Measurements of attenuation of sound in marine sediments at low frequencies

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Objective

Estimate sediment attenuation from single bounce reflections from sea bottom and sub-bottom

Outline

- Experimental site & set up
- The method of estimating sediment attenuation
- Data processing
- Supporting parameters in estimating attenuation
- Discussion of the results
- Conclusions and future works

Experimental site & set up

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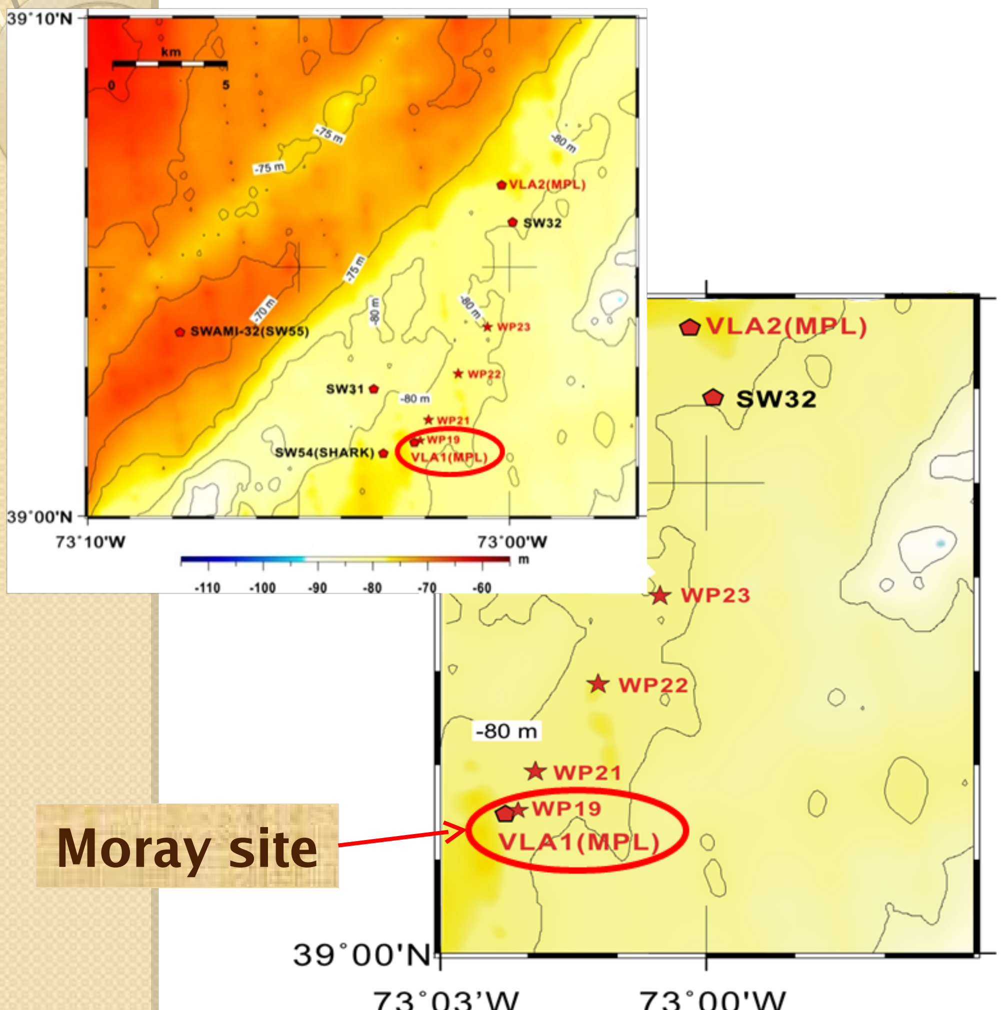

