8 m depth*
- *Data received on 4 drifting MOMAX buoys, each having hydrophones at 61 m and 64 m depths*
- *Data received on several GPS-capable 53F sonobuoys with hydrophone at 61 m depth, in some cases co-located with MOMAX buoys*

CTD and XBT measurements indicate benign water column in SW06 experimental area


Measured Field Larry and SB098:50 Hz
Relative Pressure (dB)
-50
-55
-60
-65
-70
-75
-80
-85
-90
-95
500
1000
1500
2000
2500
3000
3500
4000
Range (m)
Larry
Sonobuoy 098

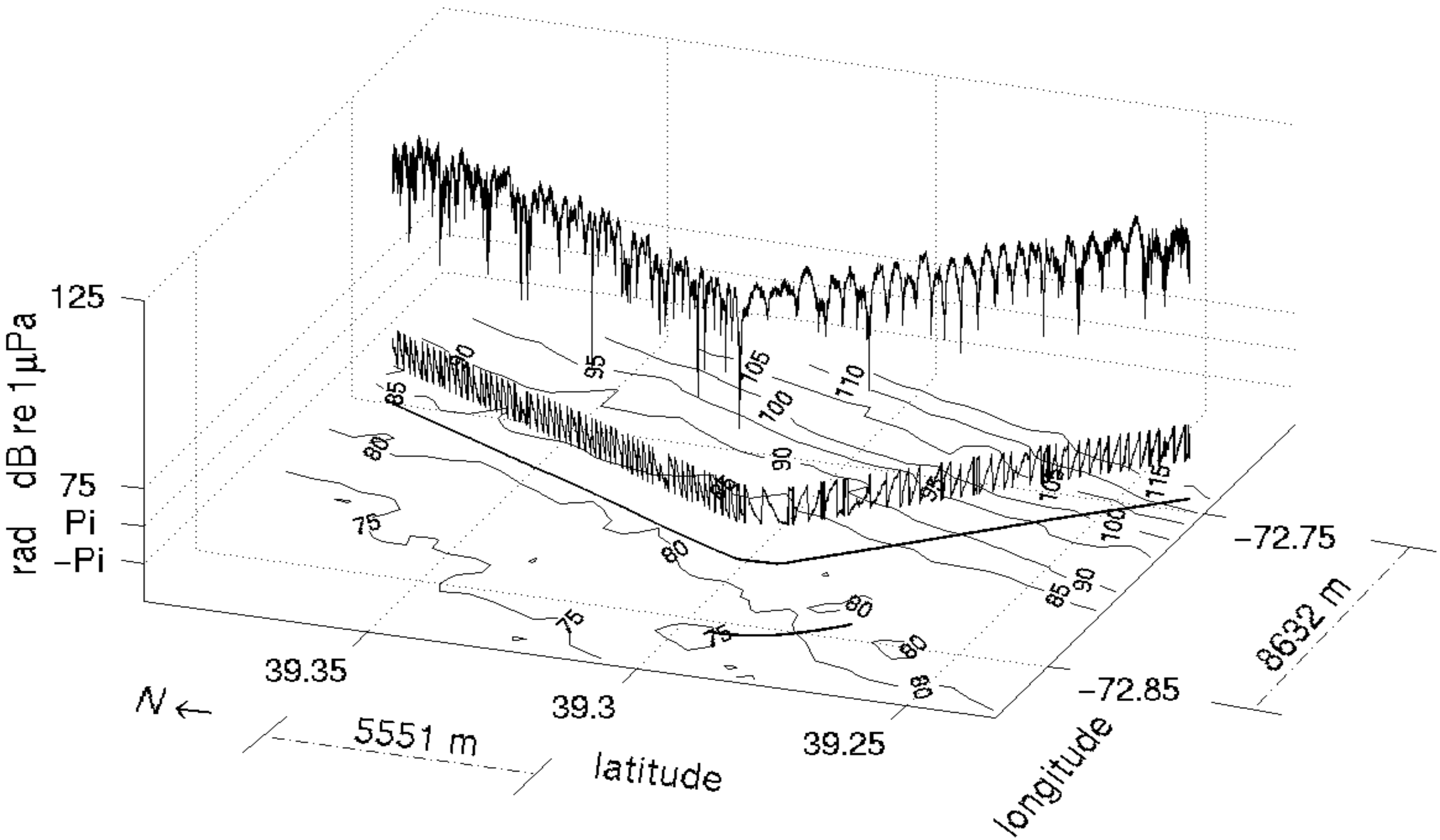


Green`s Function Larry and SB098:50 Hz
Larry
Sonobuoy 098
Norm. Magnitude Green`s Fn.
Wave Number (1/m)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0.15
0.2
0.25

