

A passive acoustic contribution to REA: Geoacoustic inversion using ship noise

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Objectives:

- To perform passive Geoacoustic inversion using ship Noise
- Algorithms adapted to REA context (one hydrophone or a sparse network of hydrophones)

idea:

- Exploitation of the modal propagation and ship movement effects

Direct Modelling:

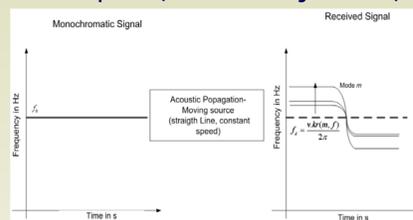
Hypothesis:

- Shallow water environment + Low frequency + range independent channel
⇒ Modal propagation (Normal modes theory)
- Ships moving in straight line with constant speed (or known trajectories)

Spectral lines

Harmonic response of the channel=>

$$\sum_n \Psi_n(Z_r, f) \Psi_n(Z_s, f) \cdot \frac{e^{-\text{Im}(k_z^2(f))r(t)}}{\sqrt{k_z^2(f)}r(t)} \cdot e^{i\text{Re}(k_z^2(f))r(t)} \cdot e^{-2\pi if}$$

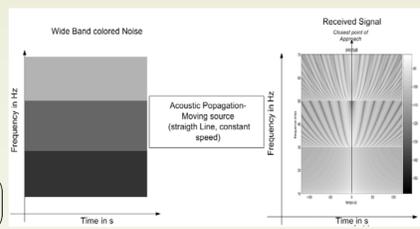


Doppler effect=> Separated modes !!

Wide Band Noise

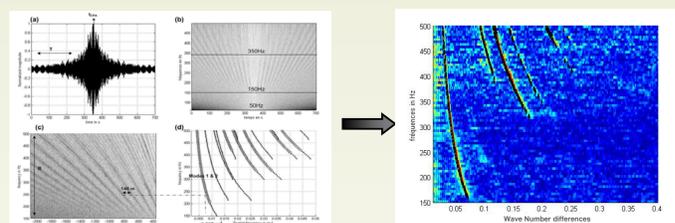
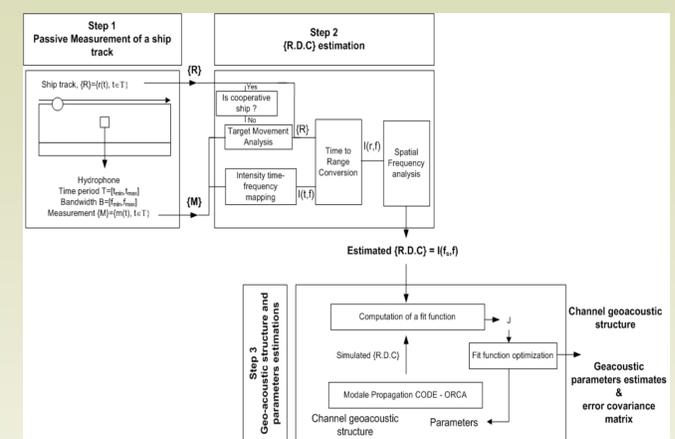
Fourier synthesis of the Harmonic response of the channel=>

$$I(f) = \langle pp^* \rangle = P(f) \left(\sum_n A_n^2 + 2 \sum_{n,m} A_n A_m \cos(\Delta k_r^{nm}(f)r) \right)$$



Interferences pattern !!

Inversion Method for Wide band Noise :



Example on synthetic realistic Data - very shallow water

Applications on real data

MOVEBOAT 2006



| Location | Channel properties | Experimental device / Sources | Wave number differences estimation | Inversion results |
|----------|--------------------|-------------------------------|------------------------------------|---|
| | | | | Parameters: Water depth (m) [10 50], Water sound speed (m/s) [1480 1530], Sediment speed (m/s) [11500 2000], Sediment attenuation (dB/A) [10.9 -0.001]. |

PASSTIME 2005



| Location | Channel properties | Experimental device / Sources | Wave number differences estimation | Inversion results |
|----------|--------------------|-------------------------------|------------------------------------|---|
| | | | | Parameters: Sediment thickness (m) [0 50], Sediment Compression speed (m/s) [1550 2500], Attenuation (dB/A) [-2 0]. |

MATANE 2006

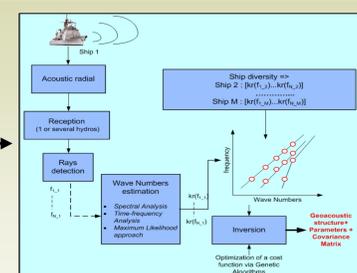


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Agreement = 64%

Future works

- Need test on all the MATANE data base (4000 ships)
- Inversion with spectral lines emitted by ships
- Combination of the two approaches
- Combination of the inversion results from moving ships and marine mammals vocalizes (cf. Oral presentation: C.Gervaise, S.Vallez, Y.Stéphan: "Passive Geoacoustic inversion using VLF marine mammals calls")



Gives promising preliminary results