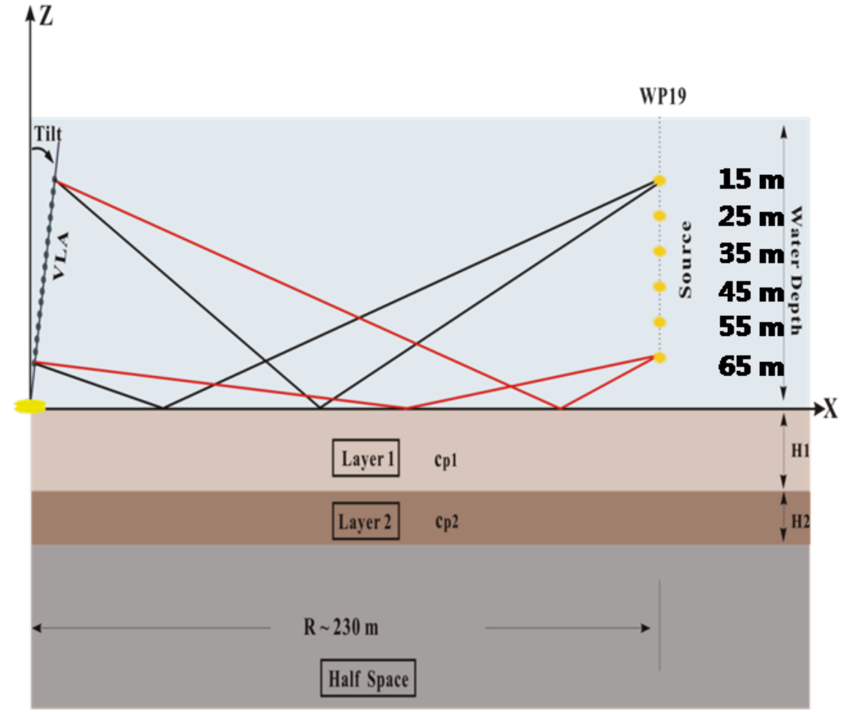

- Varying source depth + VLA to ensure angular coverage
- Water depth ~ 79m
- Range ~ 230m
- Source depth: 15-65m in 10m steps
- Receiver depth: 14.25-70.5m @ 3.75m

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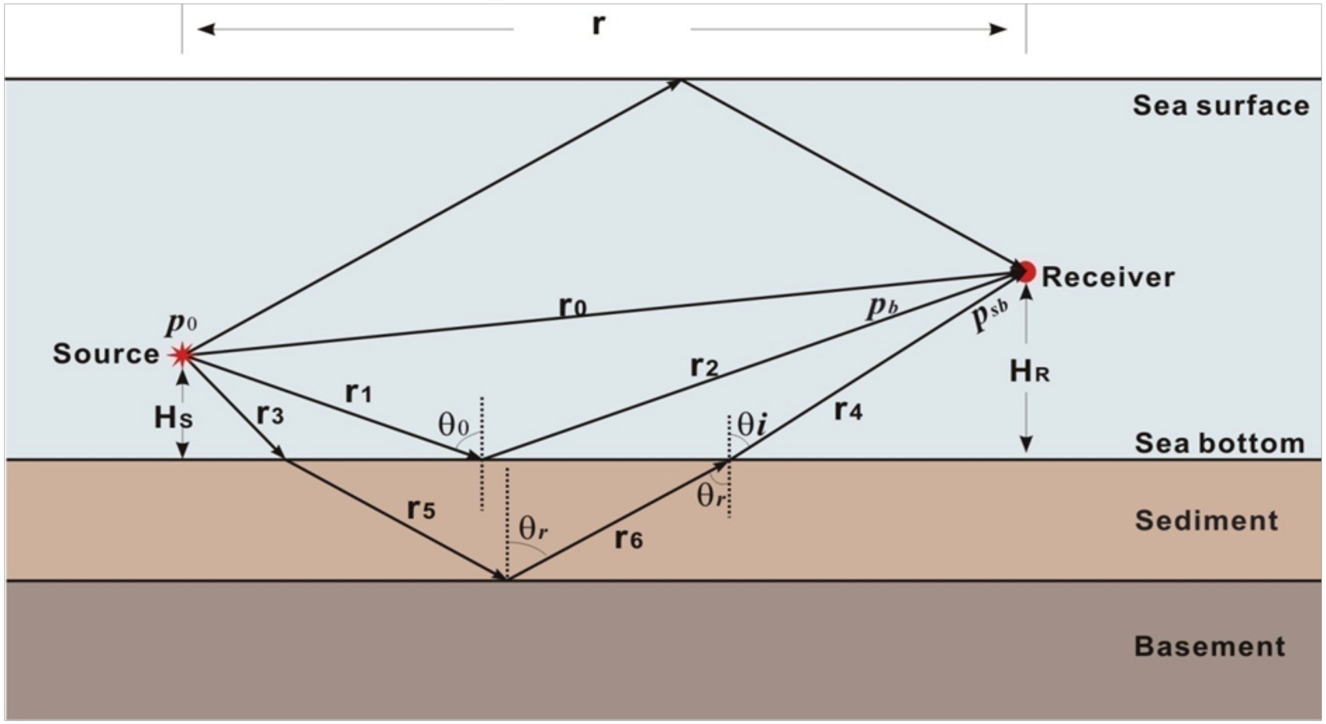
Method of estimating sediment sound attenuation



