Burial Depth Determination of Cables Using Acoustics – Requirements, Issues and Strategies

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Cable + Survey Requirements

Cable Acoustics

Survey Strategies

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Offshore Wind Farms – Cable Requirements

- Inter-array cables
- Power export cable(s)
- Cables need protection
- Burial depth typ. 1 – 3 m
- Some areas: deeper burial and/or rock dumping

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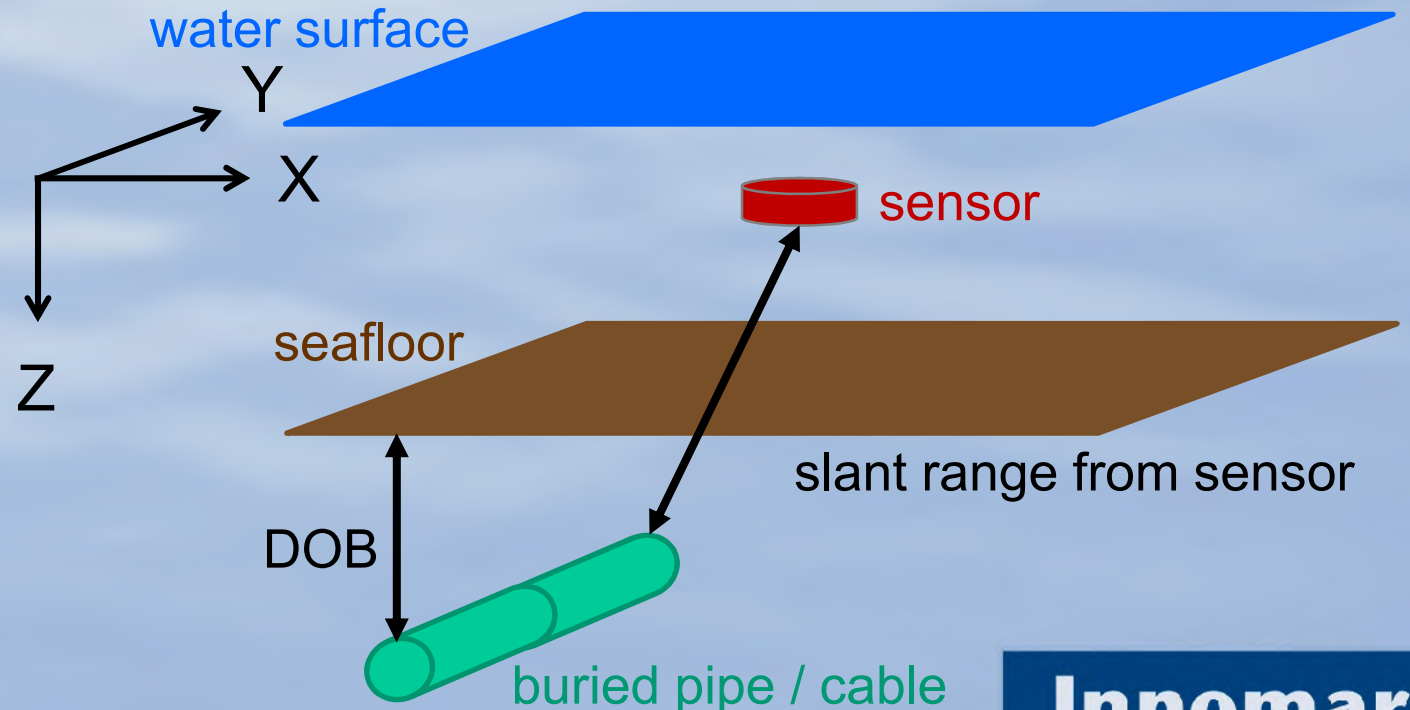
DOB Survey Requirements

Technical Requirements:

- Depth (Z) accuracy:
  - 10% of burial depth
  - 5% of range from sensor
- Horizontal (XY) position: accuracy depends on positioning system
- Position density along cable:
  - maintenance: 50 – 200m
  - “as laid”: ≤ 1m
  - pipe/cable tracker: 25cm

Depth of Burial (DOB): depth below seafloor
→ detection of pipe/cable and seafloor required



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DOB Survey Requirements

Keep Costs Low !

Operational Costs

Vessel

Survey time

Other sensors?

Processing Costs

Processing offshore within 24 hours

Online data for QC and helmsman

Operational Requirements:

- Survey along the cable route at sufficient speed
- Good online position and visualisation
- Fast on-board processing with full accuracy

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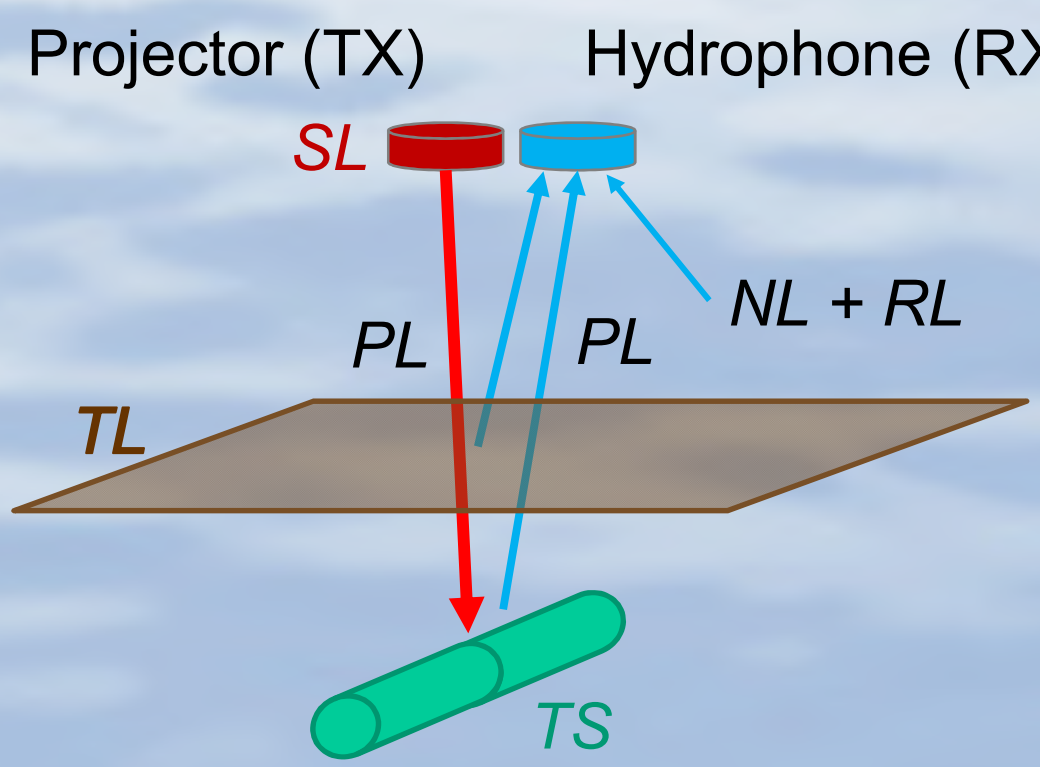
Acoustic Cable Detection – SONAR Target



- Sound pulse towards cable (*SL*)
- Echo received from cable (*TS*)
- Energy loss along sound path (*PL*)
- Energy loss at seabed (*TL*)
- Noise (*NL*) and Reverberation (*RL*)
- Detection probability and processing gain (*DT*)

