SELECTED RESULTS OF THE PARAMETRIC SOUNDINGS OF THE GDAŃSK BAY

GRAŻYNA GRELOWSKA[1], EUGENIUSZ KOZACZKA[1,2]

[1]Polish Naval Academy
Śmidowicza 69 , 81-103 Gdynia, Poland
[2]Gdańsk University of Technology
Narutowicza 11/12, 80-952 Gdańsk, Poland
ggrel@wp.pl; koe@o2.pl

The aim of the paper is to present results of experimental investigation using parametric echosounder in natural conditions for profiling the sub-bottom sediments in the Gdansk Bay. The special experimental setup has been arranged allowing penetration of bottom sediments as well as precise positioning and following a given route. Measurements were conducted exactly along given routes, for those geological profiles have bean taken by means of another method. It allow as to compare detailed date obtained by means of parametric echosounding to ones given at geological map. In all investigations the primary frequency of the array was of 100 kHz, whereas the secondary frequency changed in range 5 kHz - 15 kHz.

INTORDUCTION

The sub-bottom reflection profiling is an essential methodology for better understanding of seafloor and its shallow subsurface on a wider scale with good detail in a most economical manner possible. This is a method whereby an acoustic impulse is directed down to the seabed from a transducer. Part of the sound wave then reflects off the seabed and it's subsurface and returns to the transducer (transceiver) or an independent receiver.

There are various types of high resolution sub-bottom profiling systems, mainly varying in energy source and receiving element, with their respective merits and demerits as well as applications. One of the most popular and widely used sub-bottom profiling system is system utilizing air gun(s) as an energy source and a separate receiving cable for recording the reflected acoustic signals.

The other type of the system is based on parametric sound generation, called sometimes parasound sediment echosounder. The most famous TOPAS that allows to penetrate sea floor up to thousands meters is a superior sub-bottom profiling system in resolution but is less common due to its high cost. There are also available mobile parametric sediment echosounder systems that allow to survey in shallow water.

The ultimate objective of this technique is to provide a spatially detailed and resolved picture of the seafloor and the subsurface sediment structures. High resolution seismic surveys are primarily confined in the uppermost 80 meters of soil. This is the area where most engineering applications take place. It is estimated that about 80% of this work is done in the first 15 to 20 meters. Some typical major applications include reconnaissance geological surveys, mineral exploration, foundation studies for offshore platforms, detailed site surveys for engineering projects, cable and pipeline route investigations, harbor development and environmental studies.

The most extensive commercial use of this technique is however, in the hydrocarbon and engineering industries. High-resolution seismic/subbottom profiling survey has become an essential requirement for the oil rig/platform site selection. Cable and pipeline route investigations need a very detailed picture of the top few tens of meters of sediment and therefore, sub-bottom reflection profiling method is the primary source for this information.

The technique of precise subbottom survey finds one more application important for safety at sea. Presently more often mass destruction weapon is placed in shallow water in the very difficult way to find it. Searching of such objects at sea requires usage of devices that have possibility of penetration of sediment that covers the searched object.

The southern Baltic is a geologically complex area with highly variable seafloor geomorphology and subsurface structures. Therefore, the subbottom profiling is a very important tool for geological and mineral studies in this area. The data may also be very useful for possible future activities like submarine cable/pipeline laying.

2. NATURAL CONDITION OF THE SOUTHERN BALTIC

The evolution of the coastal zone of the Southern Baltic Sea, formed as a result of the decay of the last Scandinavian ice-sheet, has been the subject of numerous studies (e.g. [6]). In the area several drastic changes of environmental status are recorded in Late Glacial and Holocene sediments. The postglacial history of the development of this region, which has a wide connection with open water, shows a strong genetic relationship with the concurrent paleoecological state of the Baltic Sea. The paleohydrological regime of the study area is impacted by water masses flowing in from the Gdańsk Basin and the inflow of the Vistula river.

The Gulf of Gdansk is a southeastern bay of the Baltic Sea. It is named after the adjacent port city of Gdańsk in Poland. The western part of Gdańsk Bay is formed by the shallow water of the Bay of Puck. The southeastern part is the Vistula Lagoon, separated by the Vistula Spit and connected to the open sea by the Strait of Baltiysk. The bay is enclosed by a large curve of the shores of Gdansk Pomerania in Poland (Cape Rozewie, Hel Peninsula) and the Kaliningrad Oblast of Russia (Sambian Peninsula). The coast of the bay features two very long sandspits, the Hel peninsula and the Vistula Spit.