$$p_b = \frac{p_0 V_{bott}}{r_1 + r_2} e^{-\alpha_w (r_1 + r_2)}, \qquad p_{sb} = \frac{p_0 (T_{ws} T_{sw} V_s)}{r_3 + r_4 + r_5 + r_6} e^{-a_w (r_3 + r_4)} e^{-a_s(f)\cdot(r_5 + r_6)}$$

$$\Rightarrow \quad 20 \bullet \log(p_b / p_{sb}) = b + (r_5 + r_6) \bullet \alpha_s'(f)$$

→ Estimated at different frequencies by band pass filtering the signal

From data

Constant under frequency independent assumption and ignor the attenuation in the water

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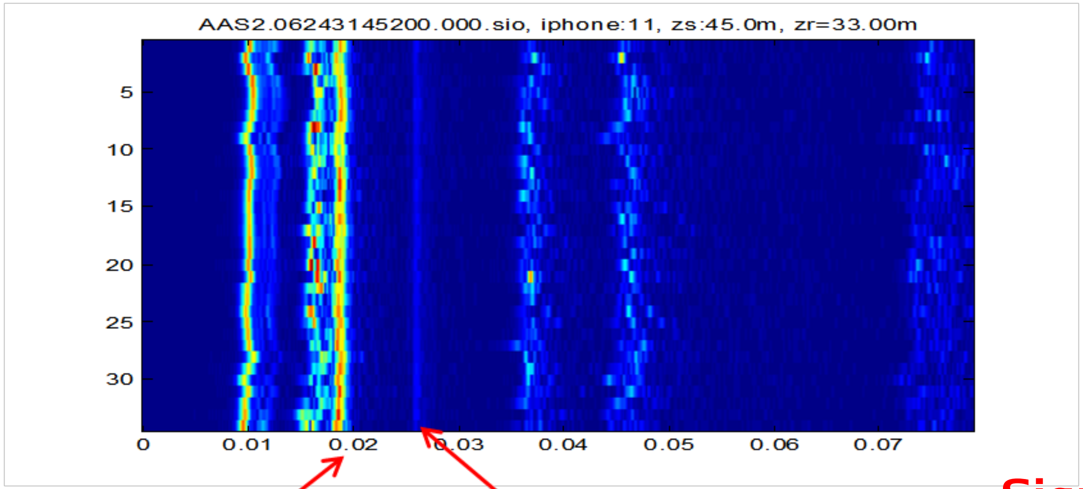
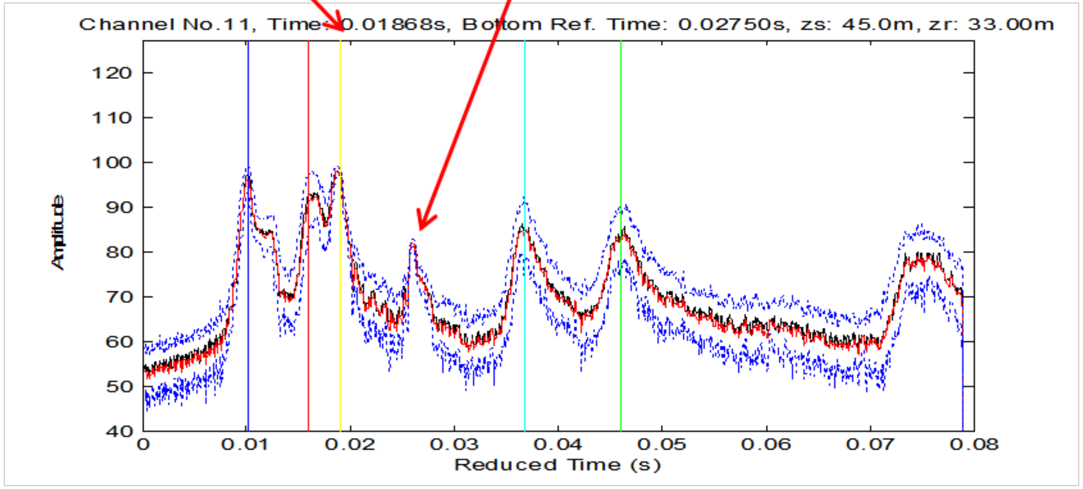
Data processing example