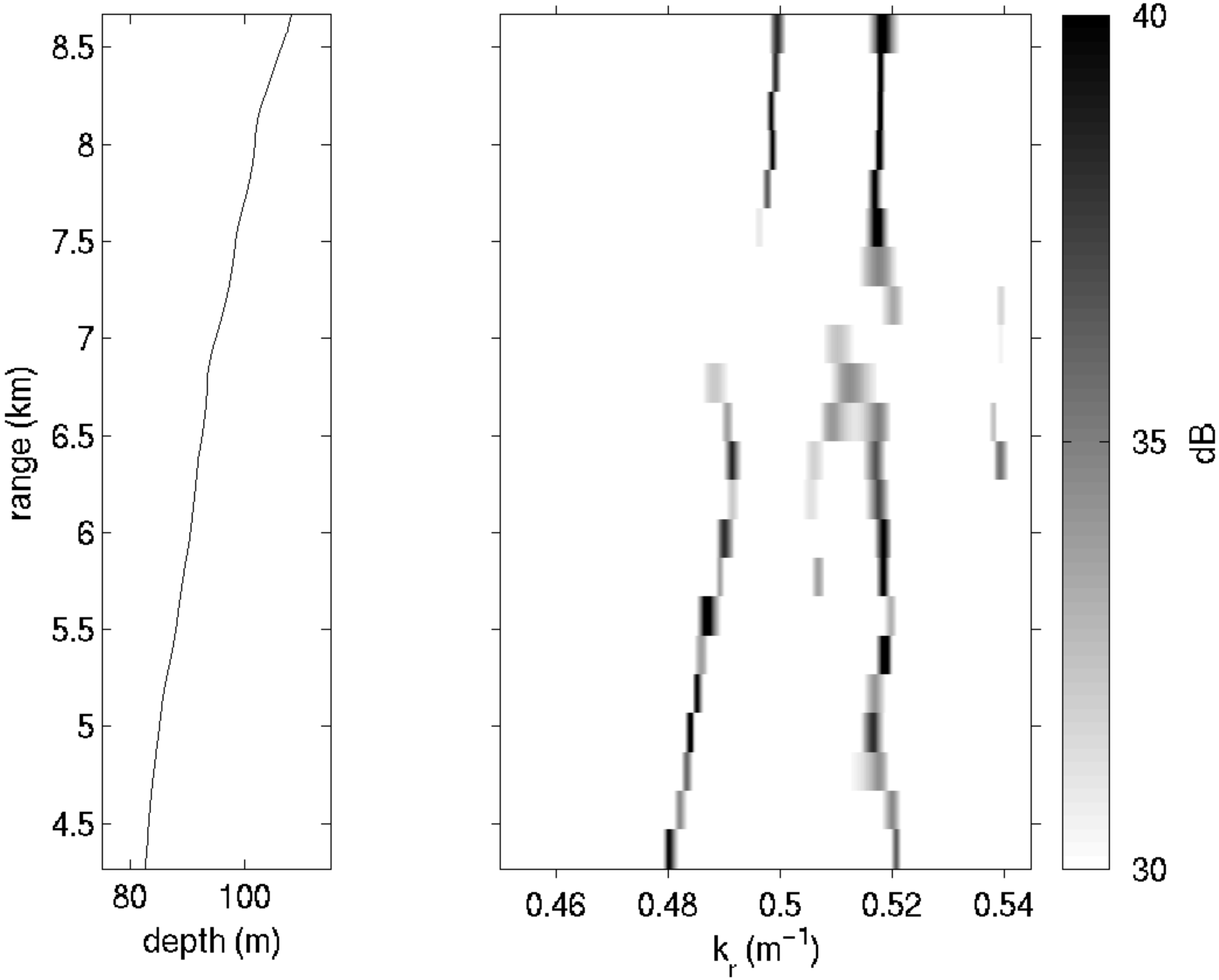


Profile Model 1
Profile Model 2
Profile HC Expt
Depth (m)
Compressional Wave Speed (m/s)
0
5
10
15
20
25
30
35
40
45
50
1500
1600
1700
1800
1900
2000

