

2D and 3D acoustic investigation of a submerged archaeological site near Ostend, Belgium

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2D and 3D acoustic investigation of a submerged archaeological site near Ostend, Belgium

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Goal of the study

- Gain more insight into the recent geological evolution of the area, stretching a time period of ~5000 years;
- Map the tidal channels and former coastline;
- Identify archaeological layers or (pre)historic artefacts buried below the seabed
 - Roman/medieval coastal defense structures
 - Relics of human occupation or activity
 - Houses (medieval)
 - Peat digging (Roman + medieval)
 - Salt exploitation (Roman)

Study site



Offshore Raversijde, 3 km W of Ostend



Subtidal and intertidal area
1 km x 3 km

Holocene history



Mid-Late Holocene: tidal flat/marsh environment cut by tidal gullies.

⇒ alternating peat, clay, sand layers with high lateral variability

Early Middle Ages start of land reclamation and dyke building

"Walraf's Yde"



Medieval settlement *Walraversijde* located on peninsula "Testerep"



Gradually drowned in 14th century
⇒ relocated in the dunes behind a new dyke (15th c.)

Archaeological finds



Photo A. Choqueel

Remains of medieval houses – location unknown



Photo VIOE

Wooden paddle
(6300-2600 BP)



Photo E. Cools

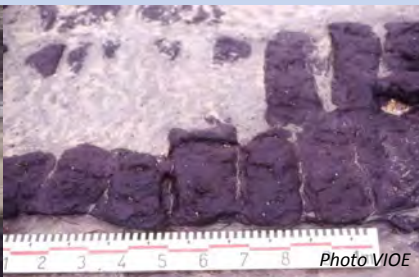


Photo VIOE

↑
in the dunes

Roman dyke (peat reinforced)

↑
on the beach – location unknown

Peat and salt exploitation

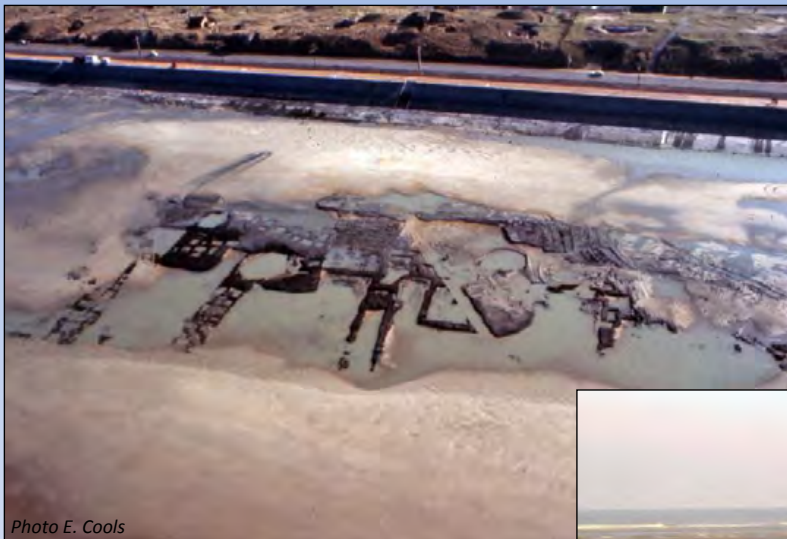


Photo E. Cools

Peat digging pits, salt pans,
trenches, log road, ...