Sea bottom reflection

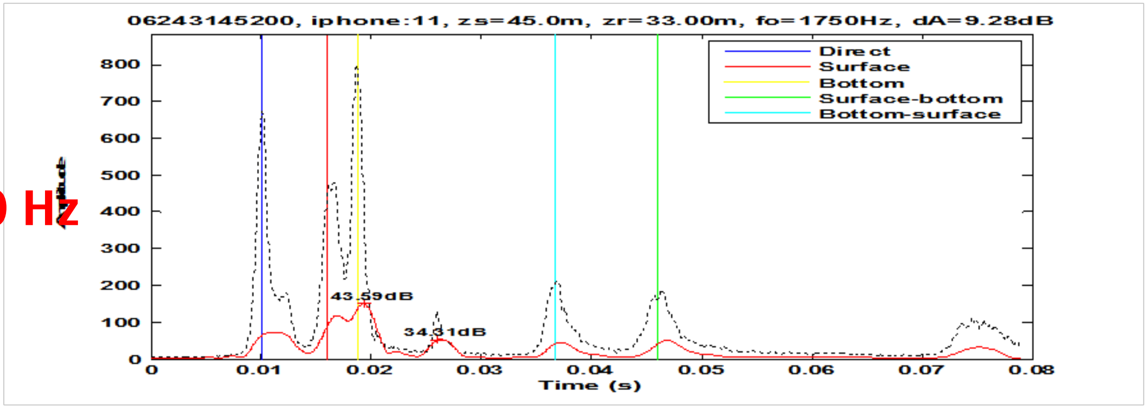
Sub- bottom reflection

Signal frequency band 1500~4500Hz

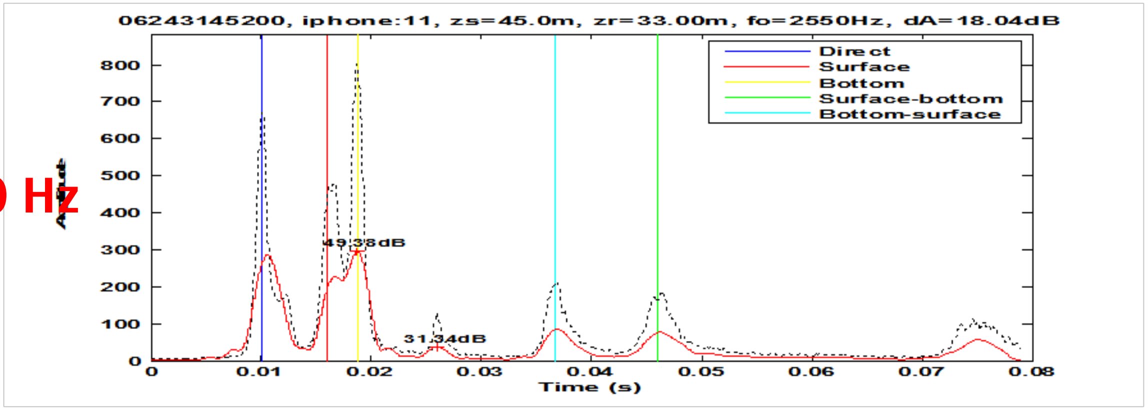


Data processing example cont.