The maximum depth is 120 meters, and it has a salinity about of 7 PSU at the sea surface and of 11 – 12 PSU at the sea bottom.

3. METHOD OF MEASUREMENTS

The echograms investigated were taken during the research project devoted to searching of objects buried into sea bottom. The purpose of this study is to observe sea bottom structure and compare obtained results to data given at the geological map of the region. Measurements were carried out along the paths transect the Gulf of Gdansk as shown in Fig. 1.

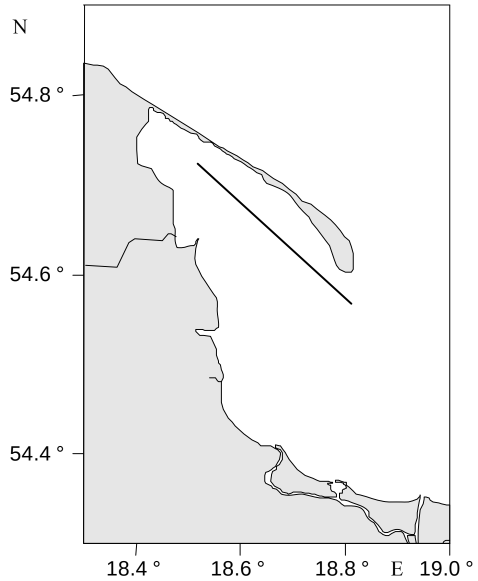


Fig.1 The Gulf of Gdansk: paths of sub-bottom profiling

Measurements were done from boat that was navigated using the differential Global Positioning System (DGPS). The average navigational accuracy is estimated to be better than 1.5 m. Moreover the position was controlled using radar Nobeltec. The set-up used in investigation is shown in Fig. 2.

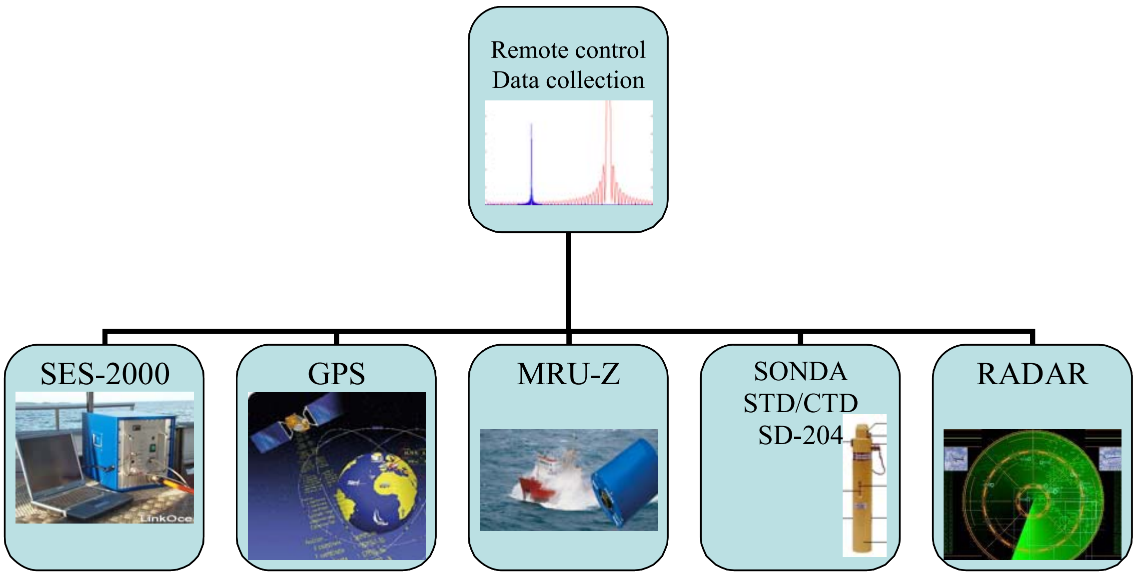


Fig.2 The set-up used in observation of sub-bottom structure in the Southern Baltic

