IWT SBO PROJECT 120003 "SEARCH"

Archaeological heritage in the North Sea

Development of an efficient assessment methodology and approach towards a sustainable management policy and legal framework in Belgium.

Archeologisch erfgoed in de Noordzee

Ontwikkeling van een efficiënte evaluatiemethodologie en voorstellen tot een duurzaam beheer in België.

3D SEISMIC CAMPAIGN
4-8 MAY 2015

WP1.3.1

Responsible partners: UG-RCMG (+ subcontractor Innomar)

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1. Framework and objectives

1.1. Framework

In May 2015 a very high resolution 3D seismic survey was carried out in the nearshore and intertidal zone of Ostend and Raversijde in the framework of the IWT-SBO project SeArch ("Archaeological heritage in the North Sea: development of an efficient methodology and approach towards a sustainable management policy and legal framework in Belgium"). The purpose of this project is to assess the archaeological potential of the Quaternary deposits in the Belgian part of the North Sea. To this date no efficient survey methodology exists that is particularly aimed at archaeological assessment studies. Standard geophysical and remote sensing techniques are mainly used on an *ad hoc* basis (if at all) and these techniques are often not well adapted for archaeological investigations. Moreover they are ineffective in large parts of the nearshore zone due to the presence of biogenic gas in the sediments, and generally cannot be applied appropriately in intertidal areas.

One of the main goals of the SeArch project is to supply an efficient survey methodology for the nearshore and intertidal zone through the development and improvement of non-conventional marine geophysical techniques for seafloor and sub-seafloor imaging, with major focus on acquisition, data processing and interpretation of high-quality data. This should allow an accurate assessment of the archaeological potential of these shallow water areas which are often known to be rich in submerged archaeological and cultural heritage.

Conventional subbottom profiling systems yield a 2-dimensional image of the sub-seafloor. However, small buried archaeological or geological structures of meter scale will easily be missed on these 2D data. Very high resolution true 3-dimensional imaging is therefore needed in order to image these structures correctly, but this is a highly complex technique and rarely achieved (due to the physical constraints placed on sampling and positioning accuracy). Very recently a multi-transducer parametric echosounder system has been developed by the German company Innomar (SES-2000 Quattro) which opens new perspectives for detailed 3D imaging of the sub-seafloor.

1.2. Survey Objectives

The seismic campaign in May 2015 was carried out on board of the vessel Hydro I from the Flemish Hydrography. This vessel allowed maximum manoeuvrability in very shallow water (due to the small draught and short length (~6.5 m) of the vessel). The main objectives of the survey included:

- To test the multi-transducer system over buried peat excavation features;
- To image partly buried shipwrecks in 3D;
- To test the applicability for the detection of small objects buried in fluid mud.

2. Study area

The survey zones comprised three different areas (figure 1):

- Raversijde (intertidal area) (A)
- Wreck sites offshore Ostend (B)
- Ostend harbour (C)

Figure 1 – Areas investigated with the multi-transducer echosounder system. A: Raversijde. B: shipwrecks. C: Ostend harbour.

The area of Raversijde is known for the presence of peat and salt extraction that dates from the Roman, and possibly also medieval, times. Till the 1970's the peat and salt extraction remnants were still visible on the beach (especially after storms). After the construction of breakwaters at regular intervals these features have become buried below 1-2 m of sand. Previous marine 2D seismic investigations as well as electromagnetic investigations (carried out on the beach at low tide) have confirmed the presence of interrupted peat layers, but the full pattern of peat digging was never established. The shipwrecks offshore Ostend were surveyed in order to image possible buried & scattered remnants. The main target was a wreck site located just off the harbor entrance. It concerns a wooden wreck that presumably dates from the 18th-19th century and that was recently assigned the status of marine cultural heritage. The third survey area, located inside the Ostend harbour, was not planned originally but was investigated because weather conditions did not allow to work at sea during some days. The target here was a buried object that was encountered during recent maintenance work (i.e. dredging operations) inside the harbour.