fo=1750 Hz

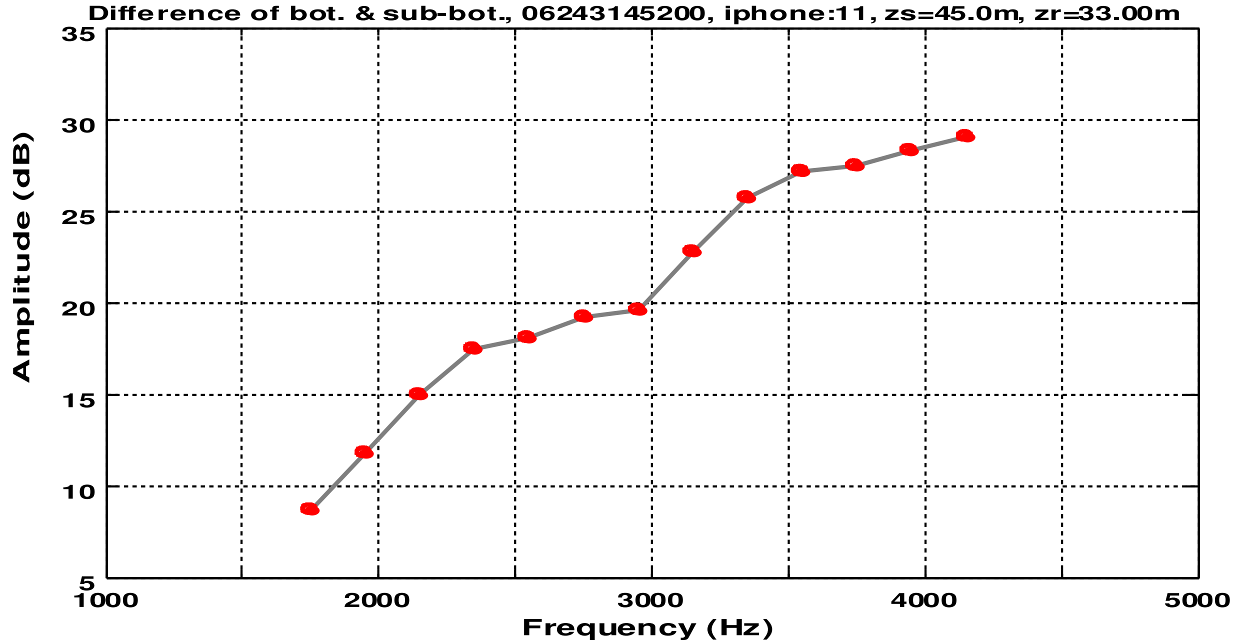


fo=2550 Hz



Signals after band passing fo=1750-4150Hz, 200Hz separation

Data processing example cont.