→ SONAR equation gives signal excess (*SE*):

$$SE = [SL - 2PL - TL + TS - (NL_R + RL) - DT] > 0$$

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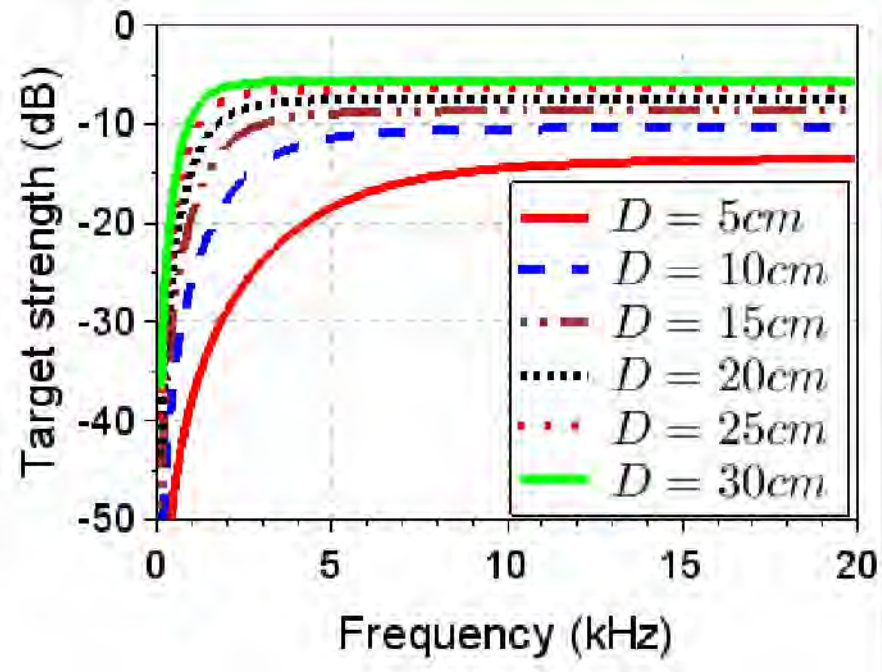
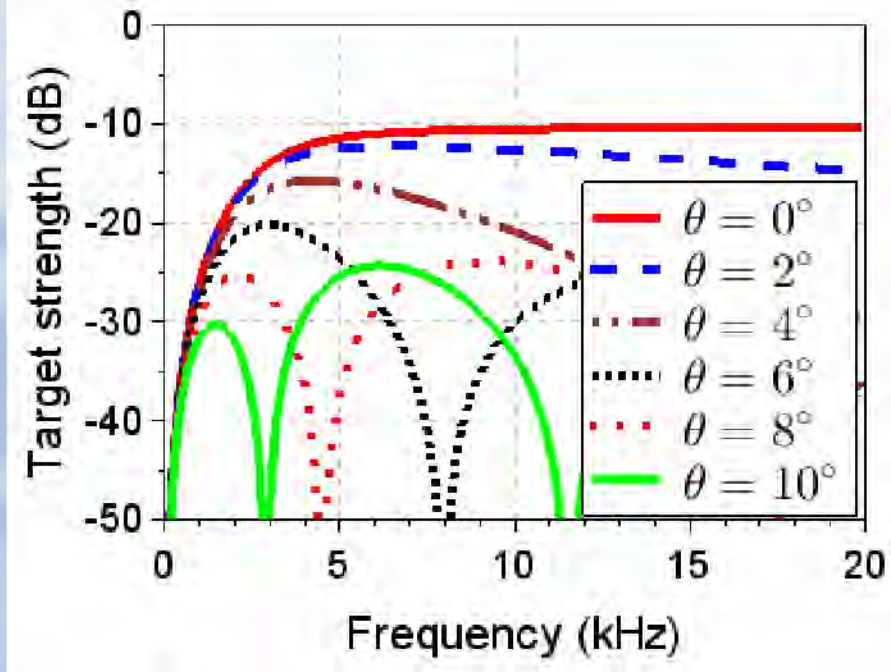
Acoustic Cable Detection – Target Strength





TS depends on

- Frequency
- Cable diameter
- Incidence angle
- (Material)

→ Frequencies: 5 – 15 kHz

→ Incidence angle: nearly vertical

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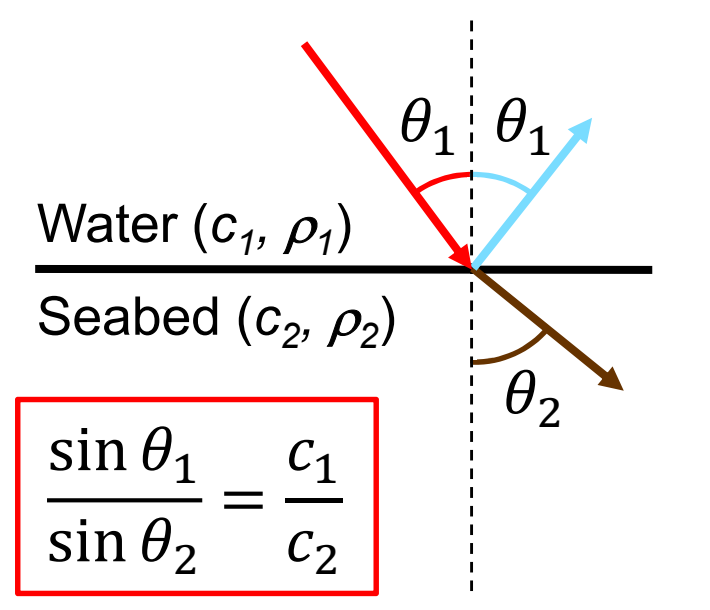
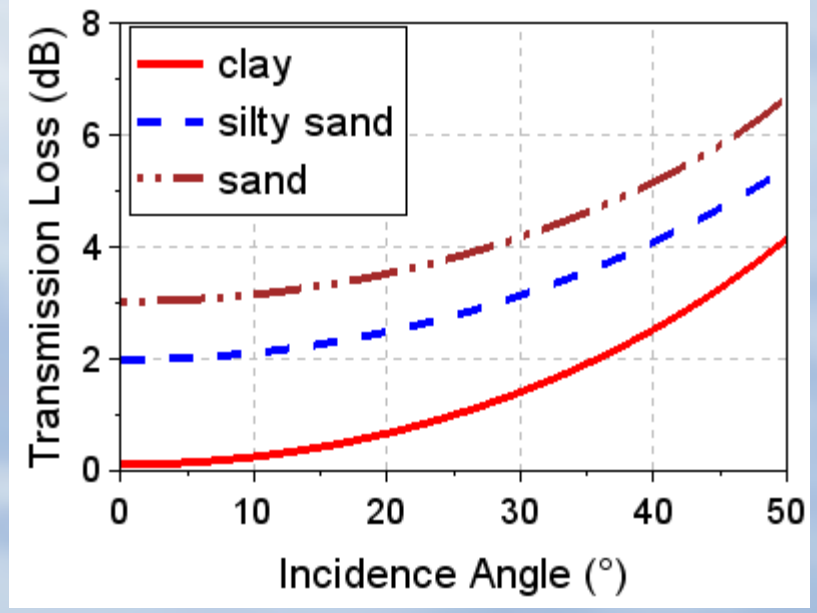
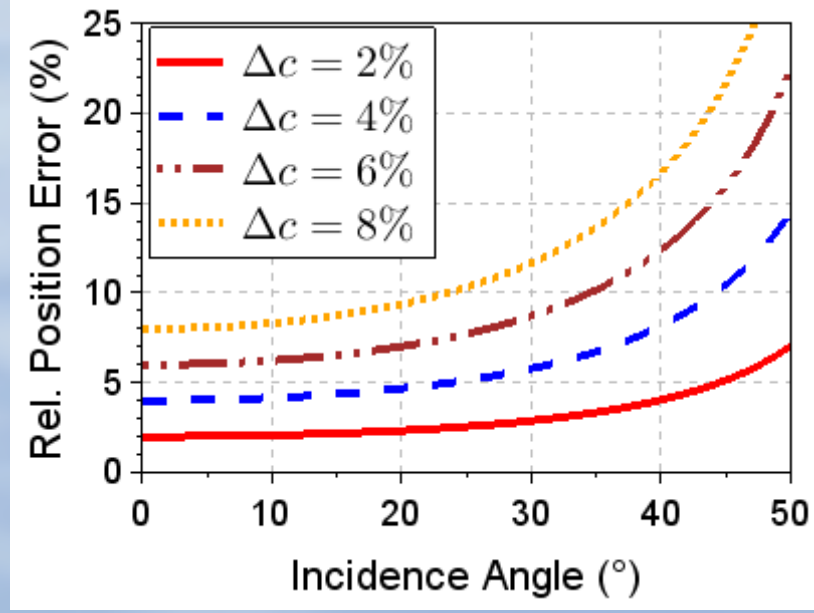
Acoustic Cable Detection – Seabed







- Reflection → Incidence angle should be as small as possible
- Transmission → Transmission Loss (TL) = f(θ)
- Refraction
- Unknown c_2, ρ_2 → Position Error = f(θ)