3. List of participants

Name	Organisation	Function	04/05	05/05	06/05	07/05	08/05
Tine Missiaen	RCMG	Geophysicist	x	-	-	x	x
Jens Lowag	Innomar	Geophysicist	x	-	-	x	x
Samuel Deleu	Flemish Hydrography	Hydrographer	x	-	-	x	x
Kris Vanparys	Flemish Hydrography	Hydrographer	x	-	-	x	x

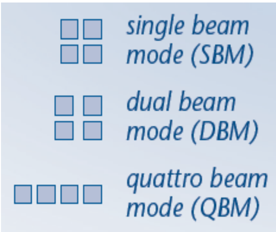
Table 1 – List of participants. Remark: on 5 and 6 May no survey work was performed due to stormy weather.

4. Data acquisition

4.1. Equipment and seismic characteristics

The SES-2000 Quattro is a multi-transducer parametric echosounder that has been especially designed for detailed investigations of the sub-seafloor. The short signal length and high frequency (8-16 kHz) allows working in extremely shallow water (0.5 up to 15-20 m). The device consists of an array of four (4) synchronized parametrical transducers with a total spread of 1 meter (see figure 2-left). Each transducer works as a source/receiver. The fix mounted transducers seriously reduce the volume rendering 3D processing (since time-consuming migration and beam forming processing is no longer required) which makes this system particularly fit for rapid, cost-efficient site surveys.

The system has a high level of flexibility regarding the configuration of the transducers:



- Quadrangle configuration with simultaneous use as one single (single beam mode SBM) => for higher energy and higher penetration in the bottom;
- Combined configuration – quadrangle used as 2 transducers (dual beam mode DBM) => for higher data density and more energy;
- Linear configuration with individual transducers (Quattrobeam mode QBM) => for the highest data density;

For the survey at Ostend and Raversijde the linear Quattrobeam configuration (QBM) was used. The transducer array was mounted on a steel pole that was attached to the side of the ship (see fig. 2 left). The acquisition unit was put inside the vessel cabin. During the entire survey multibeam data were recorded simultaneously. In order to allow correct 3D modeling of the seismic data very precise positioning data were needed. Therefore a GPS RTK positioning system was used (x/y/z with cm precision, 10 Hz update rate), together with a high-frequency Octans motion sensor (cm precision, 50 Hz update rate). Transducer, motion sensor and GPS antenna offsets were known with cm precision (Figure 2-right).

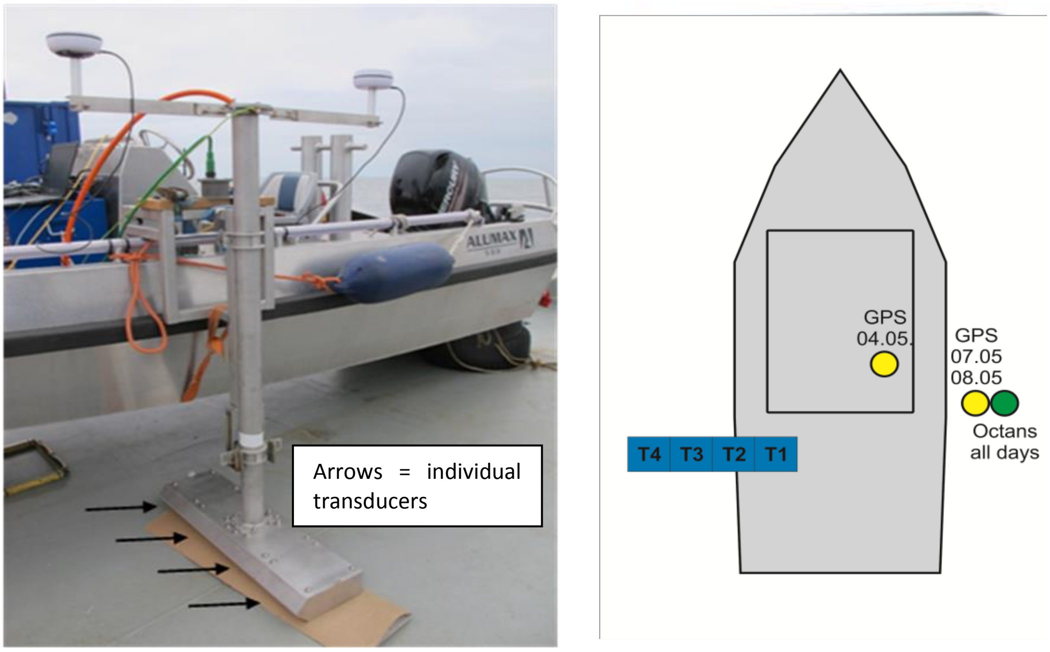


Figure 2 – Left: multitransducer parameteric echosounder array used for the seismic survey at Ostend and Raversijde. Right: Schematic layout of the mounted equipment (transducers T1-T4, Octans and GPS).