The slope = $(r_5 + r_6)*\alpha'_s$,

where $(r_5 + r_6)$ is the path length in the sediment,

α'_s is in dB/m.kHz

$\alpha_{(\lambda)} = \alpha'_s * c_s/1000$

c_s is the sound speed in the sediment,

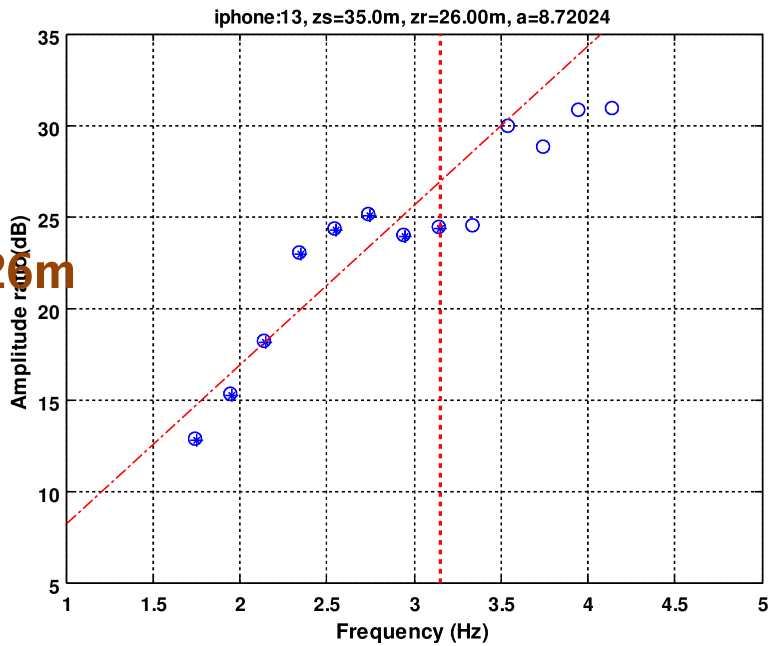
$\alpha_{(\lambda)}$ is in dB/λ

Need to be inverted

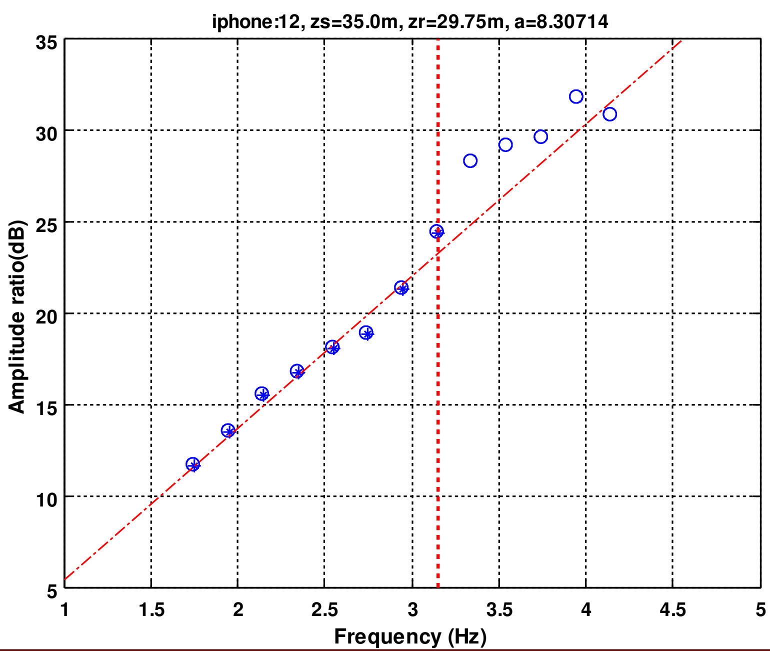
Review of the inversions of sediment sound speed and layer thickness

- Invert for water depth, range, source depth and array tilt fr
  SD=65m data;
- Invert for water column SSP for desired source depth data
- Invert for sediment sound speed and layer thickness by us
  inverted geometric parameters and SSP in the water;
  - optimal inversion approach
  - use of travel time information
  - forward model is based on ray theory

Processed results: (Source depth : 35m)