Till '70s visible on the beach,
now covered by 1-2 m sand



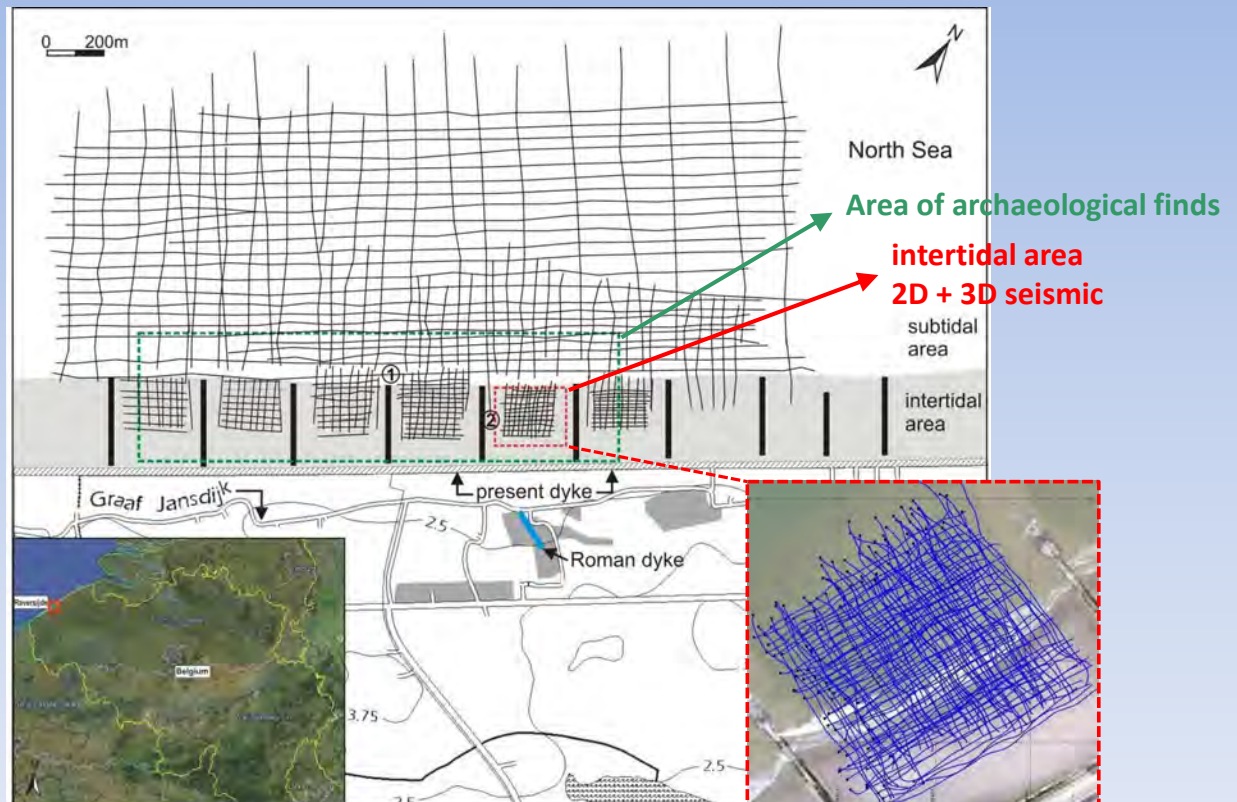
Photo E. Cools

Salt pan with wooden casing



Photo E. Cools

Seismic network



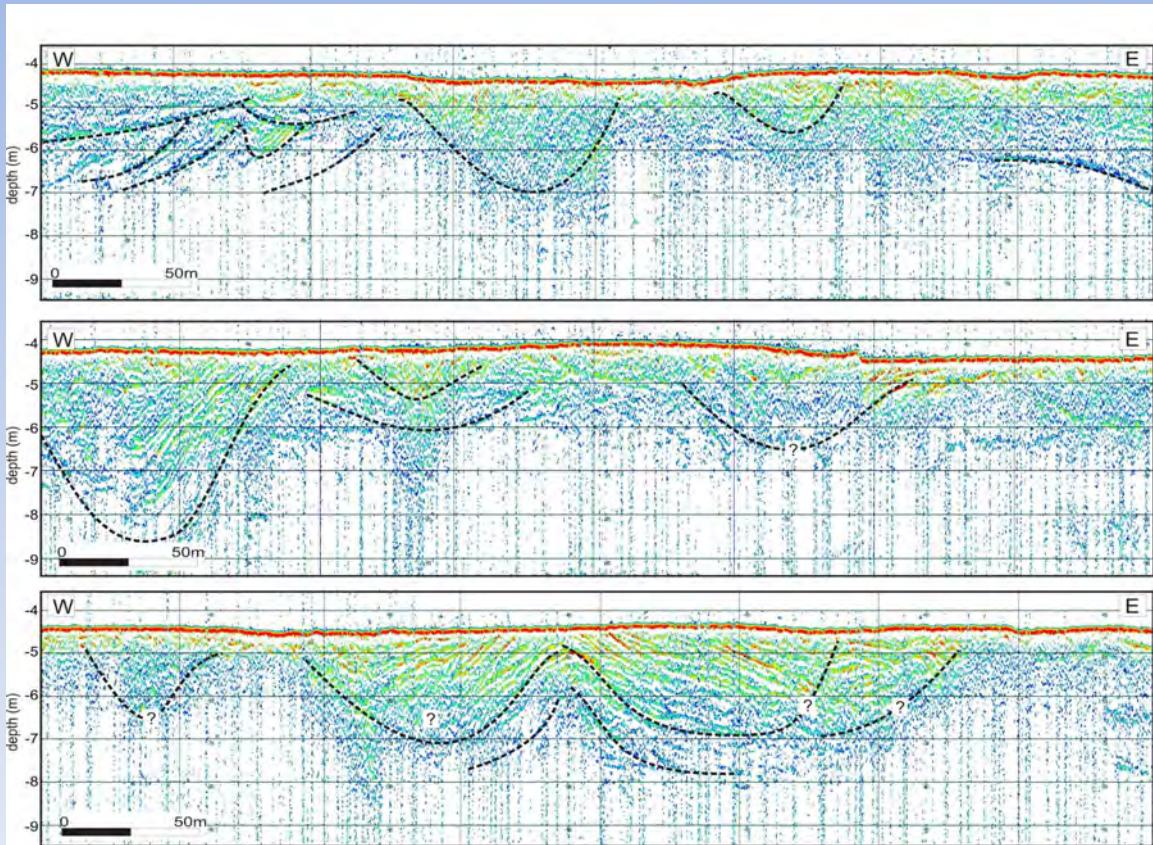
2D seismic (subtidal and intertidal)

- Parametric echosounder (SES-2000)
- Subtidal: 5 – 10 m water depth
- Intertidal: 0 - 3 m water depth
- Line spacing 25 – 75 m / 5 - 10 m