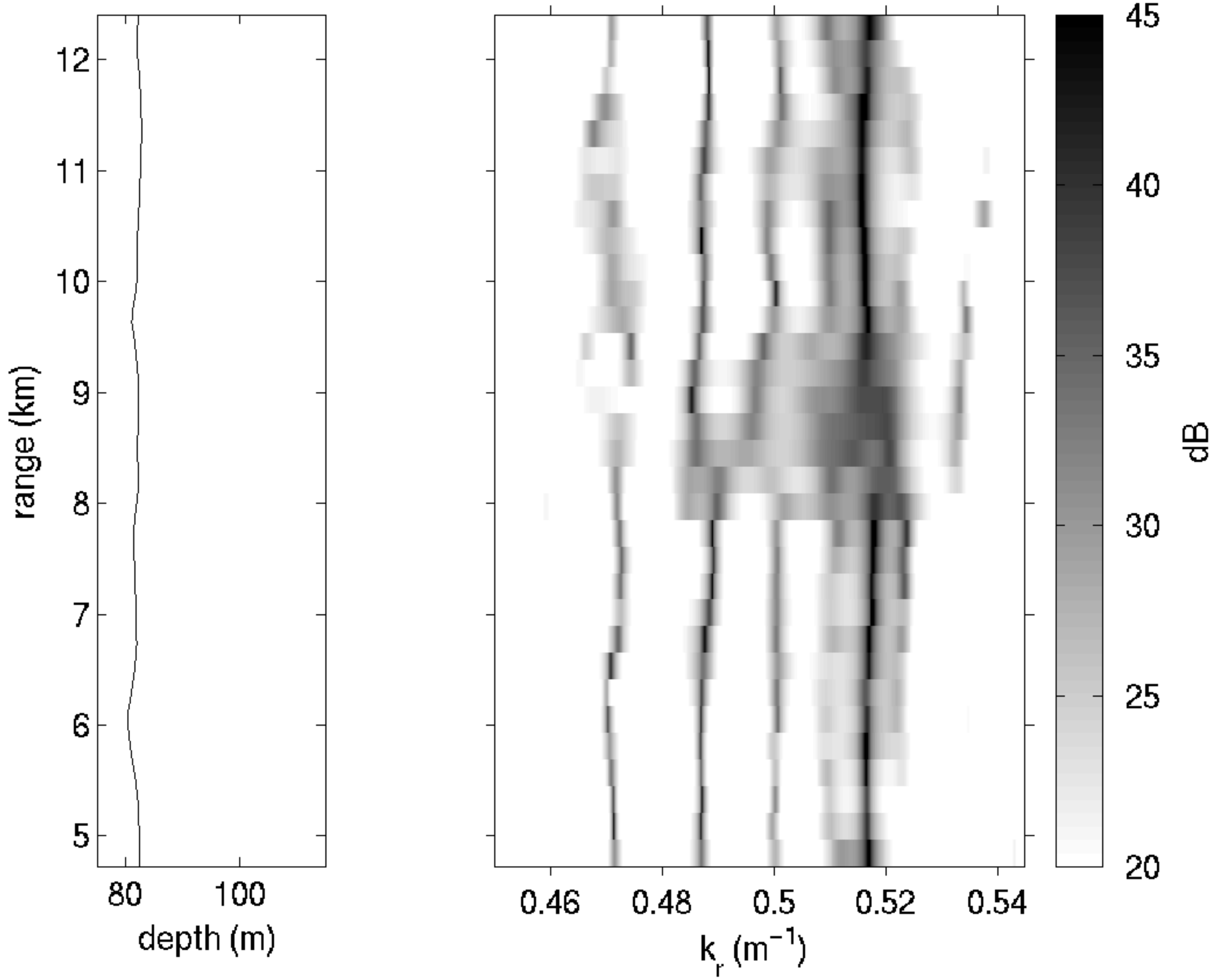
125 Hz Pressure Magnitude and Phase



