Selected acoustic images of the Gdansk Bay

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Introduction

The main goal of the paper is to describe the results of sounding the Gdansk Bay seabed by using a parametric sub-bottom profiler, multibeam echosounder and side scan sonar. Quality of data obtained during trials depends interalia on a proper location of antenna to reduce influence of pitch, roll and heave motions as well as ship noise (resulting from bubbles due to propeller and flow around hull, vibration generated by main engine and peripheral devices). Furthermore, calibration of complementary units (which fulfil information of sounding data) such as GPS, heading sensor, MRU-Z motion sensor and navigation devices make sea bed investigating system capable of working with its whole efficiency. Results of so prepared trials have been presented and discussed. They contain also an elaborated map of the Gdansk Bay with preliminarily classified sea bed materials and description of most interesting areas.

Research vessel

The configuration of equipment set on measurement vessel is presented in Fig. 1.

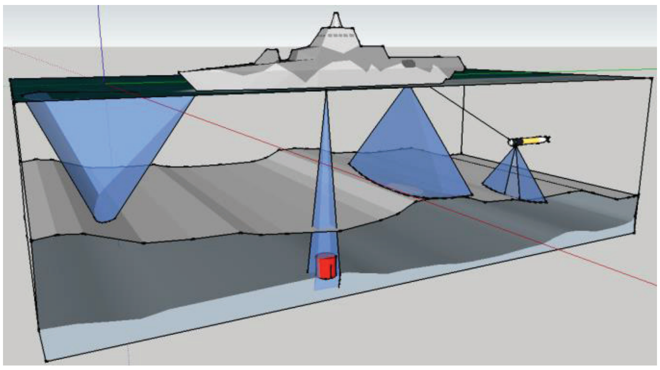

Fig 1. Sounding equipment configuration.

- the single-beam echo-sounder, aiming straight below the surveying vessel and imaging a wide portion of seabed (and sub-seabed) at once;

- the multibeam echosounder, composed from narrower beams and mapping a wide swath of seabed across the track of the surveying vessel;

- the side scan sonar, often towed separately and close to the seabed, imaging at grazing angles;

- the forward looking sonar displays the seabed terrain and potential hazards. This is a real time sonar image of what is actually ahead of the boat.

The platform for sea trials was set on board s/y Windspeel, a small research vessel. The main device was the SES-2000 Compact sub-bottom echosounder which consisted of the main unit situated below the deck and the transducer array mounted on aluminium arm starboard. The unit makes it possible to radiate low frequency sounding pulses set by the user within the range from 4 to 15 kHz and a definite changeable length. An interesting function during sounding was the option of obtaining sub-bottom data by applying two or three different pulses with defined frequencies. During described sea trials frequencies of 4 kHz, 8 kHz and 12 kHz were set and combined to each other. As the best weather conditions are during calm sea which is not always achievable, hence a beam steering to compensate for vessel pitching and rolling was necessary. The obtained data were stored on hard disc in the two formats: *.SES one which includes information about signal envelope and *.RAW data containing full waveform. The whole unit was powered with 230V (AC) provided from DC-AC converter connected to the set of three 110 Ah gel batteries charged during trials from solar batteries and a generator driven by vessel's engine. During breaks in measurements the charging was provided by on-board 230 V Honda electric generating set. Additionally sea bed was sounded with the use of the multi-beam EM3002 echosounder which transmitted pulses synchronized by means of an external trigger installed in the SES-2000 sounder that ensured undisturbed results. Complementary devices like the MRU-Z sensor of pitch, roll and heave motions, precise GPS with heading sensor were installed and calibrated on the vessel. Signals from the sensors were distributed to the devices by means of RS-232 splitters. During the trials sound velocity profiles were stored in STD/CTD 204 unit and put into controlling programs of sub-bottom and multi-beam echosounder. The investigated area and transects selection along which the sounding took place were determined on the basis of geological maps delivered by Państwowy Instytut Geologiczny (State Geological Institute). The appropriate data were delivered to the navigation software (Nobeltec) connected to autopilot, that ensured a satisfying accuracy of sounding along the set tracks. To help the skipper to control situation on sea two monitors were duplicated in cockpit to display navigation map and sounding results. The research vessel prepared to measurement trials on Gdansk Bay is presented in Fig. 2.