The sub-bottom structure was investigated using the parametric echosounder SES-2000 produced by Innomar. It is a non-linear transducer source which simultaneously transmits two signals of slightly different high frequencies at high sound pressures. Nonlinear interactions generate new frequencies in the water, one of them being the difference frequency that has a bandwidth similar to the primary frequency. Both the primary HF signal (100 kHz) and the secondary LF signal (6 to 12 kHz) are recorded. Penetration can reach up to a few tens of meters in soft sediments. Advantages of the parametric acoustic system include (1) small beam width at low frequencies, (2) deep penetration with high resolution of sediment layers and objects, and (3) accurate depth measurements with the high frequency signal. The parametric echosounder was used in combination with a motion sensor (MRU-Z, Kongsberg) to correct for swell movement. Data processing was carried out with the processing software "ISE 2.9" which allows layer editing and export to ASCII data, extended signal processing, data conversion and data export, tide, water sound velocity and GPS z-level correction.

The conditions of elastic wave propagation in the Baltic Sea depend strongly on hydrological conditions. Therefore vertical distributions of sound speed as well as temperature and salinity were determined before measurements using STD/CTD sounder (SAIV A/S).

The investigations were carried out at the begining of September 2007 at the sea state 2-3. The example of distribution of sound speed and hydrological parameters of seawater taken during measurements is shown in Fig. 3.

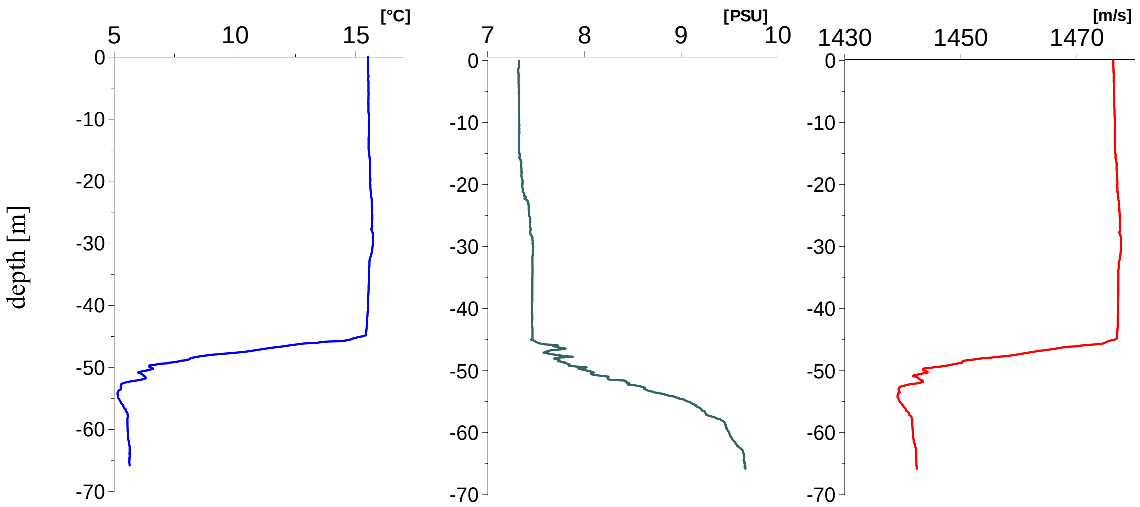


Fig.3 Vertical distribution of temperature, salinity and speed of sound in the region of investigation

4. RESULTS OF INVESTIGATION

Some examples of data collected during observation are given at following figures. They allow to assess the penetration properties of the equipment.

High-resolution sediment-echosounding (parasound) allows distinguishing between sediment layers of different impedance.

Most common is an echofacies characterised by numerous distinct, closely spaced and continuous parallel horizontal reflectors. There are particularly strong major reflectors within the vertical sequence which can be traced over several kilometers distance (Fig.4). Acoustic penetration was at given weather conditions of about 10 - 15 m.