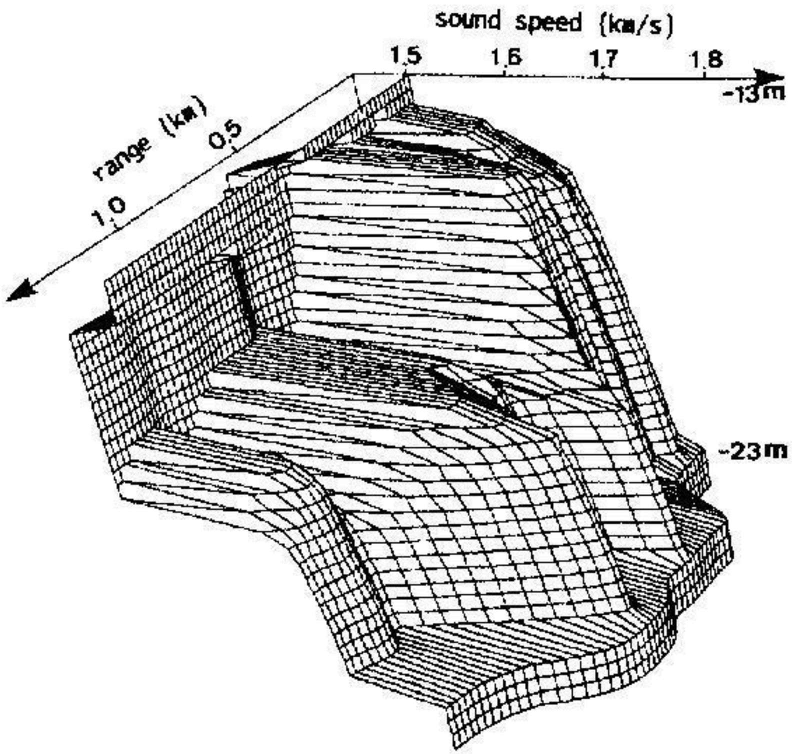
125 Hz Horizontal Wavenumber Spectrogram (Cross-Shelf)