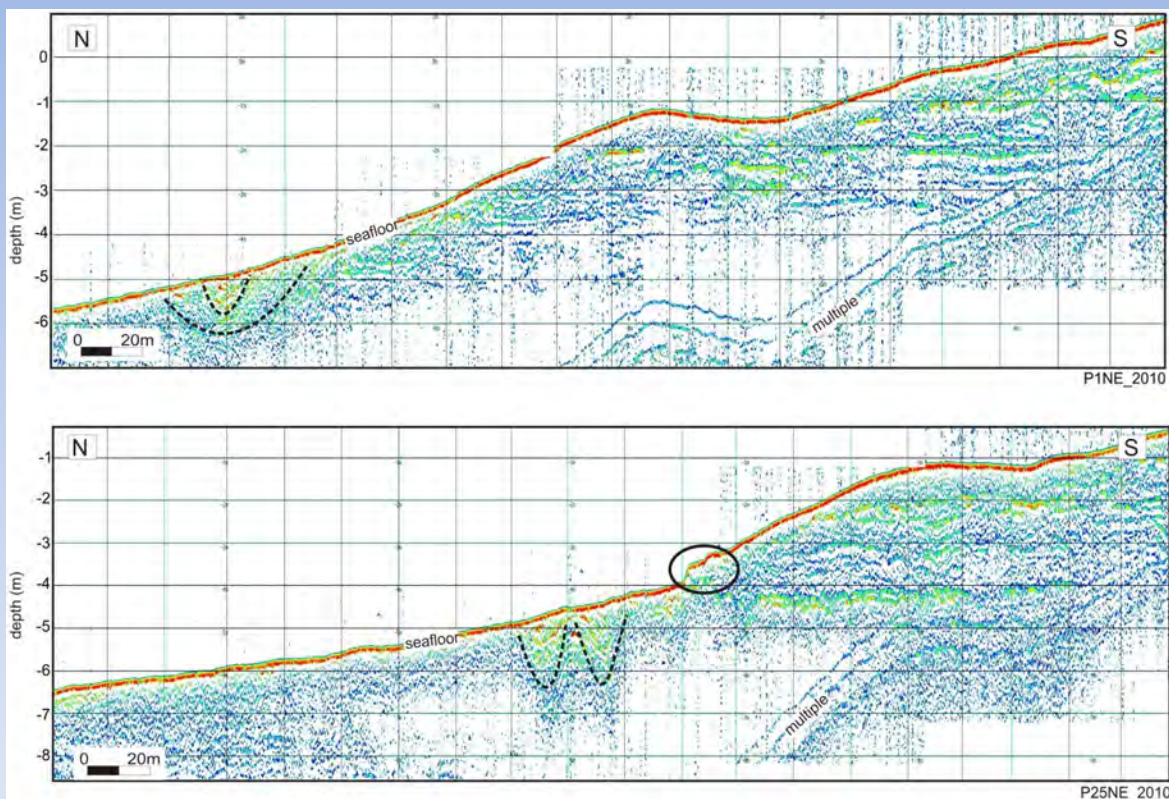


Tidal range 4-5 m
Limited working time in intertidal
area (2-3 hours)

2D subtidal – palaeochannels

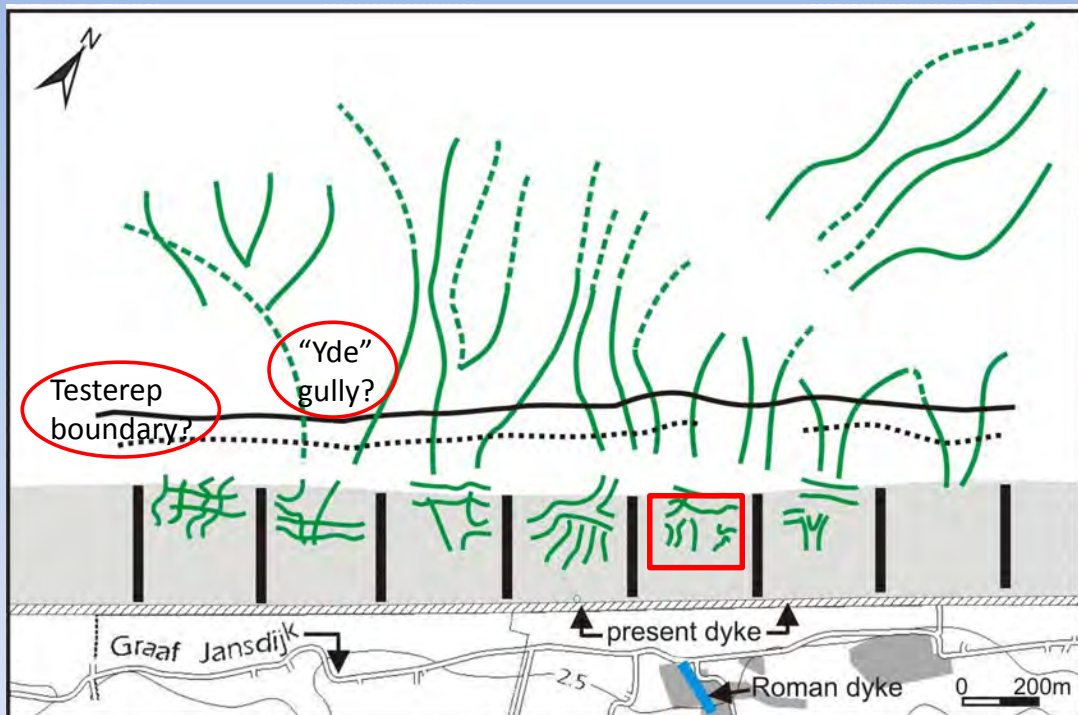


2D subtidal – seafloor terrace



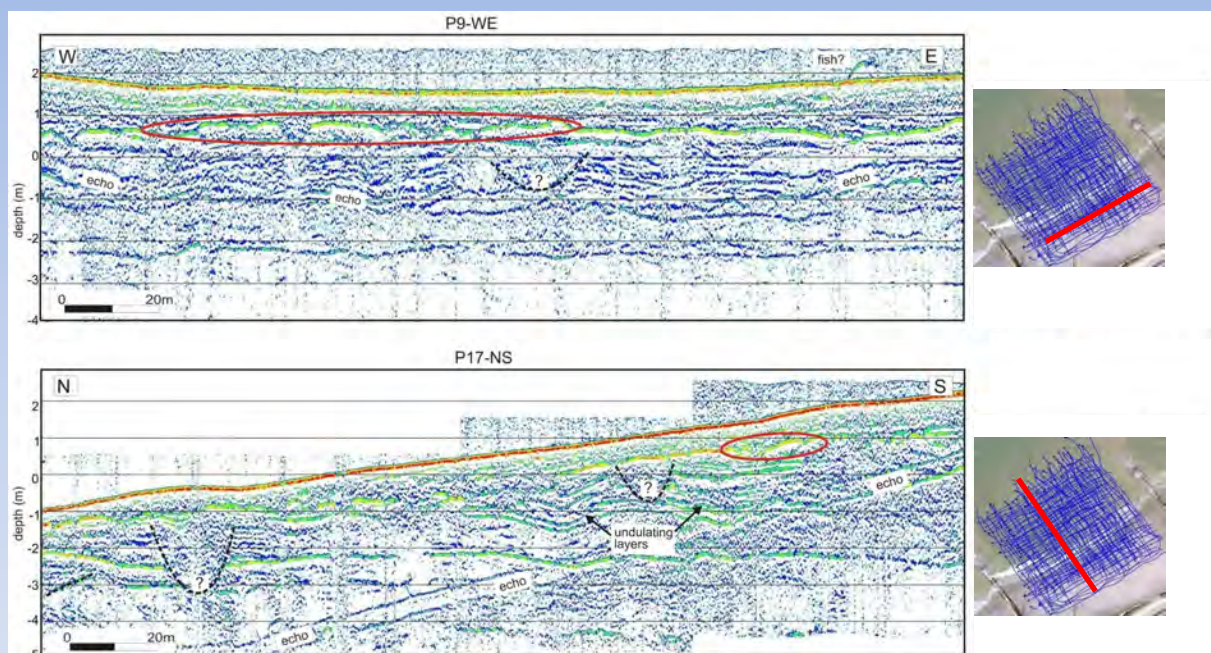
Recent shallow palaeochannel running parallel to the shoreline