4.2. Recorded seismic networks

Due to bad weather the seismic investigations could only be carried out during 2,5 days (on 5, 7 and 8 May 2015). On May 7 measurements were only possible in the relatively sheltered location of Ostend harbour. During the surveys an average trackline spacing of 1m was envisaged in order to obtain full lateral coverage. However due to a lack of time and difficult navigation in nearshore areas (a result of waves and currents) this was not always possible. Each seismic trackline resulted in four parallel profiles (corresponding with the 4 transducers) located a short lateral distance away (~30 cm).

4.2.1. Raversijde

At Raversijde two different networks were obtained: one small northern network (± 100 x 50m) consisting of 48 parallel tracklines and one large southern network (± 220 x 80m) consisting of roughly 140 parallel tracklines (Figure 3). Because it was practically impossible for the ship to navigate precisely along pre-fixed lines 1 m or less apart (also due to the extremely small size (6.5 m) of the vessel), it was decided to record two different networks over the southern area (resp. on May 5 and May 8) and then later on integrate the two data sets. Due to bad weather it was not possible to obtain full coverage (i.e. 1 m line spacing) in the small northern network.

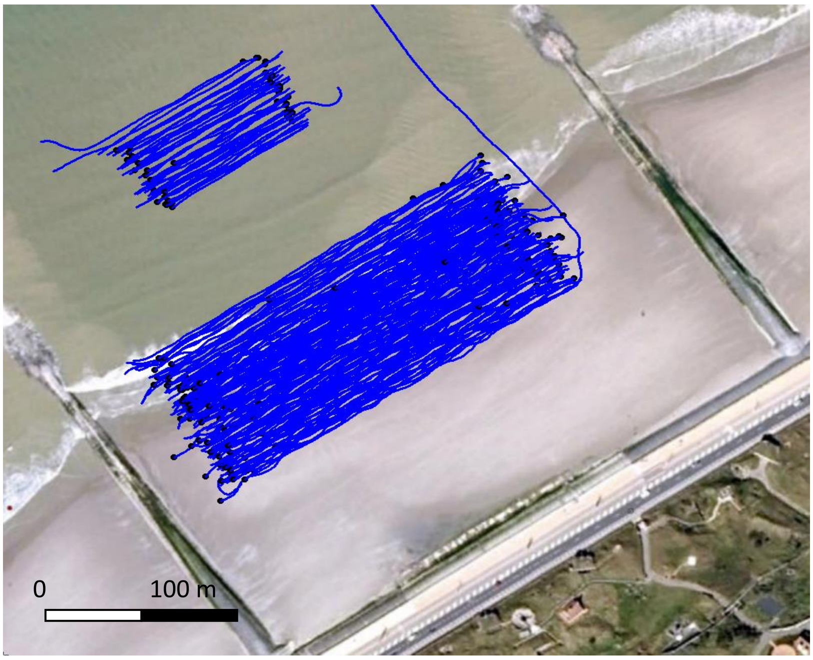


Figure 3. Seismic networks obtained at Raversijde. Only the southern, large network shows a full coverage. In the northern network still some holes can be observed.

4.2.2. Shipwrecks offshore Ostend

Three different wreck locations were envisaged in the area offshore Ostend. However two of these wreck sites did not show any buried features and were therefore discarded for further 3D imaging. Over the third wreck site, just off the harbour entrance, a total of 70 parallel seismic tracklines were recorded (Figure 4). The wooden wreck, which is partly exposed, is thought to be 30 m long and 6 m wide. However a much larger area was surveyed in order to map potential scattered wreck pieces. Due to a lack of time (caused by stormy weather) it was not possible to obtain full spatial coverage over the entire wreck site. Some gaps can therefore be observed in the data volume.