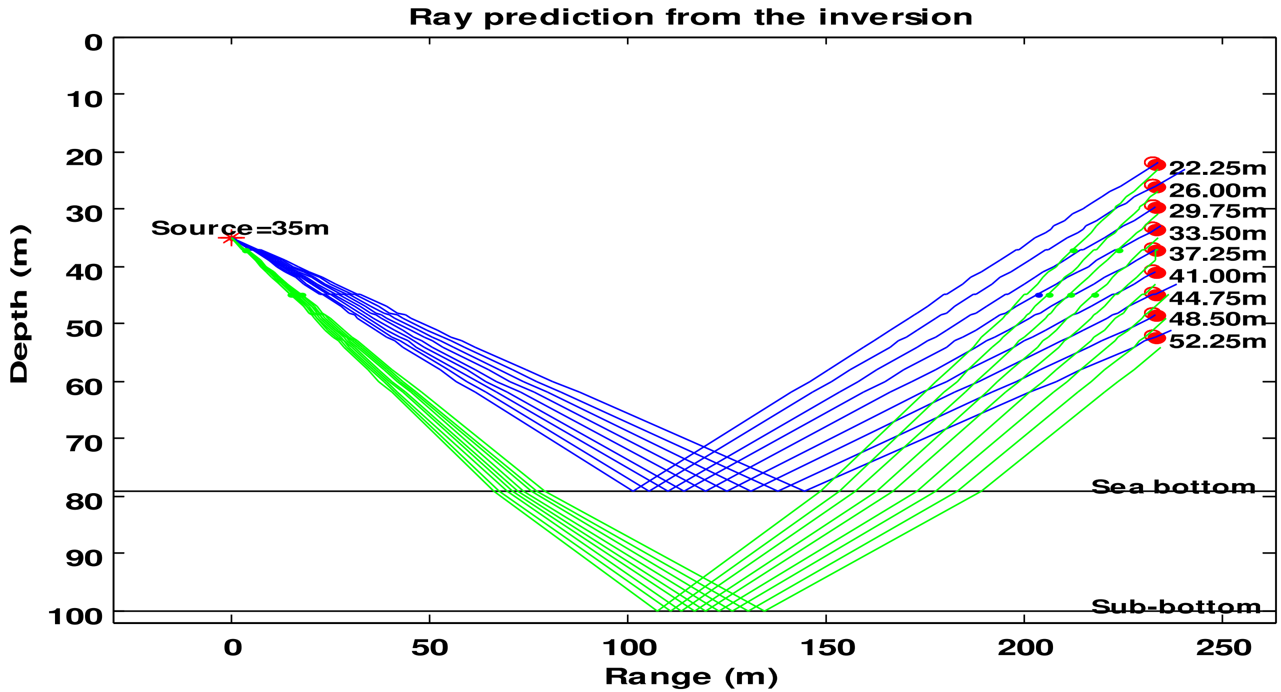


Receiver depth = 26m



Receiver depth = 29.75m

Supporting parameters from the inversion (35m)



Sediment Sound speed: 1602.2 m

Sediment layer thickness: 20.8m

RD: 26.00 m Path length in the sediment: 95.1 m

RD: 29.75 m Path length in the sediment: 97.8 m

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The sediment attenuation estimates

Source depth (m)	35		45	
Receiver depth (m)	26.0	29.75	26.0	33.5
Attenuation	0.092	0.085	0.101	0.088
Attenuation (dB/λ)	0.15	0.14	0.16	0.14

The error sources

- **The signal fluctuation caused by the variable water environment and the interference of the reflections of fine structure in the sediment**
- **The errors of sediment sound speed and layer thickness estimates introduced by travel time picking**

Conclusion

- **The marine sediment sound attenuation at low frequency can be estimated from single bounce sub-bottom reflections**
- **The estimated attenuation values are consistent with previous result done in the vicinity by use of transmission loss inversion (Carey)**
- **The method could be used for future experimental design**

Future work

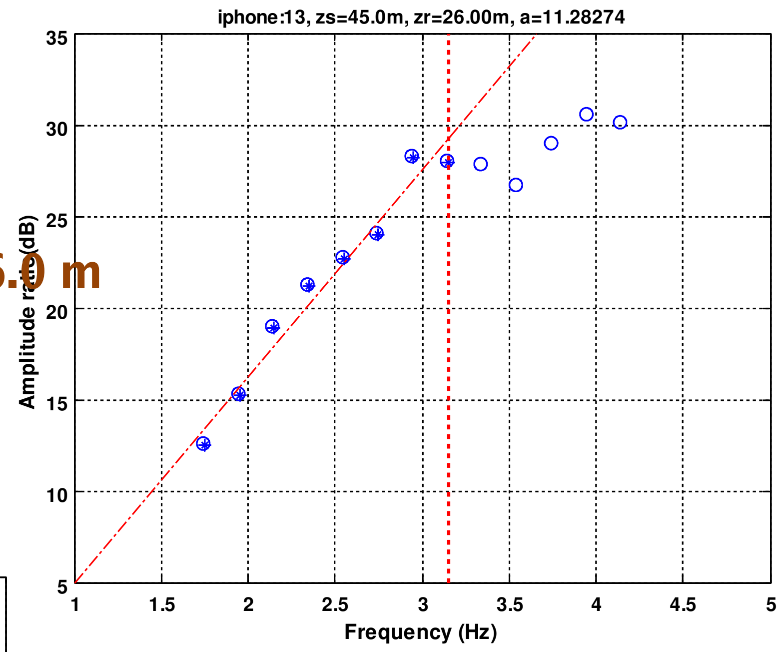
- **The uncertainty analysis of the estimate**
- **Compare with the circle data at 'Moray' site and SWAMI 32 site**