Fig 2. Prepared to measurements research vessel .

Whole data visualization was realized inside the measurement vessels on multi-screen desk presented in Fig. 3. Additionally two screens presenting navigation map and results of multibeam echosounder where placed on deck to make easier helmsman work. Each system has its own processing computer and data where automatically backed up in external server.

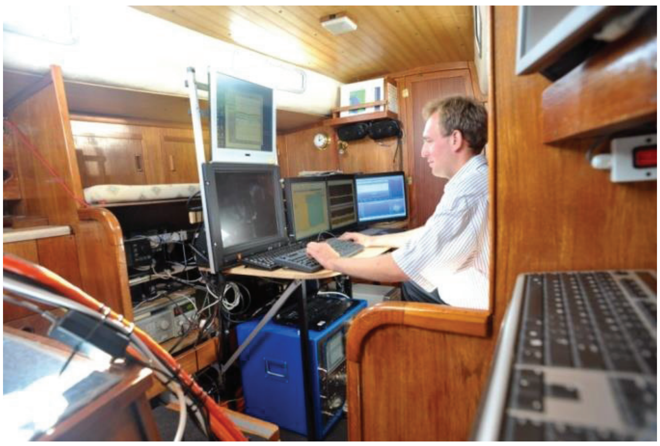

Fig 3. Operator’s desk.

Devices necessary to ensure proper work of the whole unit were placed on specially prepared working racks inside the vessel. The scheme of data fusion is presented in Fig. 4. Before beginning the trails on sea the devices were calibrated in harbor and checked during work with different parameters and configurations. Additionally, the electric system was tested and checked against possible emission of noise which could influence sounding equipment. Special RS232 splitters were implemented into the system to avoid duplication of the units delivering information such as position and motion data.

Fig 4. Equipment configuration.

Selected Acoustic Images of the Gdansk Bay

The Gdansk Bay is diverse in terms of bottom sediments types, beginning from sandy, high reflective bottom going to clay and muddy bottom with low frequency sounding pulses penetration up to 50 meters. In Fig. 5. is presented most basic echogram when echo is coming from sandy bottom with no deep penetration. Additionally it is possible to observe seven echoes from fish.

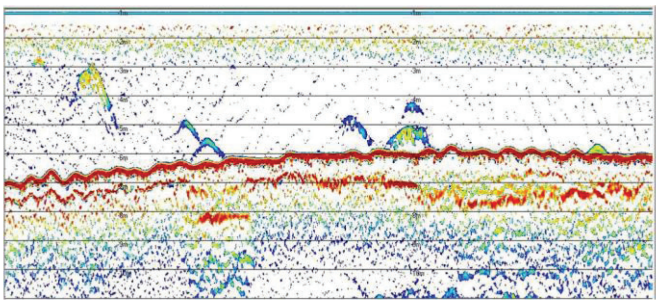

Fig 5. Single beam, low frequency echogram.

More spectacular bottom surface presentation, with fast data processing, is side scan sonar image. In Fig. 6 is presented echo from breakwater at the entrance to Gdynia yacht marina.

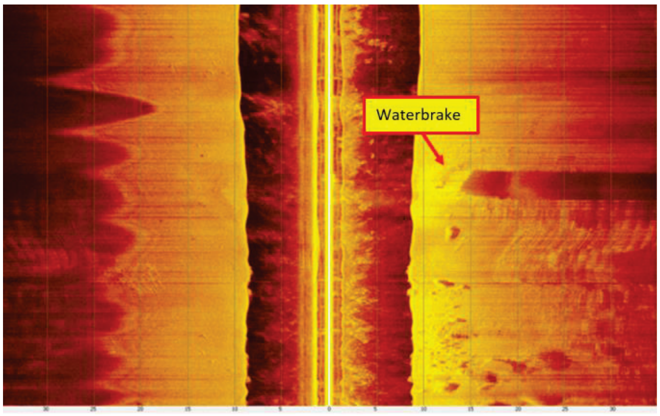

Fig 6. Side Scan Sonar image of breakwater.