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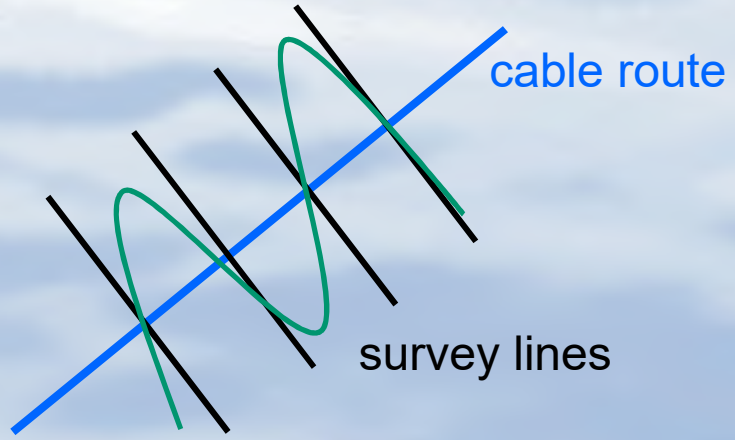
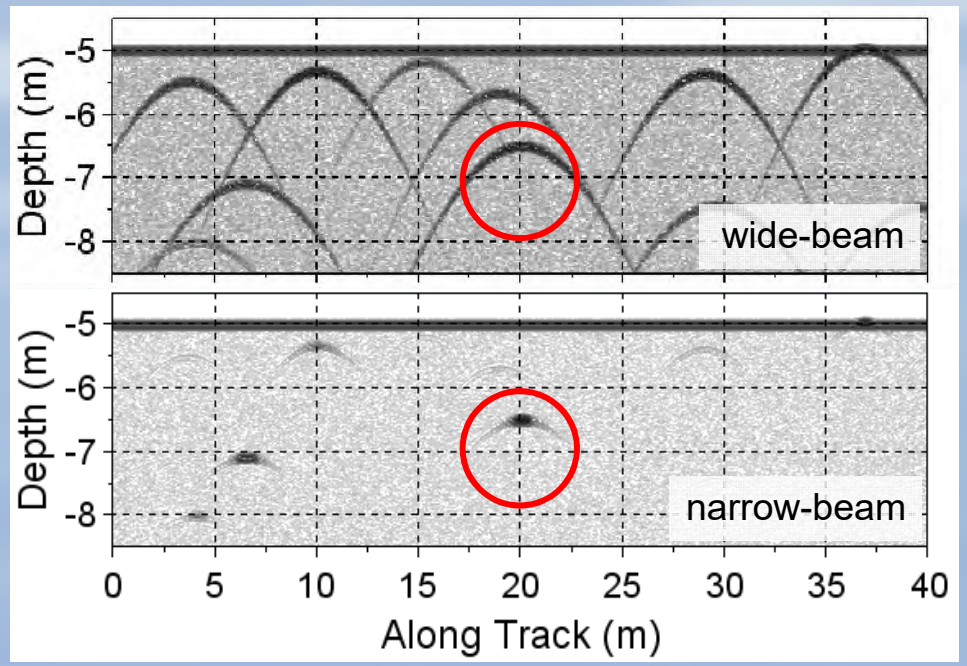
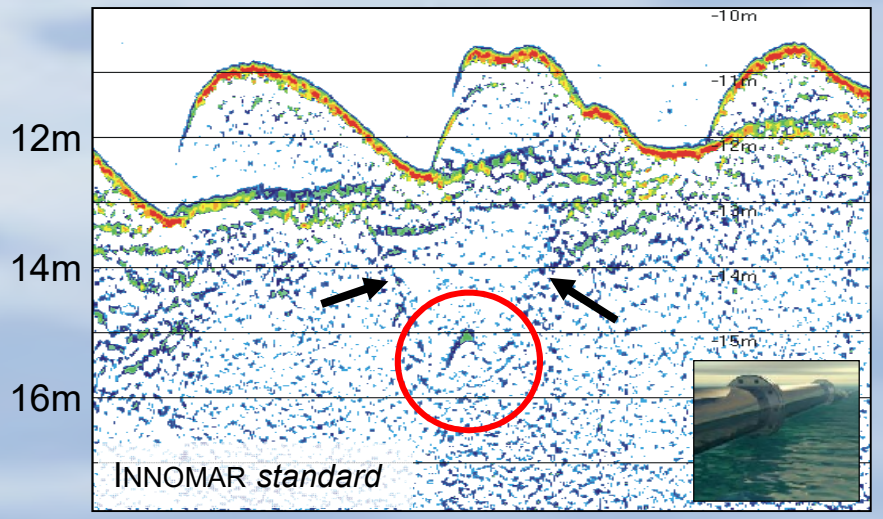
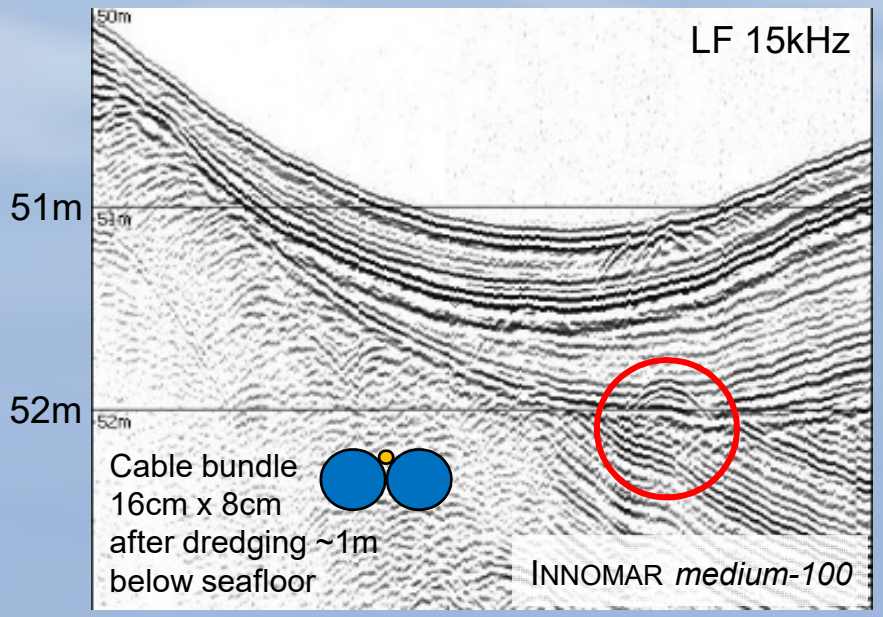
Survey Track Across Cable Route









- Many lines
- Diffraction Hyperbola
- Good detection
- Time consuming
- Ambiguities → Processing
- Narrow Beams

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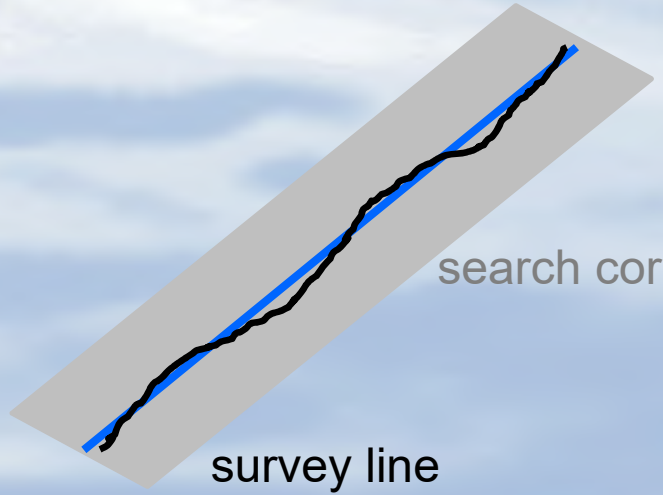
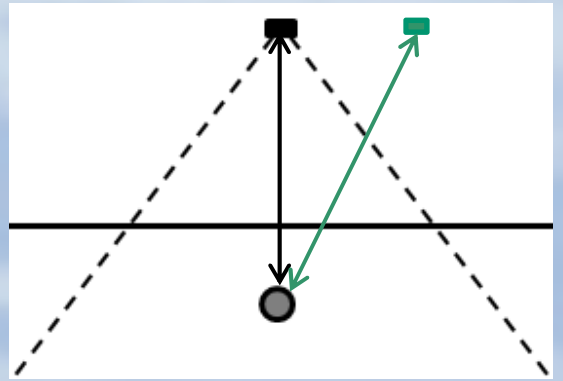
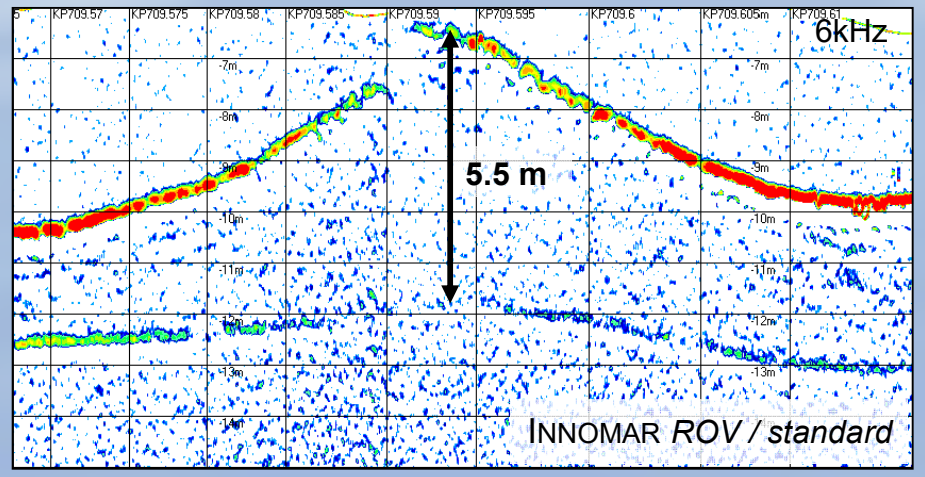
Survey Track Along Cable Route