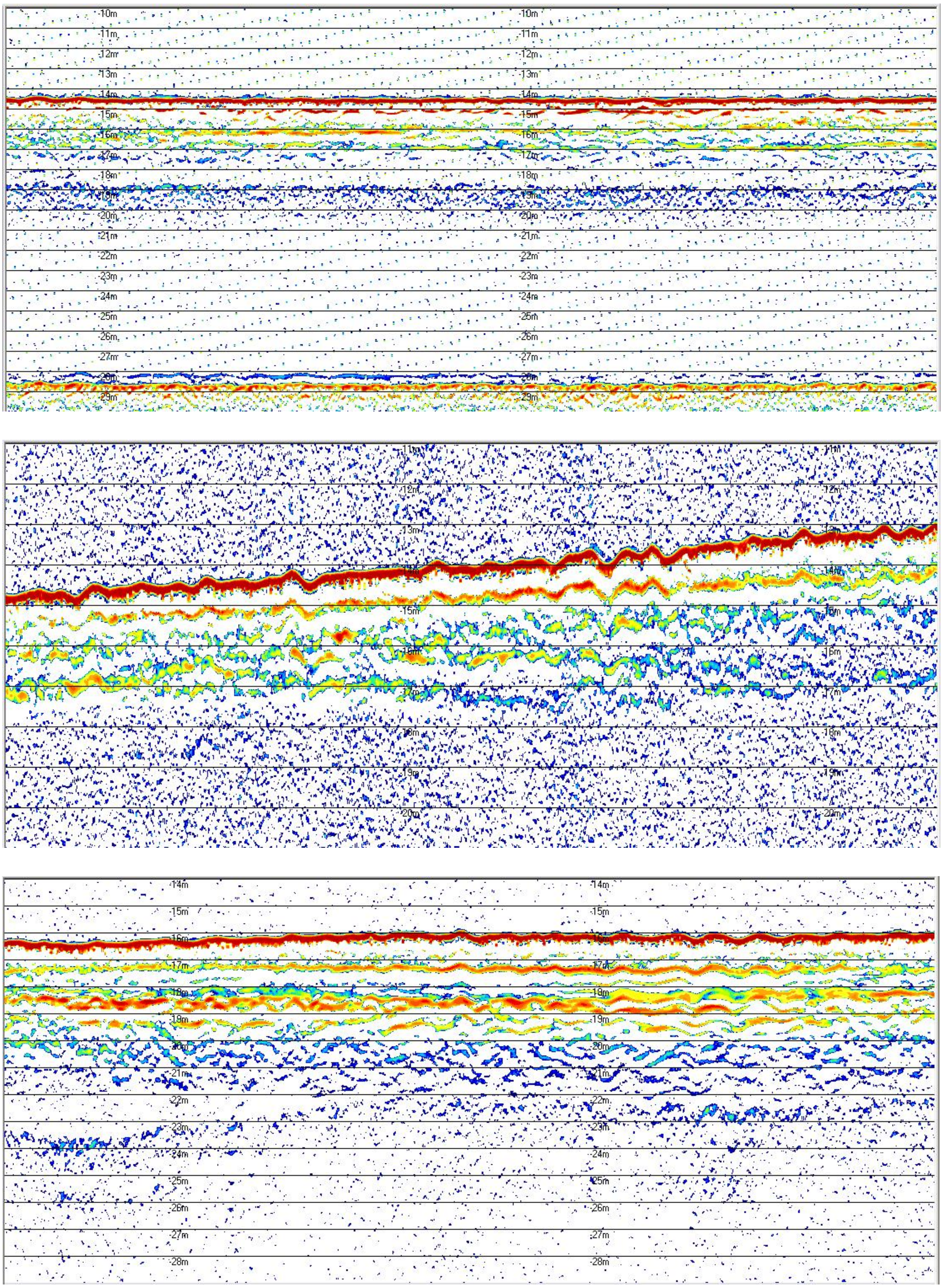
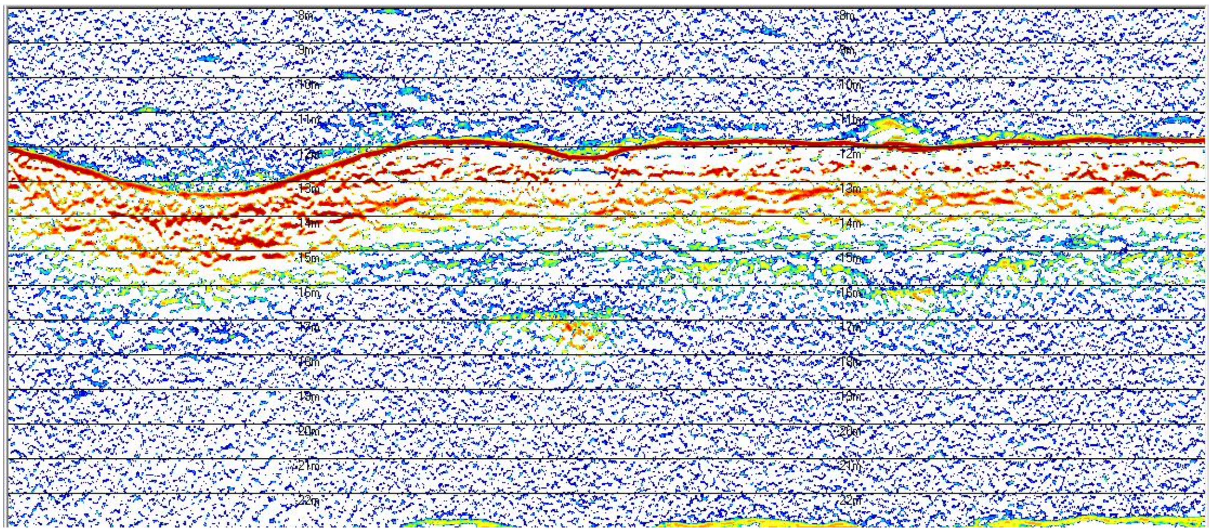