Acoustic images processed from data delivered from side scan sonar give user possibility of getting information about objects lying on bottom or floating in the depth width and high, but without precision that can be obtained during processing data from multibeam echosounder. In Fig. 7 is presented partially buried submarine image. Raw data coming from different units can be processed with original software or as in this example import from raw files directly to Matlab programming software.

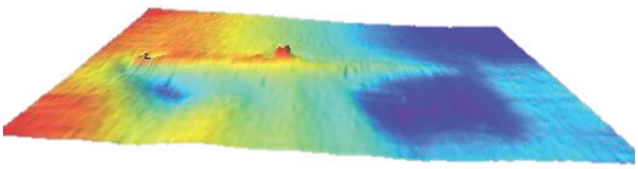

Fig 7. Multibeam image of partially buried submarine

Working with raw data give scientists possibility of different ways of signals for example filtration, processing and visualization for example as in Fig. 8 where fusion of typical bathymetrical data

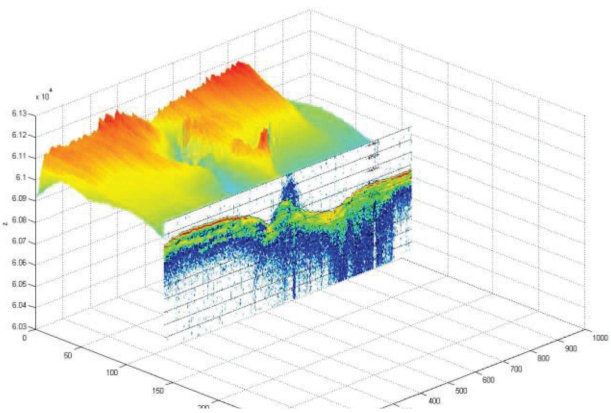

Fig 8. Fusion of bathymetrical and subbotom profiler data.

where combined with parametric echosounder results. Data obtained from subbotom profiler were successfully compared with geological maps created with invasive methods (sediments cores). In Fig. 9 is presented part of subbotom materials structure, which was compared with data obtained with noninvasive method.

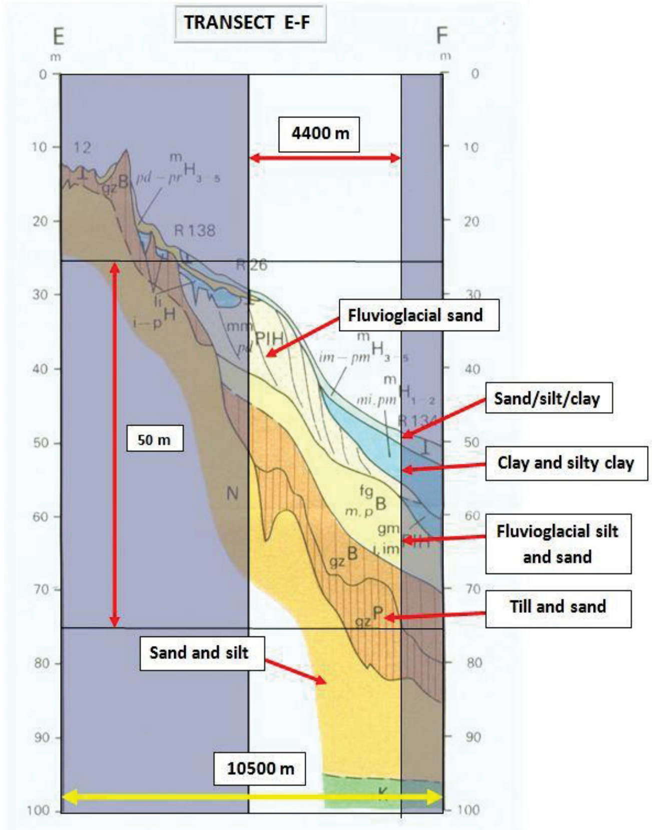

Fig 9. Sediments layers in geological map.