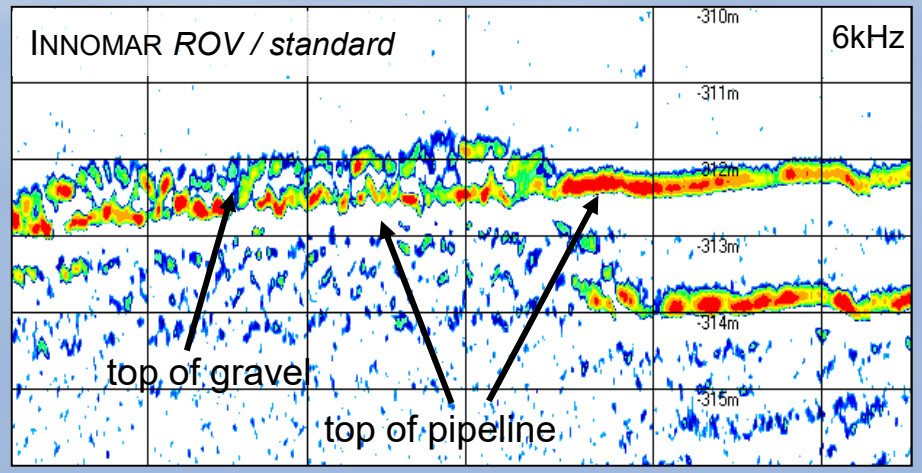




- Cable position is roughly known → try to follow
- Full illumination of search sector
- Horizontal distance variations cause “depth” changes

→ at least 2 hydrophones needed





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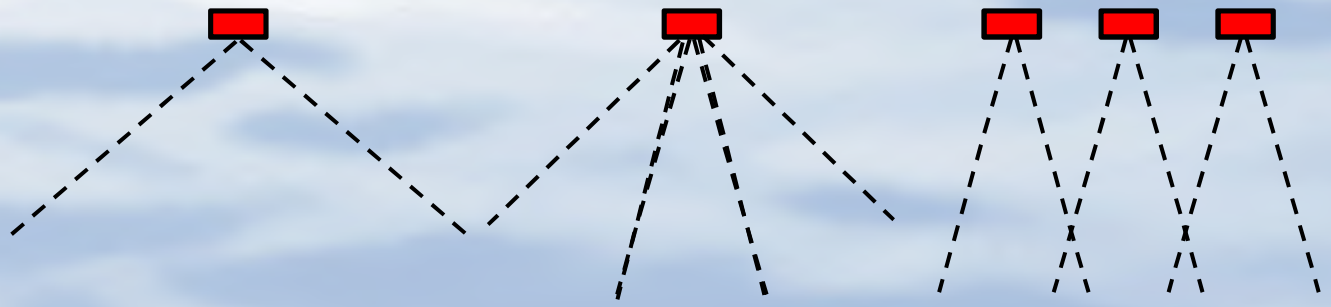
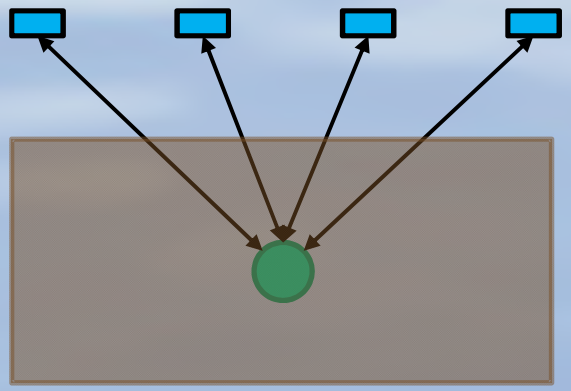
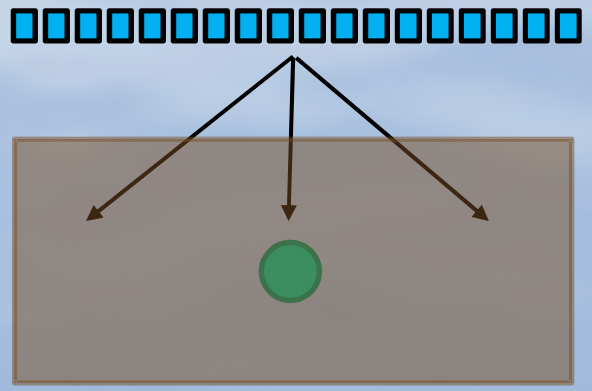
Projector & Hydrophone Configurations







- Different projector configurations:
  - one wide beam
  - several narrow beams tilted
  - several narrow beams vertical
- Hydrophones spread across track:
  - few RX at large separation
  - many RX at small separation (receiver array)

→ Different processing options:
- energy focusing
- triangulation
- beam steering
- ...