Fig.4 Layers of sub-botom

A second echofacies is more or less influenced by phenomena occurring at the sea floor (as in Fig. 5) or by objects buried into sediments (as in Fig. 6).



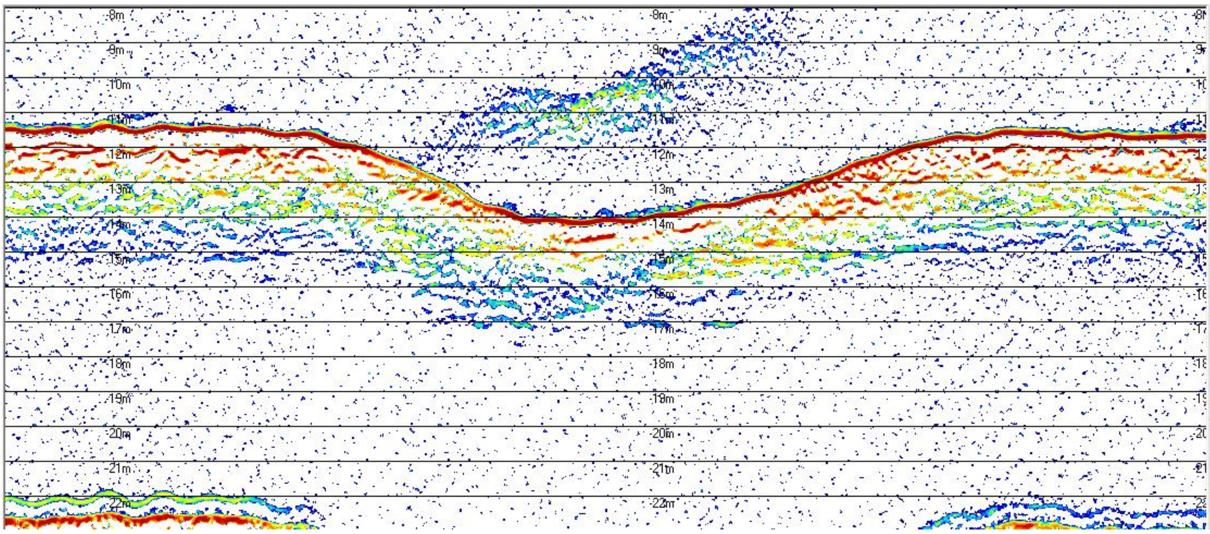


Fig.5 Echofacies of bottom structure with biological sctterers (likely) at the sea floor

5. CONCLUSION

The obtained echofacieses of bottom and sub-bottom in the Southern Baltic by means of parametric echosounder were compared to the geological map of the region elaborated by traditional method [6]. Results are rather promising taking into account resemblance between shape and distribution of sub-bottom layers determined using both of the methods. The distribution of these echofacies is closely related to bottom topography.

However, we can not discriminate between several different materials of sediments. This task needs a lot of experimental works in frame of those acoustically obtained echofacies should be compared to the sedimentary structures determined from sediment cores.