Result of sounding along specified transect E-F presented in Fig. 10 gives high correlation value between described two methods of geological structure acquisition.

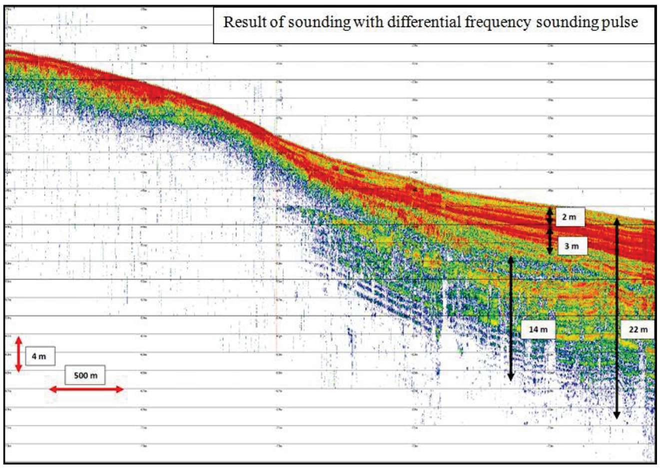

Fig 10. Image of differential frequency sounding puls.

Using features of differential sounding pulses enable also for example gas pipeline tracking (using frequency related to gas pipeline resonance parameters). In Fig. 11. can be observed four parts with characteristic resonance echoes pointing pipeline localization.

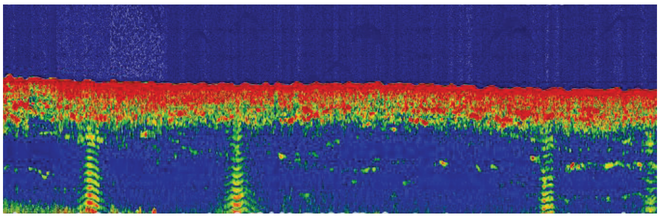

Fig 11. Gas pipeline tracking.

Some examples of data collected during sea bottom measurements allow to assess the penetration properties of the equipment and determine the presence of buried objects as shown in Fig. 12.

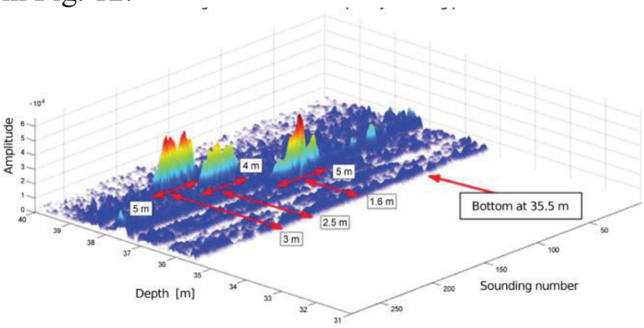

Fig 12. Three buried object detection.

SUMMARY

There are known many technologies and devices used for underwater imaging. However obtaining the complete image of the underwater world is not possible by applying any of them. In the paper were presented methods of investigation commonly used in visualization of the sea. Basing on the data obtained for the same area by means of different equipment we got unsimilar images of the investigated environment. Presented examples confirm that each of the methods of underwater imaging give us only a partial image because of limitation resulting from the technology itself. Full information is possible only by using several complementary techniques. Note worthily is new class of devices operating on the basis of the theory of nonlinear hydroacoustics - parametric echosounders. They allow to imagine an upper layer of bottom sediments, which is impossible when using other devices for underwater observation.

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