Palaeochannel system



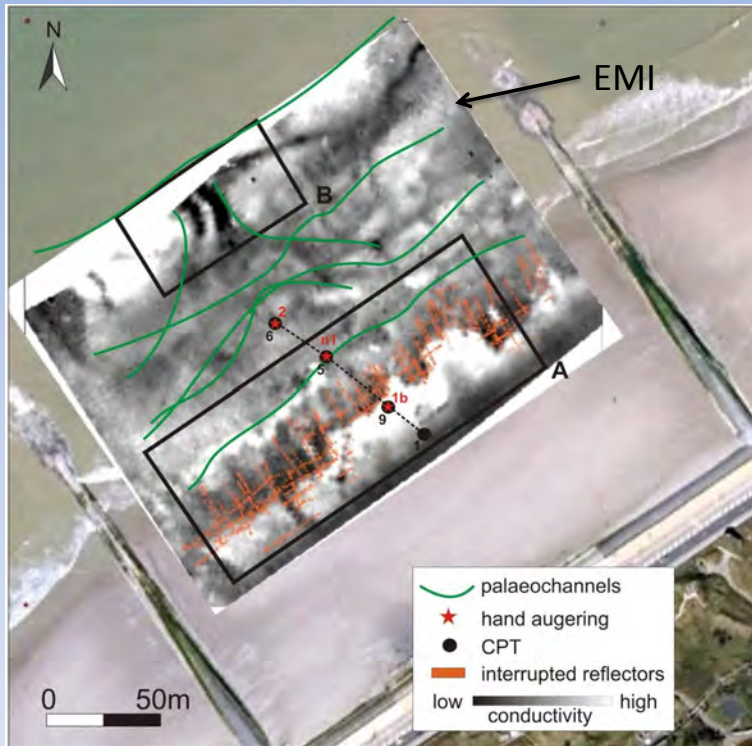
So far no proof of Roman dyke and medieval houses on 2D seismic data

2D intertidal – irregular reflectors



- Large number of strong, interrupted reflectors => peat extraction?
- Line spacing (5-10 m) insufficient to map distribution pattern

EMI & ground-truth data



- EMI data show good correlation with seismic
- Peat layers confirmed by cores and CPT's

Intertidal site - 3D seismic



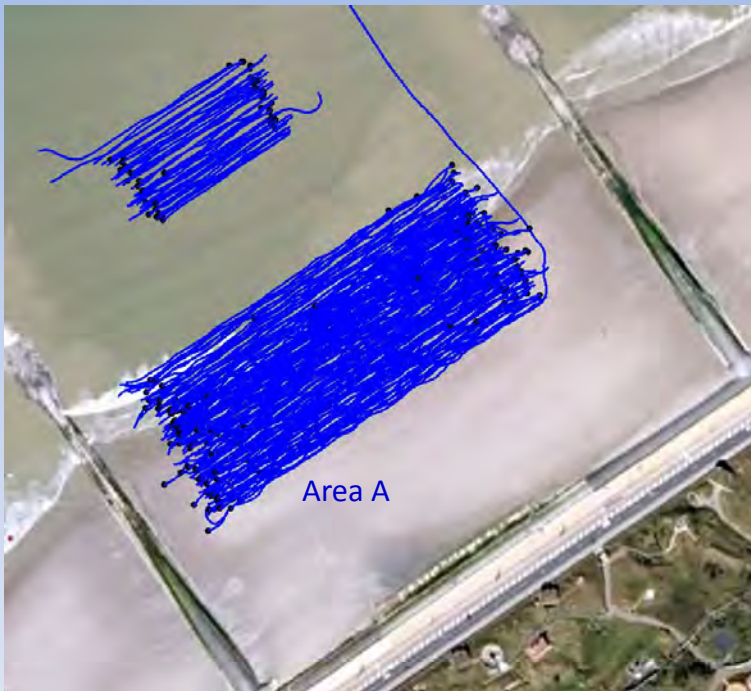
- RTK positioning (cm accuracy)
- High-res motion sensor
- Simultaneous multibeam

□ □	single beam mode (SBM)
□ □ □ □	dual beam mode (DBM)
□ □ □ □ □ □	quattro beam mode (QBM)

Multitransducer parametric echosounder

4 parallel transducers, total spread of 1 m
Possibility of different configurations