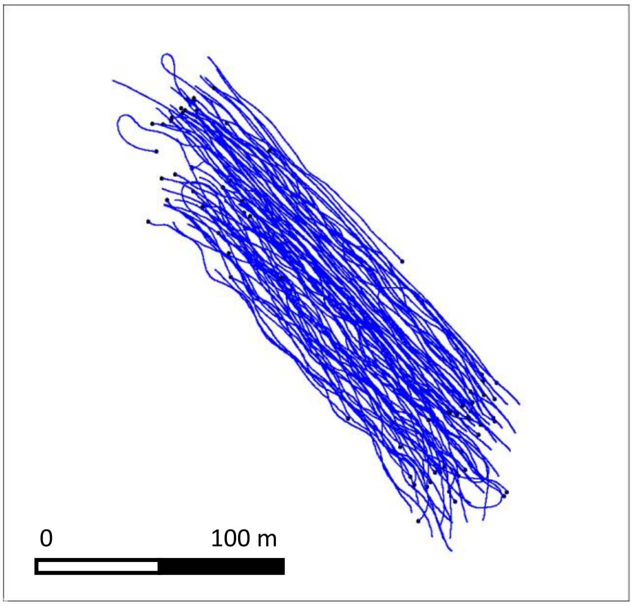


Figure 4. Seismic network obtained over the wooden shipwreck off Ostend harbour.

4.2.3. Inside Ostend harbour

In the harbour of Ostend a small 3D network was obtained alongside one of the quays (Figure 5). In total 28 parallel tracklines were obtained here over an area of roughly 30 x 100 m. The resulting data volume still showed some gaps.

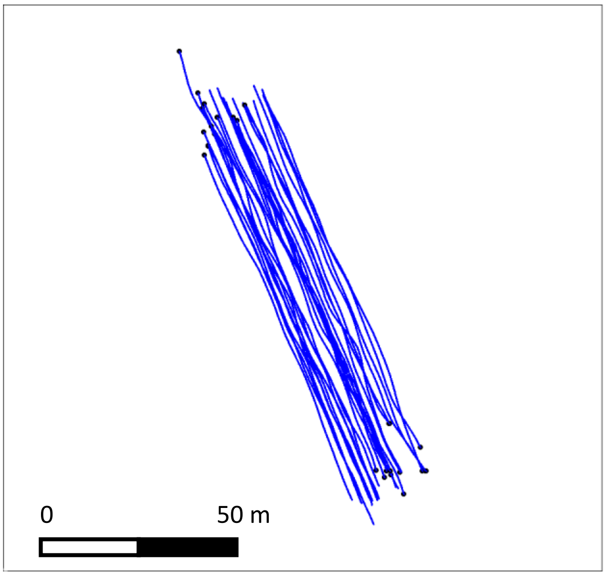


Figure 5. Seismic network obtained over the buried object(s) inside Ostend harbour.

5. Preliminary results

Processing of the seismic data was done using conventional ISE processing software (pre-processing) and a 3D rendering software programme (Voxler Golden Software, data volumes up to 200MB).

5.1. Raversijde

Thanks to the high line coverage a grid cell size of 20x20x1 cm was possible at the large survey area of Raversijde (total 3D volume 220x80x4 m). The results are astonishing. For the first time the peat and salt excavation features can be observed coherently and in high detail. Figure 6 shows a typical horizontal (depth) slice through the 3D volume. On this depth slice we can clearly observe the characteristic pattern consisting of peat strips, rectangular and circular excavation pits, and (diagonal) trenches. These observed features perfectly match with the old (aerial) photographs of the area as shown in Figure 7. Further data processing and interpretation is still ongoing.