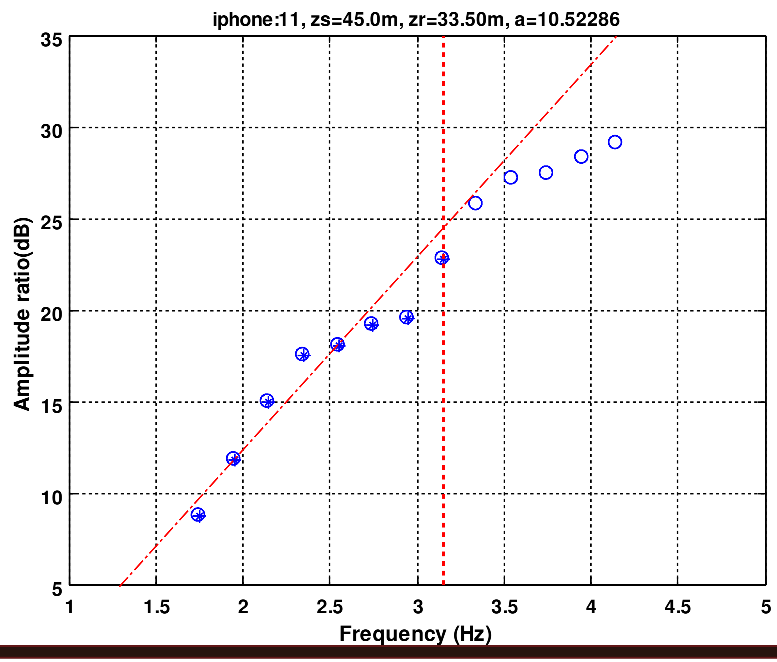
Acknowledgments

- **Office of Naval Research:** for sponsoring the research
- **Drs. William Hodgkiss and Peter Gerstoft from MPL:** acoustic data

Processed results: (Source depth : 45m)

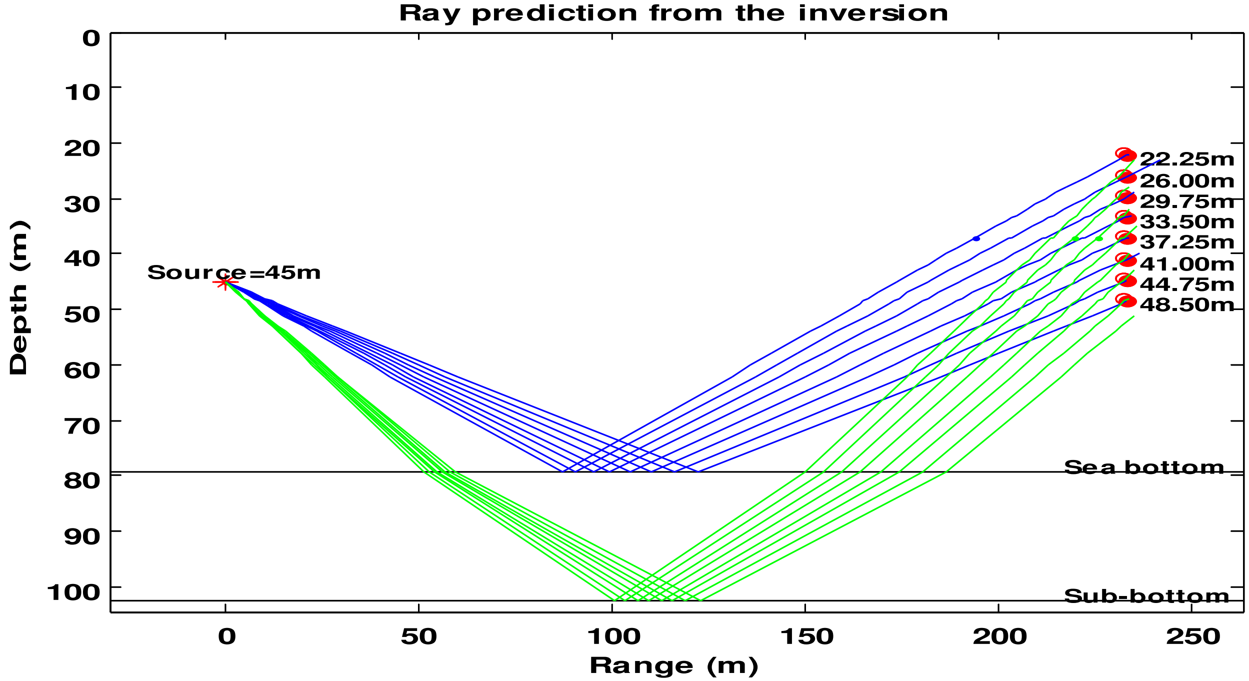
Receiver depth = 26.0 m





Receiver depth = 33.5 m

Supporting parameters from the inversion (45m)



Sediment Sound speed: 1618.2 m

Sediment layer thickness: 22.2 m

RD: 26.00 m Path length in the sediment: 112.1 m

RD: 33.50 m Path length in the sediment: 119.1 m