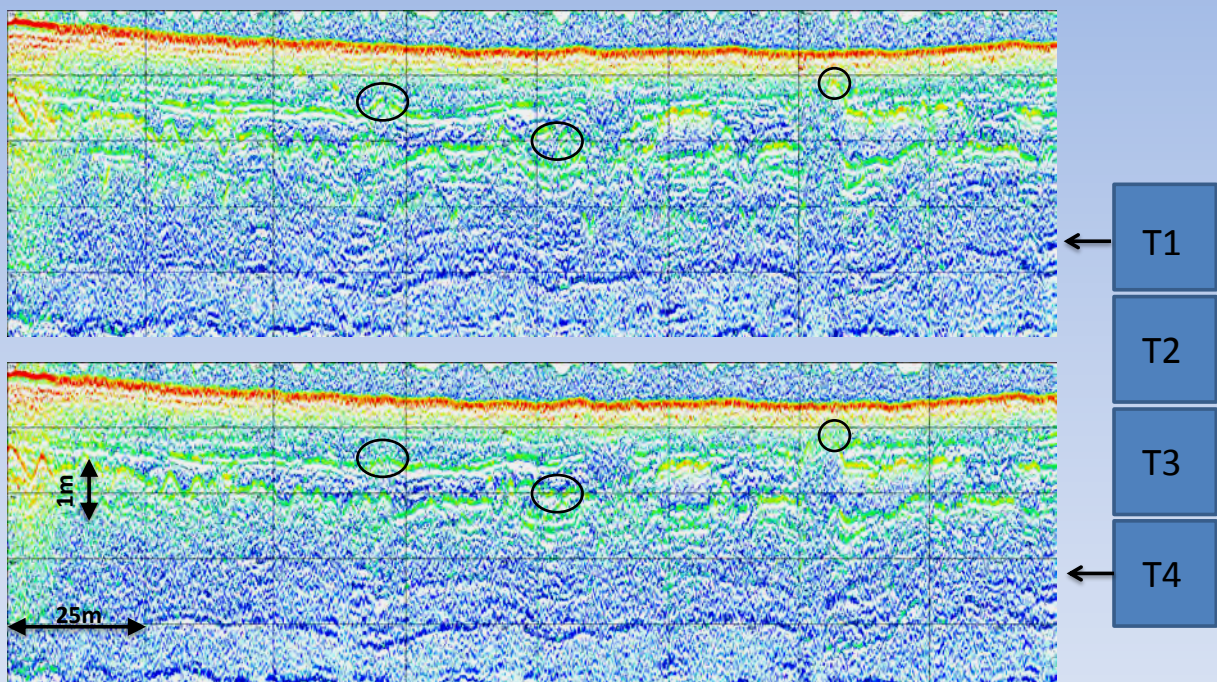
Intertidal site - 3D seismic



Area A (peat area)

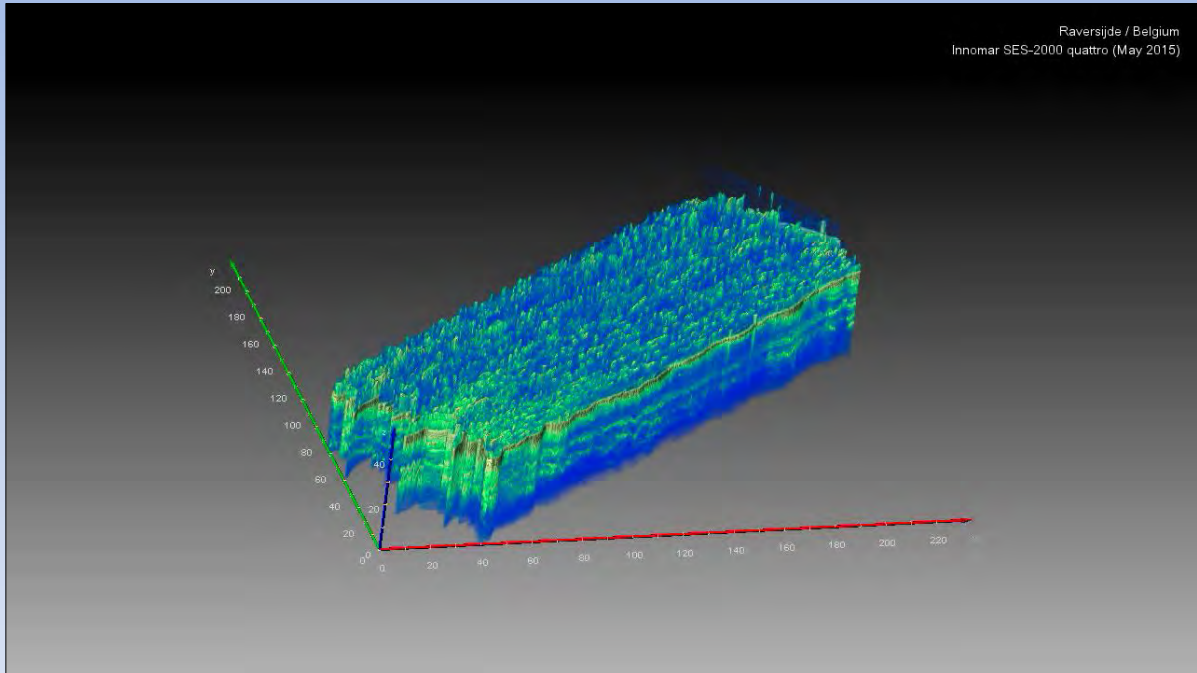
- 220 x 80 m
- 140 parallel lines
- line spacing ≤ 1 m
- recorded over two days (high tide only)
- total recording time ~ 6 hrs

Transducer data



Difference in observed features between different transducers
=> extremely high subsurface variability