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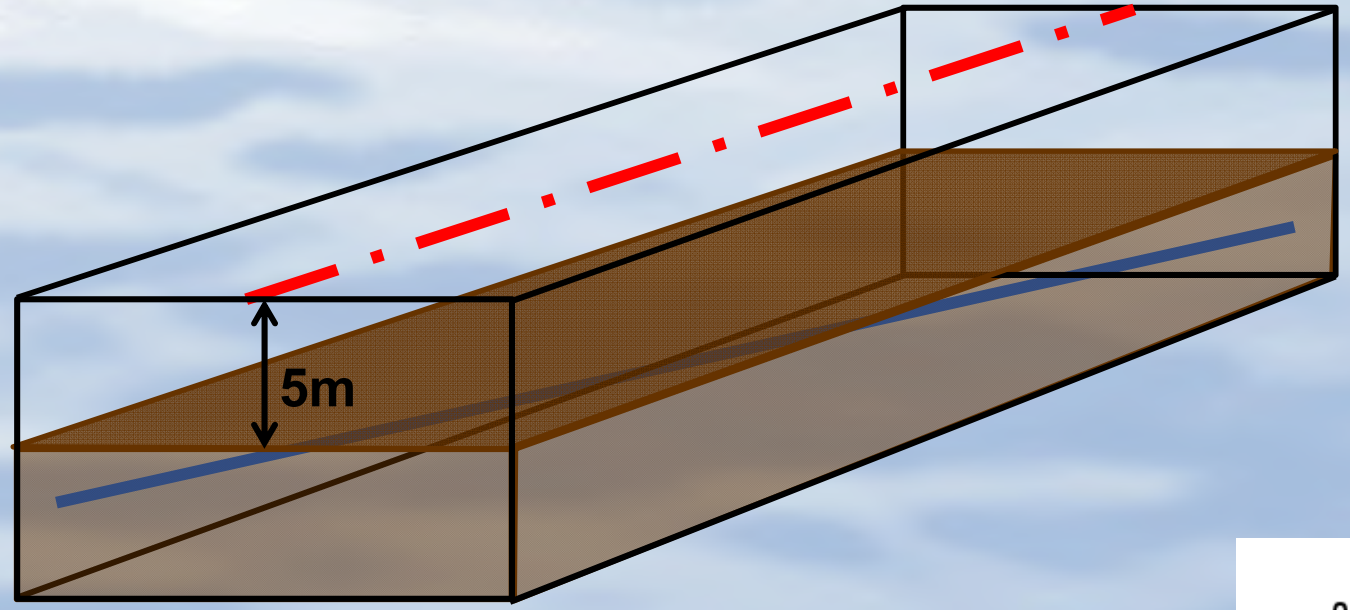
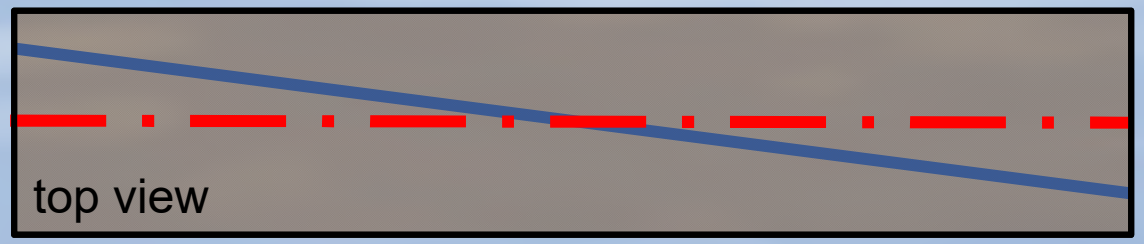
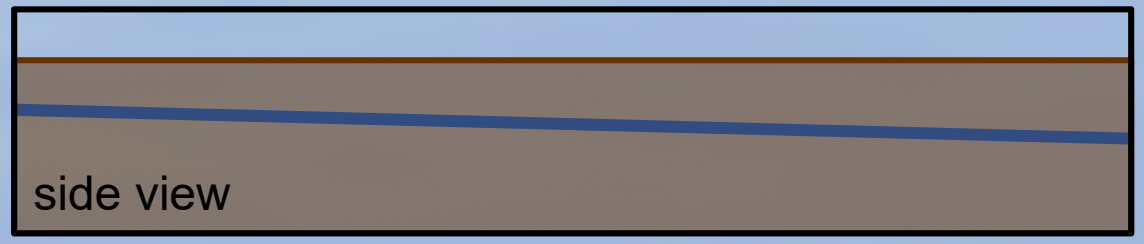
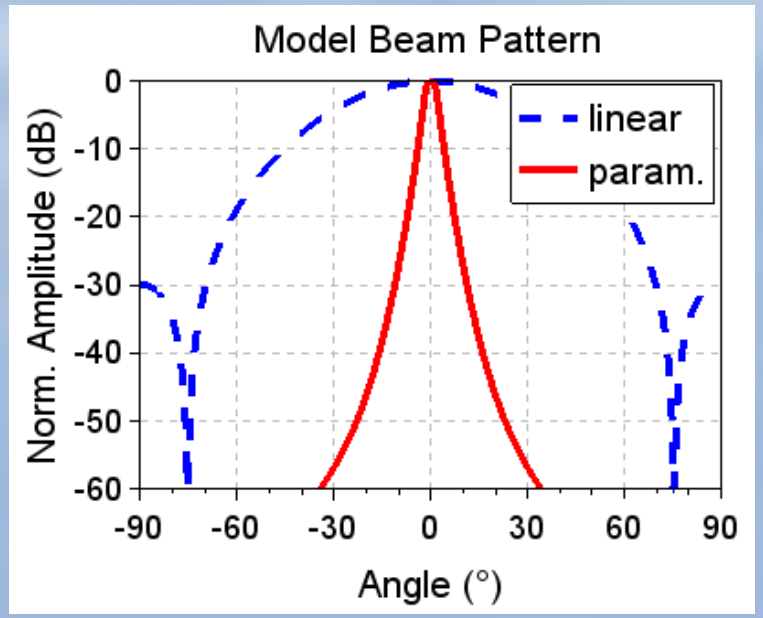
Model for Evaluation



- Flat seabed 5m below sensor
- Sediment volume with boulders
- Cable DOB ~1.5m
- Survey track along cable route
- Linear / parametric sound beams







$\Theta_{-3dB} = 50°$

$\Theta_{-3dB} = 5°$

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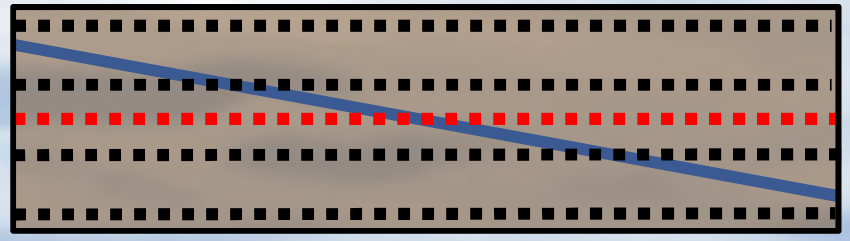
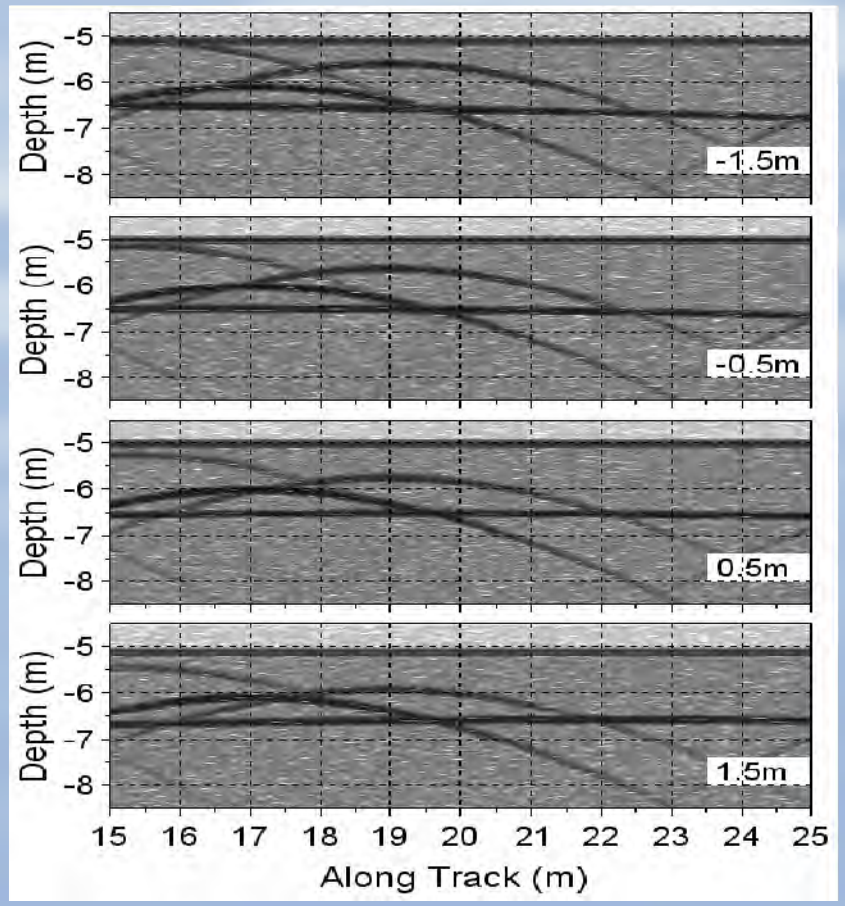
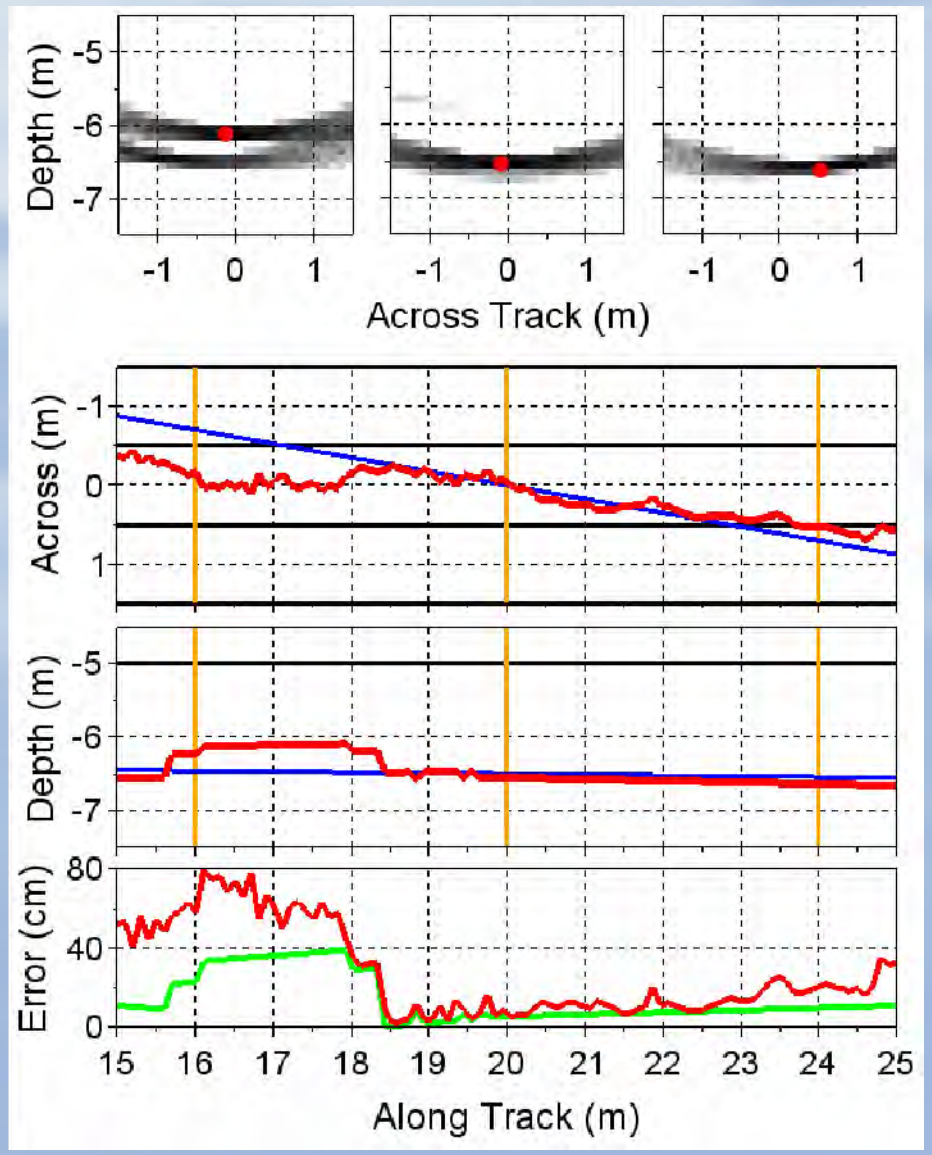
Model 1: One Projector / Four Hydrophones