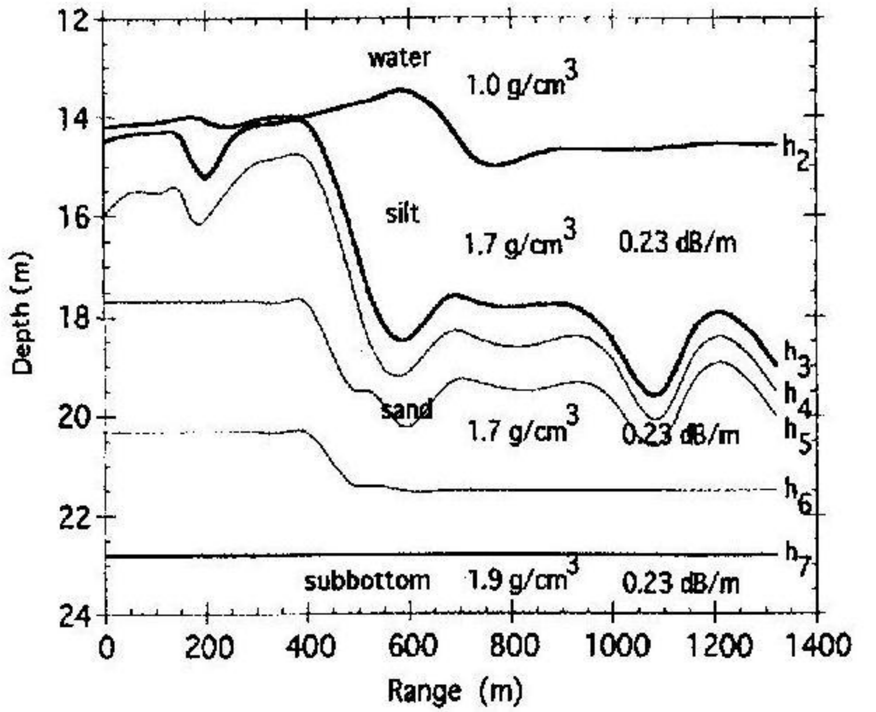


125 Hz Horizontal Wavenumber Spectrogram (Along-Shelf)



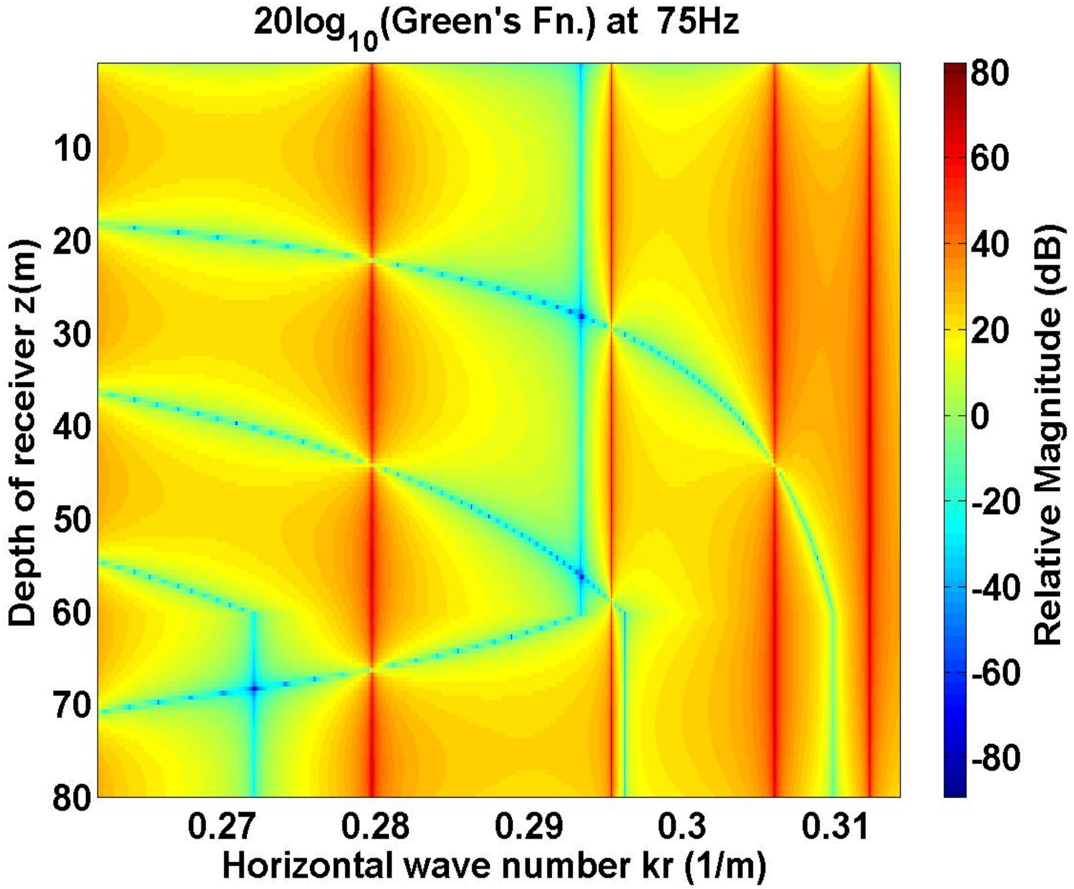
140 Hz Inversion – Ohta & Frisk (IEEE JOE 1997)