3D volume – Area A

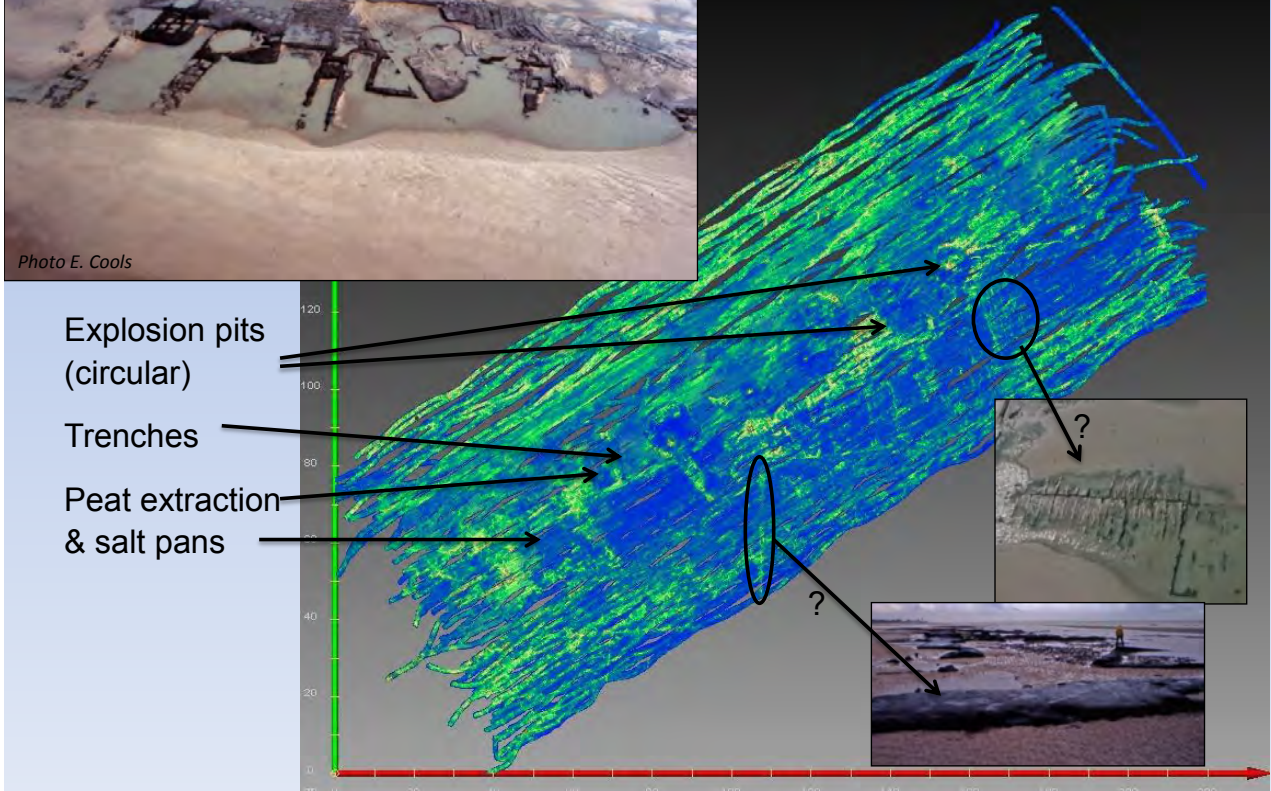


- total volume 220 x 80 x 4 m
- grid cell size 25 x 25 x 1 cm (!)

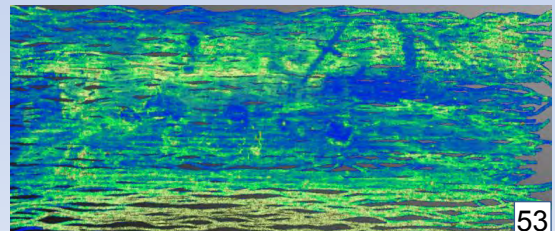
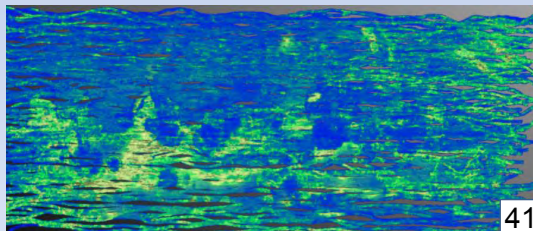
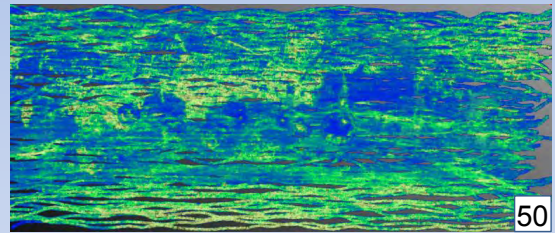
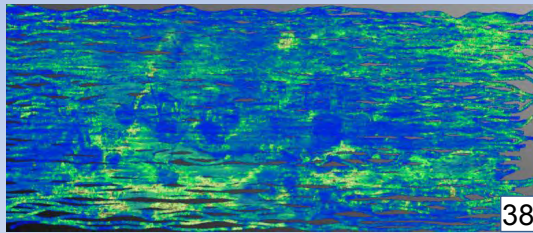
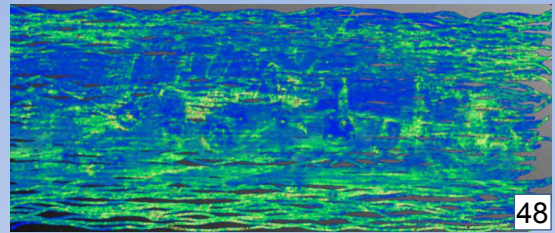
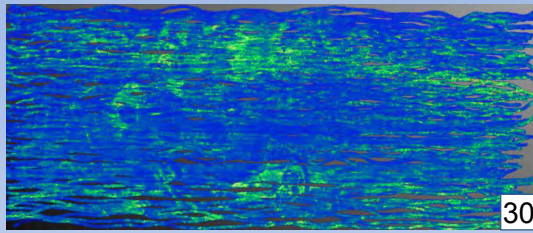


3D volume – Area A

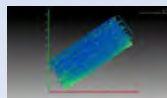
Horizontal depthslice (~1,5 m bsf)