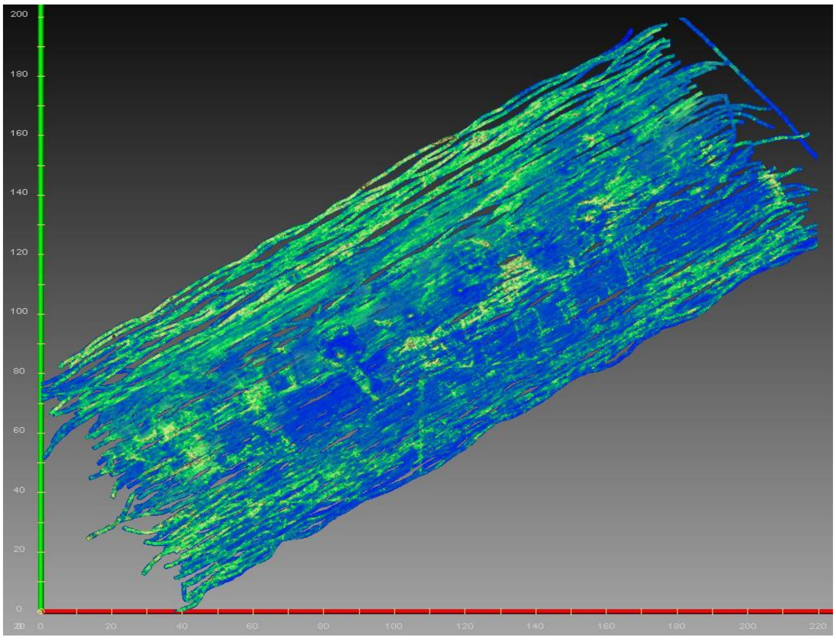


Figure 6 – Horizontal depth slice from the 3D data volume obtained at Raversijde.

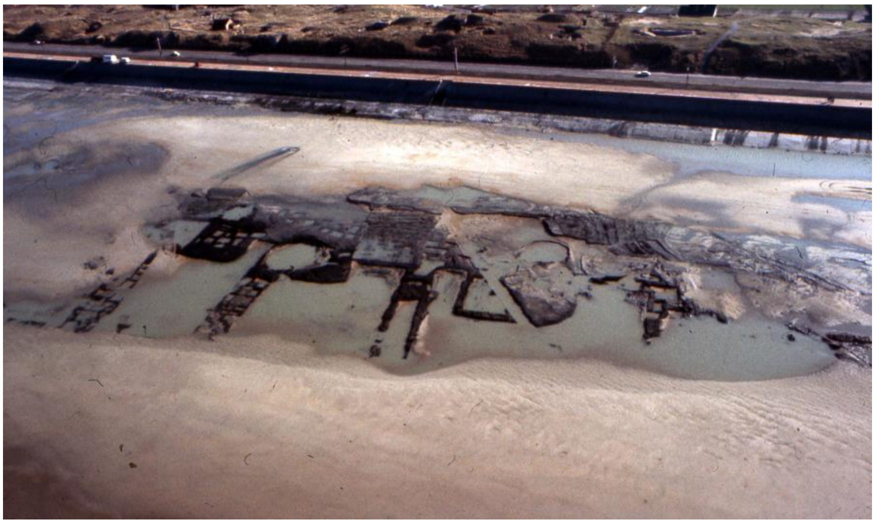


Figure 7 - Air photo of the beach at Raversijde around 1970 showing large patterns of peat extraction exposed on the beach. (Photo E. Cools)

5.2. Wreck site

A 3D volume of roughly 80x200x4 m was obtained at the wreck site. Due to the lower data coverage only a grid cell size of 40x40x1 cm was possible. Nevertheless the 3D data from the wreck site allowed to identify some parts of the wreck that are buried below the seafloor (see Figure 8). These wreckpieces had hitherto never been recognized. Due to the relative close line spacing (between 1 and 3 m) the simultaneous recorded multibeam data from the wreck furthermore exhibited a stunning resolution (Figure 9).

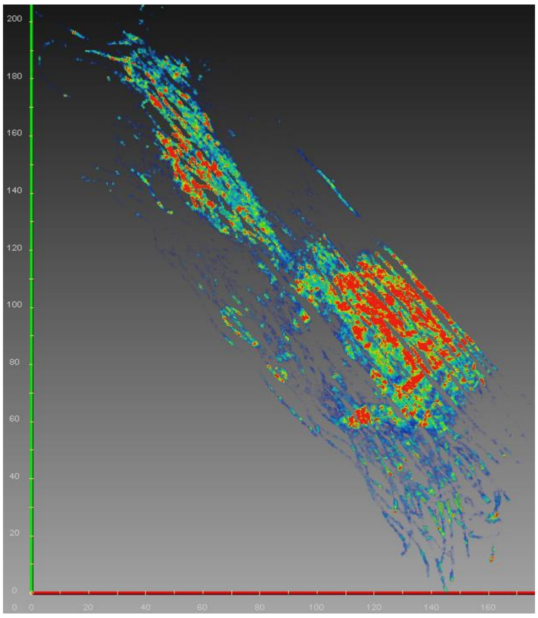


Figure 8 –Horizontal depth slice across the 3D data volume, indicating that large parts of the wreck are buried below the seafloor.