Pole Method

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



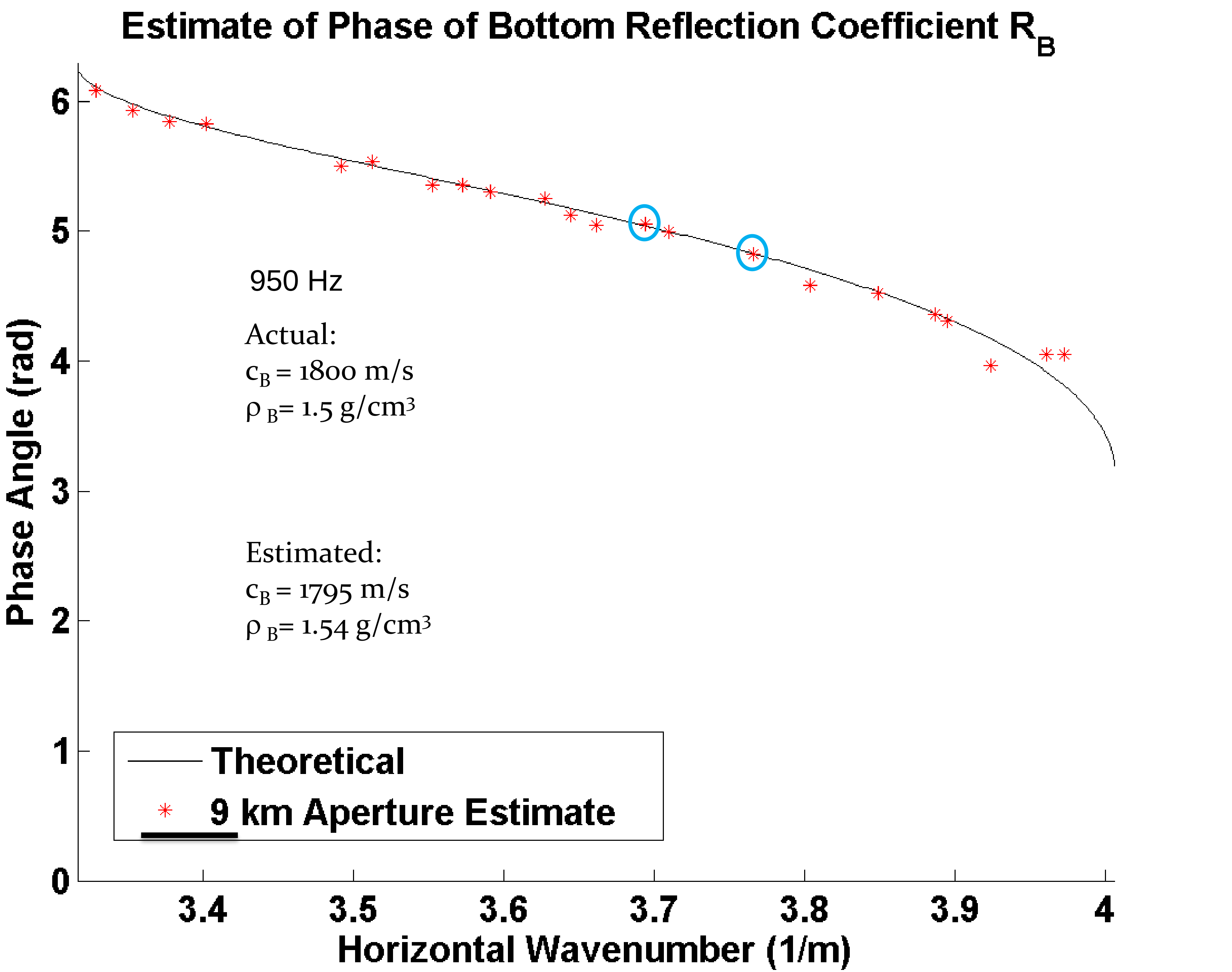
$$R_B(k_r) = |R_B| e^{i\phi(k_z)}$$

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

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

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

(Becker 2007, Shang 1996)



Estimate of Phase of Bottom Reflection Coefficient R_B
950 Hz
Actual:
c_B = 1800 m/s
ρ B= 1.5 g/cm3
Estimated:
c_B = 1795 m/s
ρ B= 1.54 g/cm3
Theoretical
9 km Aperture Estimate
Phase Angle (rad)
Horizontal Wavenumber (1/m)
0
1
2
3
4
5
6
3.4
3.5
3.6
3.7
3.8
3.9
4

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)*

Future Work

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