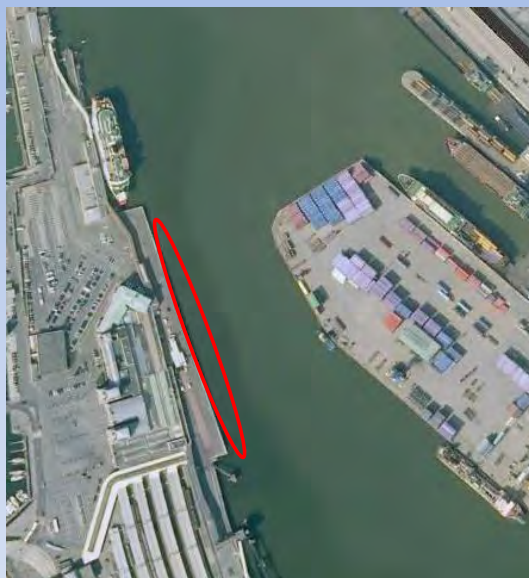
Depth slices – Area A



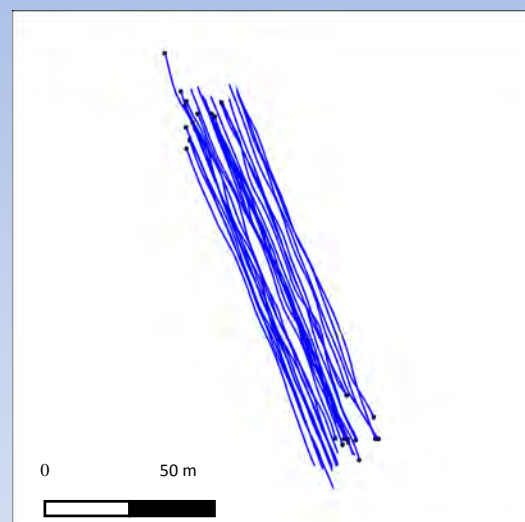
movie



Additional site – Ostend harbour

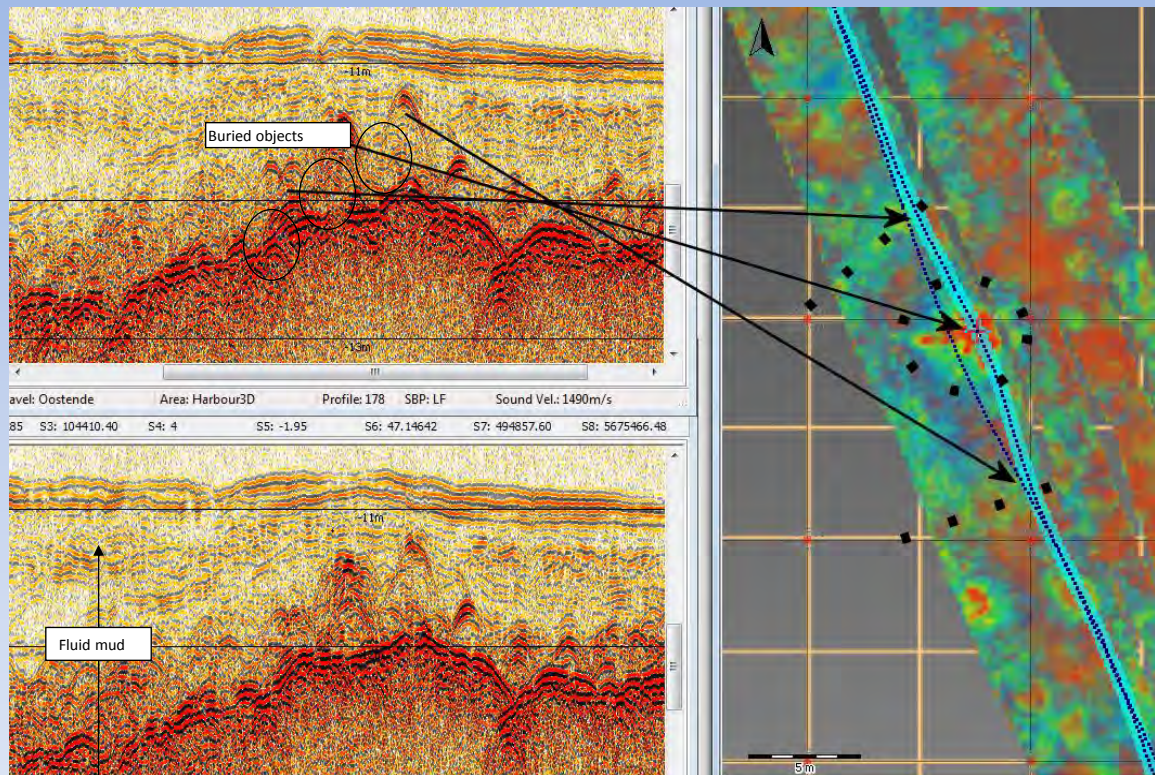


Unknown object(s)
encountered during dredging



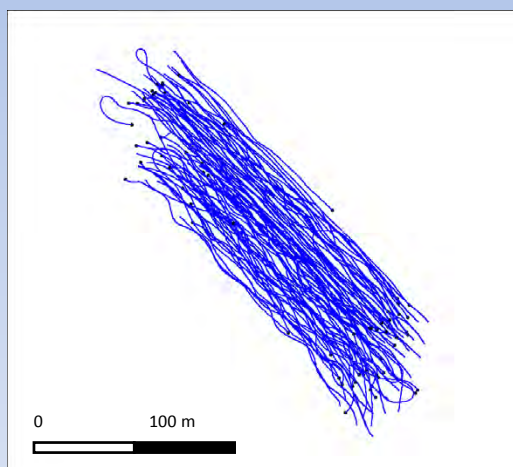
Line spacing \gg 1 m due to
lack of time