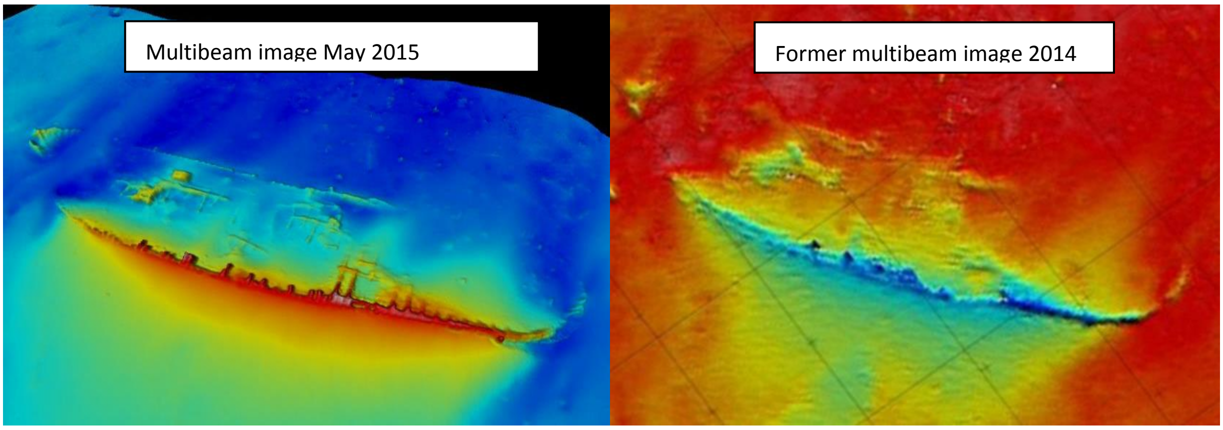


Figure 9 – Left: Multibeam image from the wreck obtained in the May 2015. Right: former multibeam image from 2014. The difference in detail is remarkable.

5.3. Ostend harbour

The 3D data volume obtained in Ostend harbour allowed to image the fluid mud layer in the highest spatial detail, including the internal layering within this layer (which is seldom observed on sub-bottom seismic data). Several buried objects were also observed on the high-resolution data (Figure 10). Notwithstanding the gaps in the data, the 3D volume allowed to determine the size, depth and inclination of the various objects. One of the objects is most likely related to a large wooden beam that was previously attached to the quayside but which recently fell down into the water. It is possibly this object that was encountered during recent dredging works.