- Similar RX echo plots
- Strong boulder echoes
- Reverberation

→ Large position error

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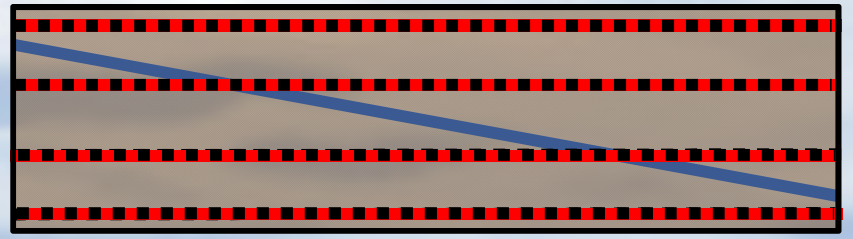
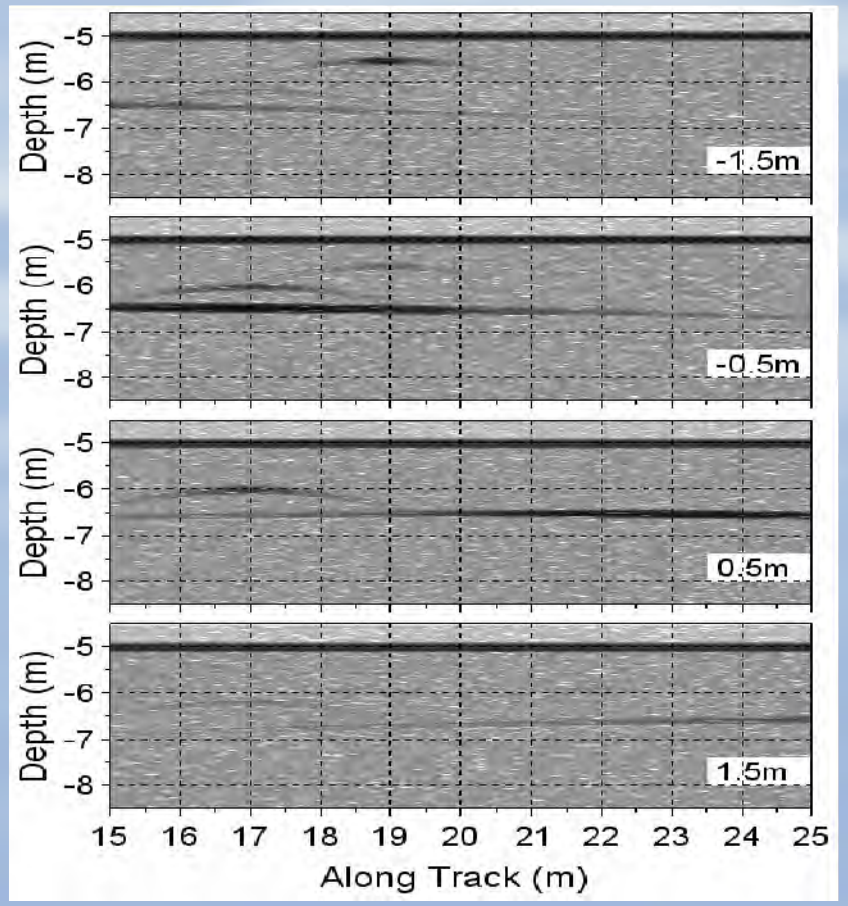
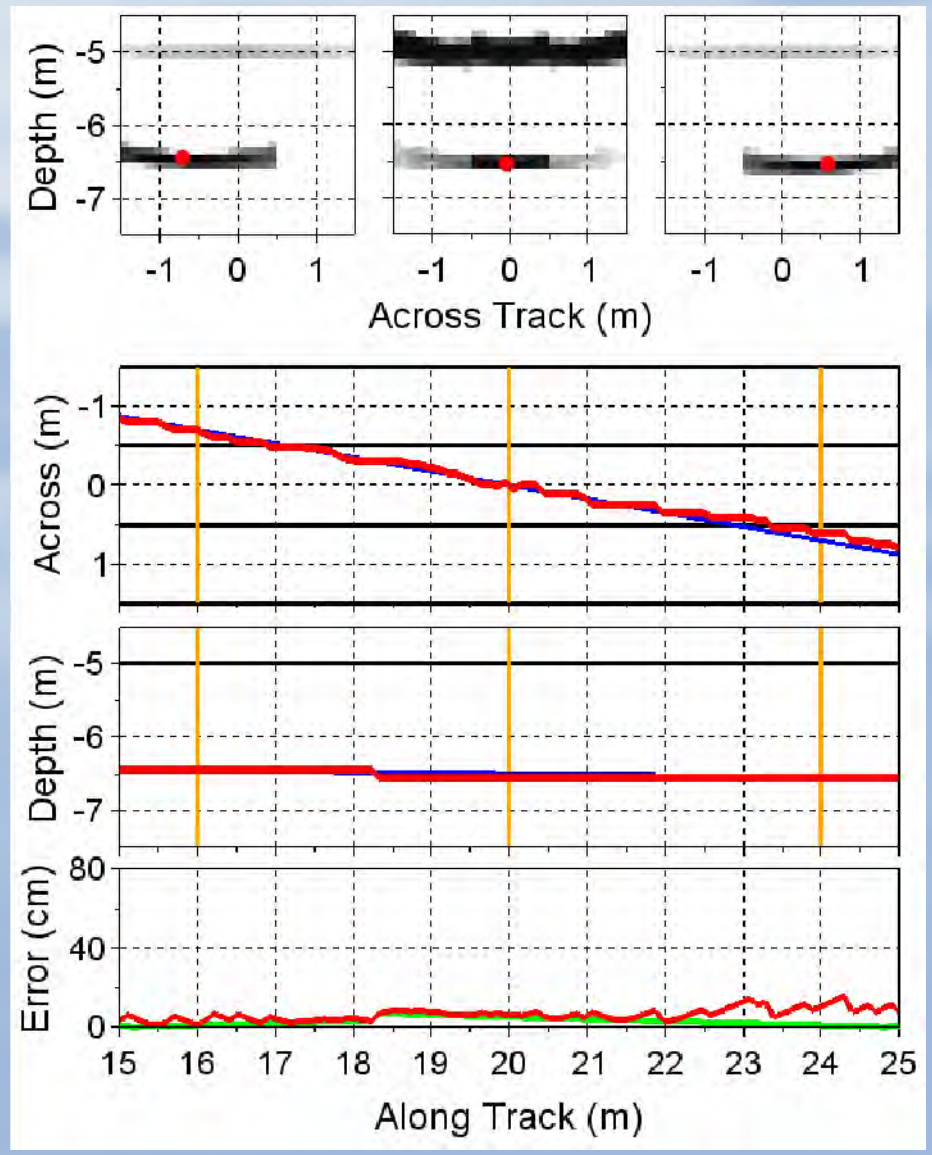
Model 2: Four Projectors / Four Hydrophones