Ostend harbour site – detected objects

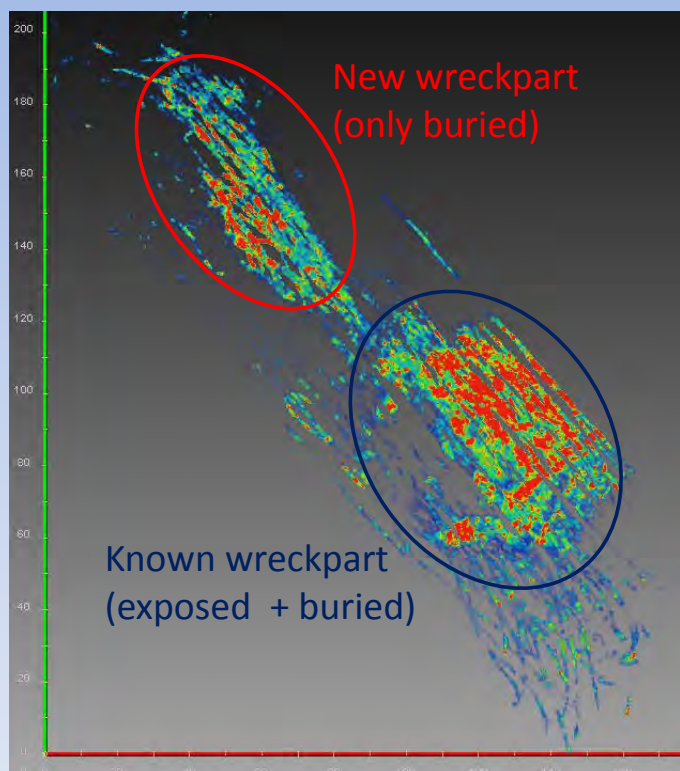


3 buried object(s) detected, likely link to wood beams broken off quayside internal stratification within the fluid mud layer

Additional site – wooden shipwreck

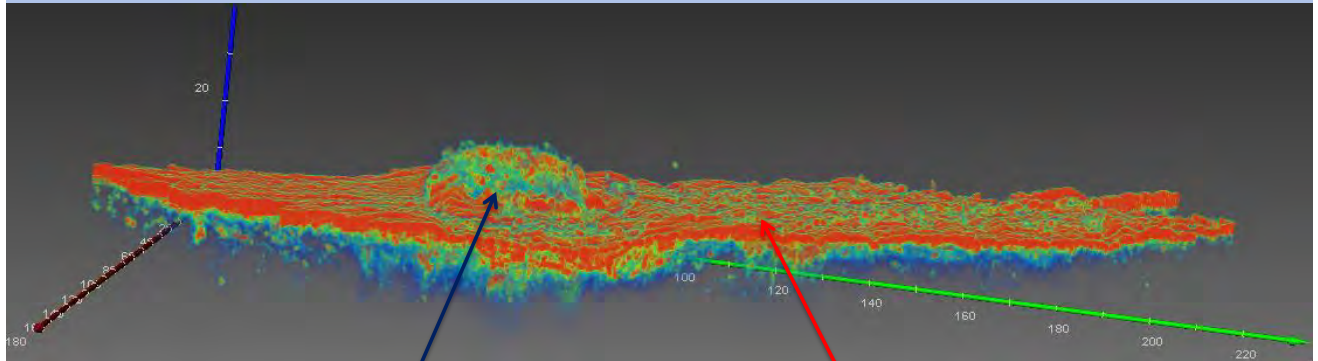


No full coverage due to lack of time



horizontal depthslice ~1 m below seafloor

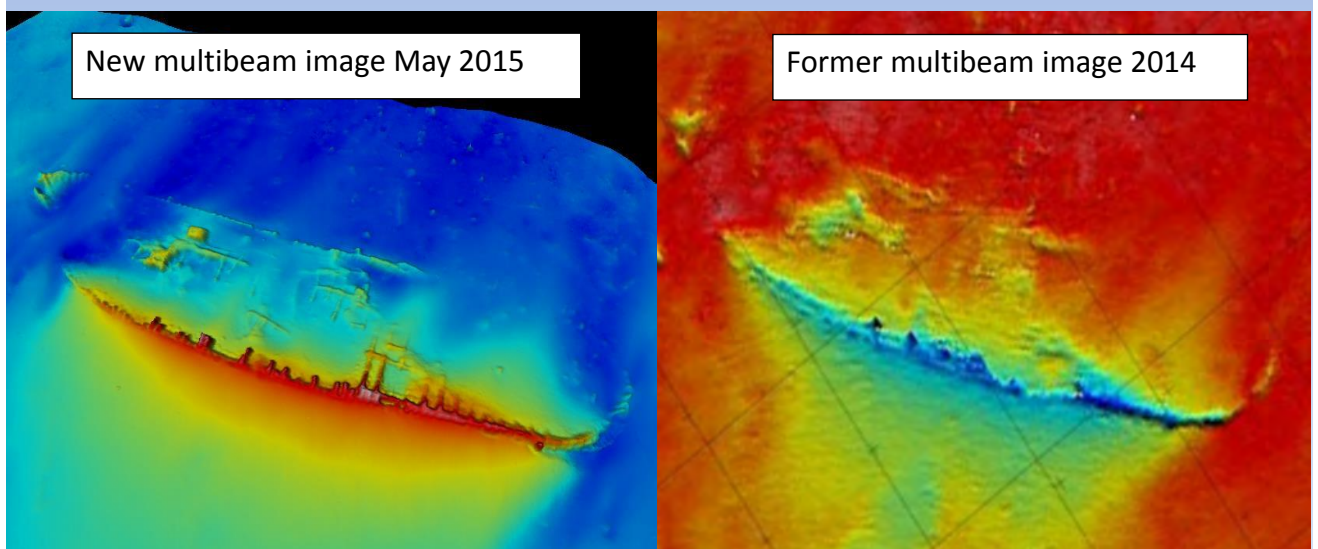
Shipwreck site – 3D volume



Exposed (known) wreckpart

Buried (unknown) wreckpart

Shipwreck site – multibeam



Astonishing resolution due to high data density and small beam width

Conclusions 3D seismic

- Multitransducer PES is highly performant tool for small-scale buried features imaging in 3D
- Very precise positioning & motion sensor is crucial
- Full coverage is essential for highest resolution (small grid cell size)
- Difficult navigation in intertidal areas – good weather mainly
- Ongoing / future work:
 - exact georeferencing of archaeological data (photos, maps)
 - more targeted 3D investigations
 - Optimal configuration for different applications