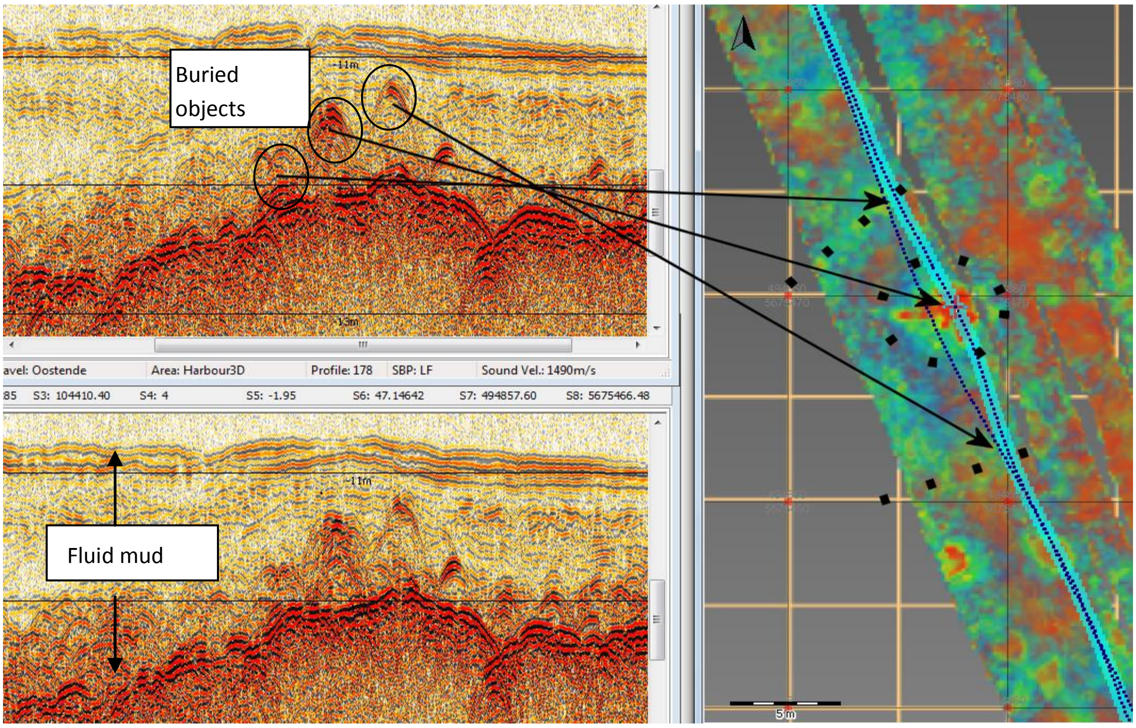
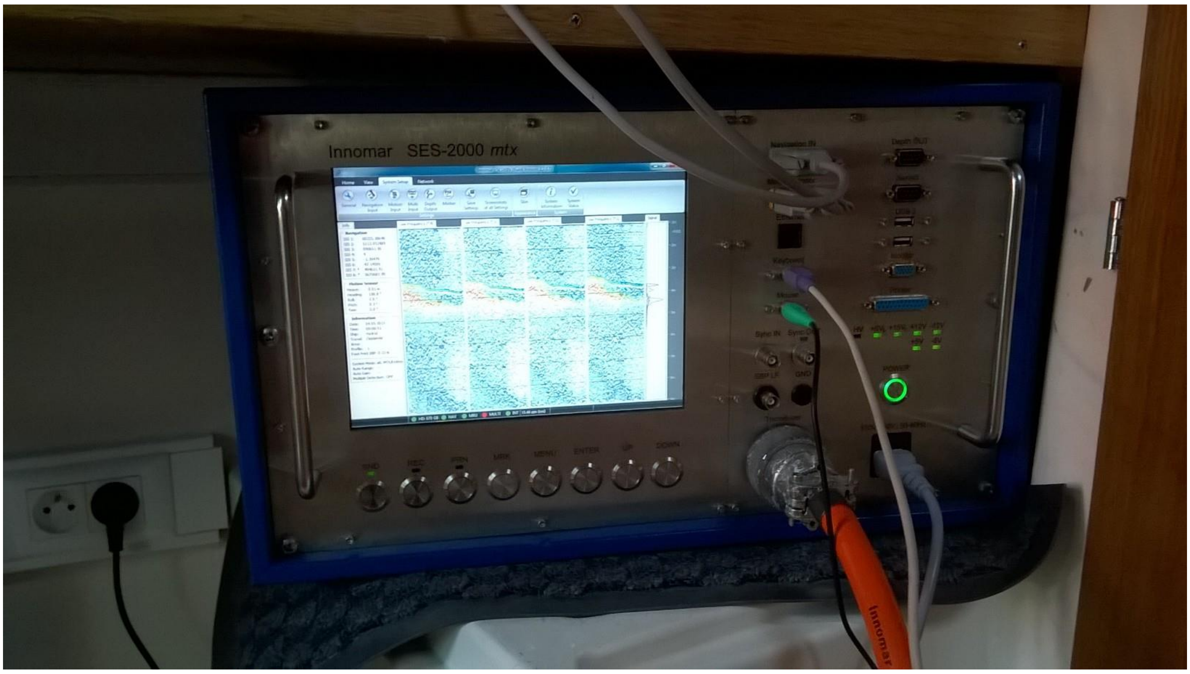


Figure 10 – Left: two vertical slices across the 3D data volume from Ostend harbour. Various buried objects and stratification within the fluid mud layer can be clearly observed. Right: horizontal (depth) slice across the 3D data volume. The arrows mark the same features that were observed on the vertical slices on the left.

6. Annex – Survey photographs

Survey vessel Hydro 1(Flemish Hydrography). The echosounder pole and orange cable are seen on the left (port side). On starboard side the pole-mounted Octans motion sensor and multibeam unit can be seen.



Seismic acquisition unit displaying data from the four transducers simultaneously.

Multi-transducer pole attached to the side of the vessel.