- Different RX echo plots → helmsman
- Less boulder echoes
- Less reverberation

→ Small position error

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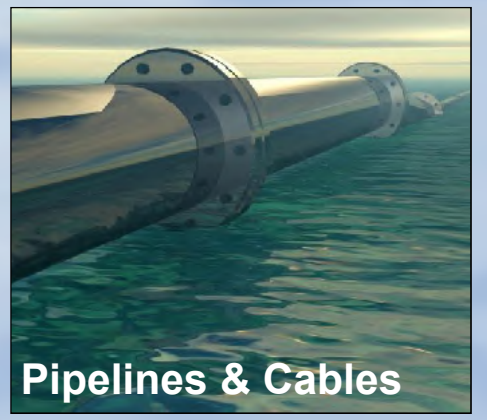
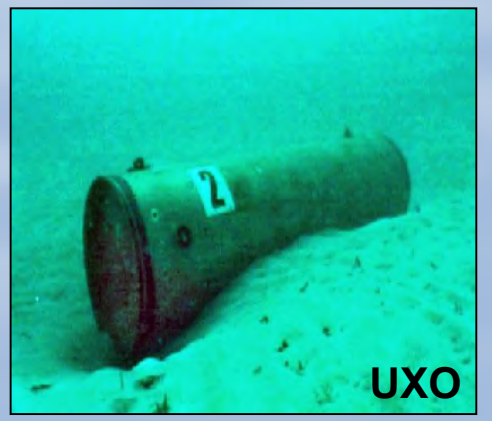
Conclusions

- Detection / tracking of buried cables using acoustics is difficult
- There are high survey requirements
- For good tracking results the incidence angles needs to be small
- Narrow sound beams give better SNR and less ambiguities than wide sound beams
- Modelling a cable tracker using parametric acoustics was successful
- Test tank evaluation and field trials to follow ...





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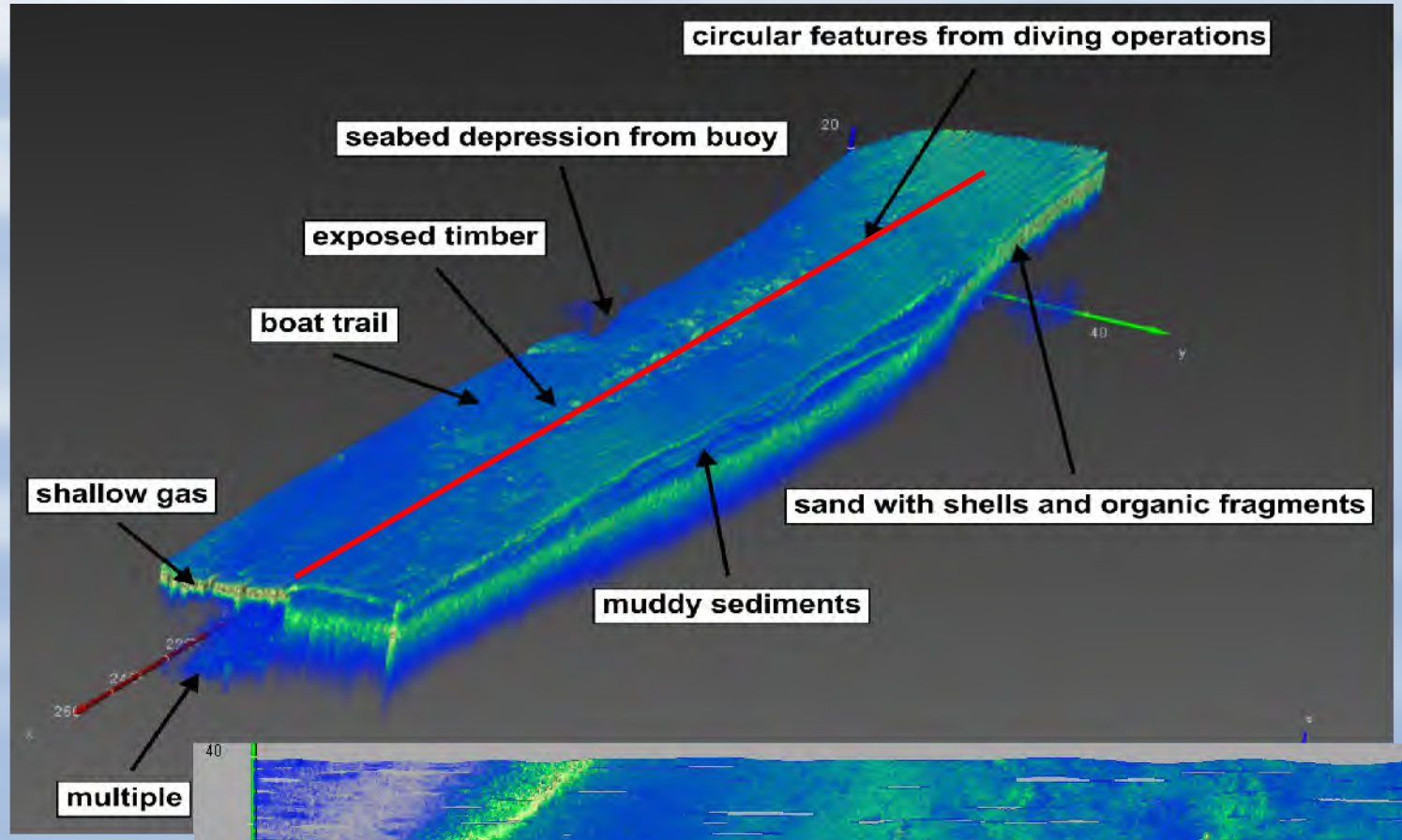
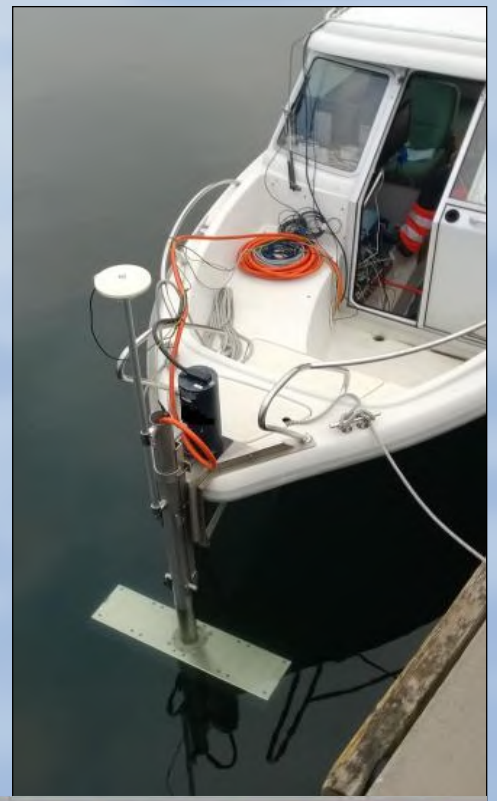
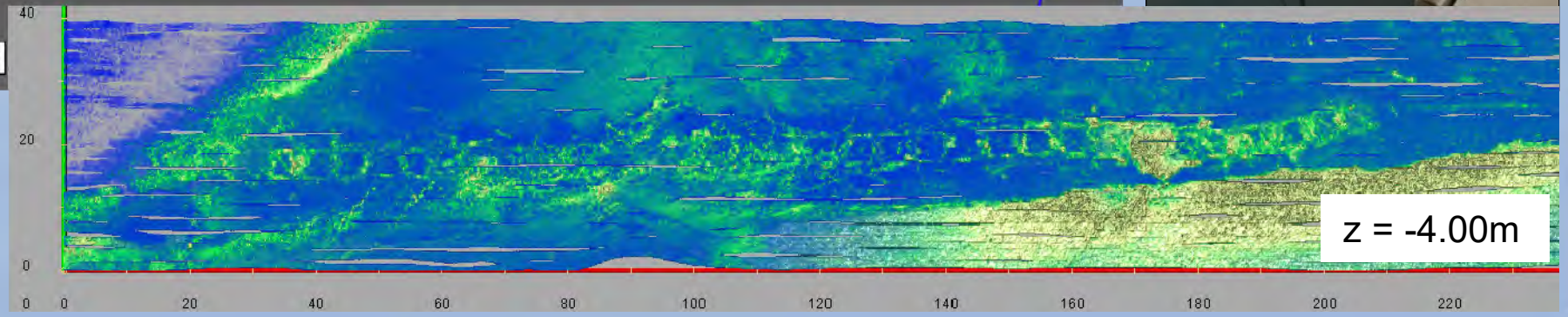
Innomar SES-2000 *quattro*







- **Boat Demo**
- **Workshop**
  Today 15:50
  (WS-2)

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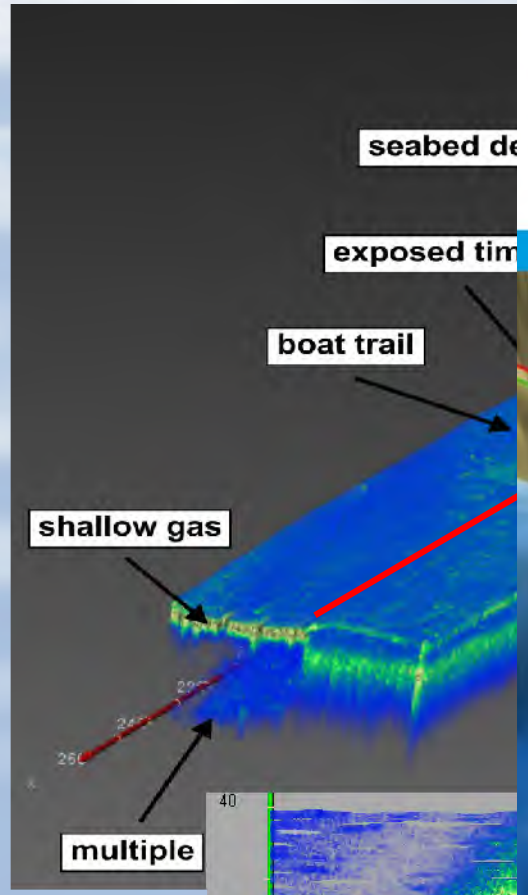
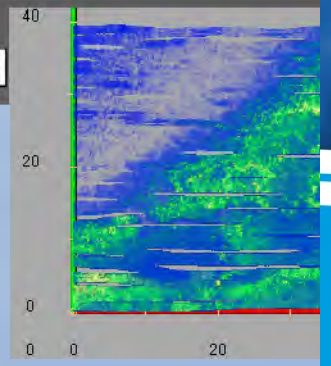
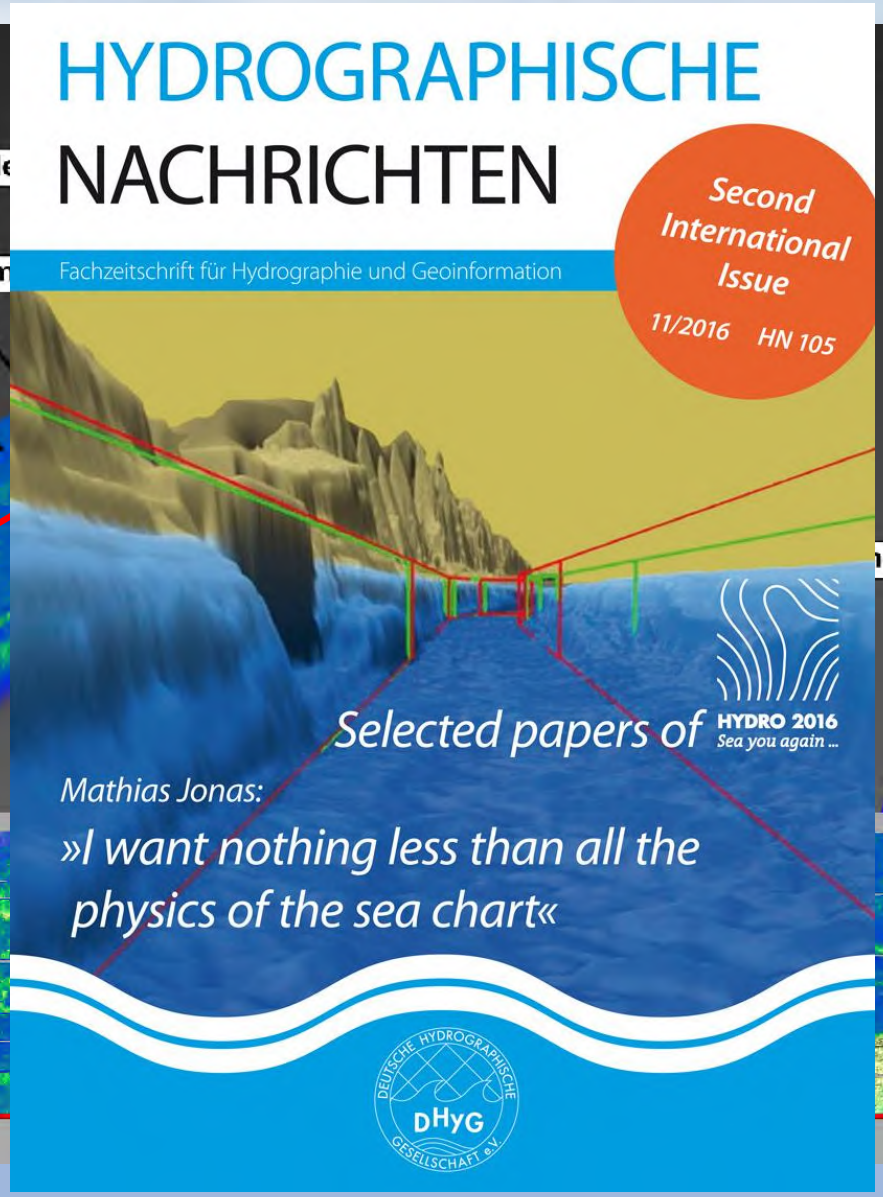
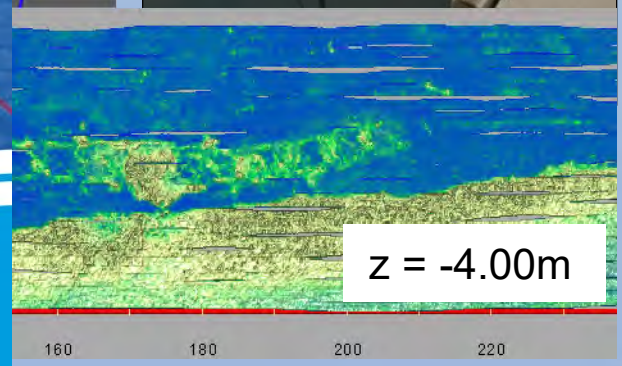
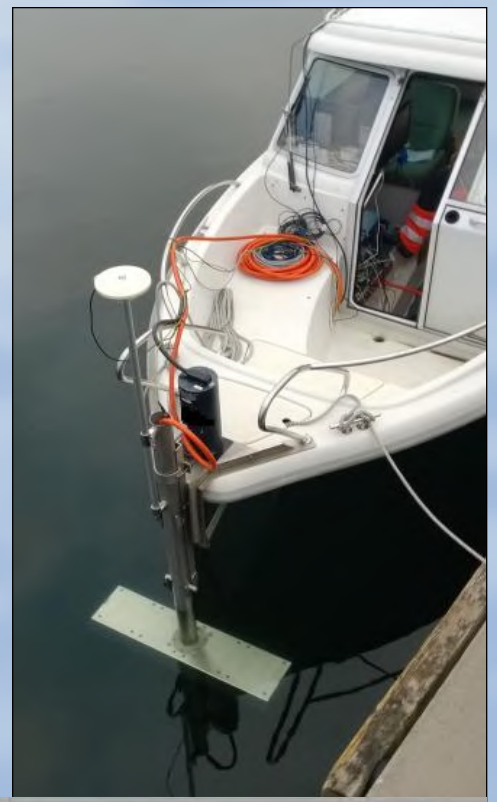
Innomar SES-2000 *quattro*











- **Boat Demo**
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  Today 15:50
  (WS-2)
- HN p. 50–54

Questions?

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