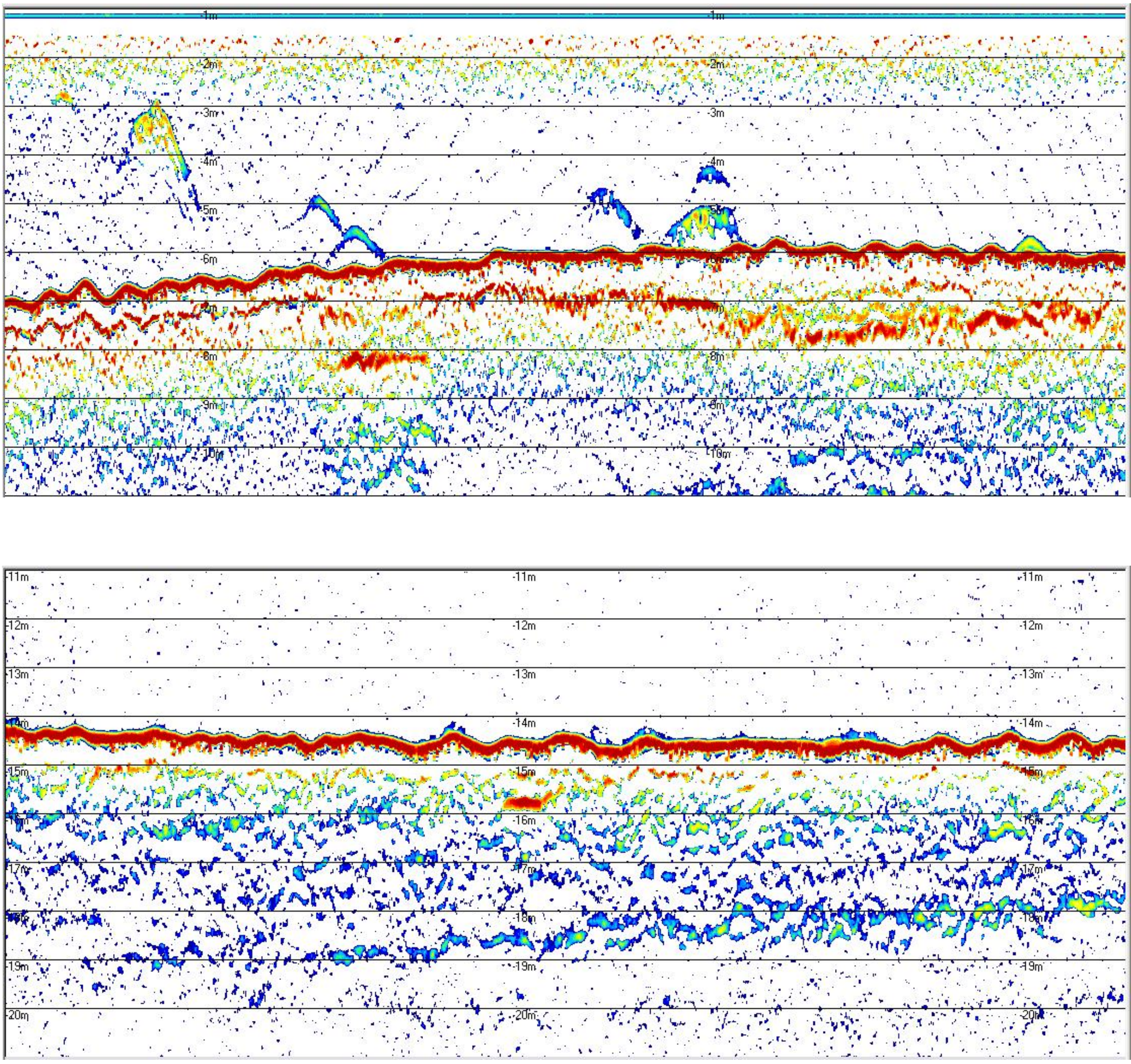


Fig.6 Buried objects covered bottom sediments

The results of observation indicate that data obtained using parametric echosounder could be useful in monitoring and explanation the sedimentary process as for example bottom material transportation. Areas of sea bottom peculiarities as furrows or slopes could be investigated regularly providing data on state of state of bottom as well as marine biological habitat. Generating accurate maps of seafloor geology in these sensitive areas is an important first step toward protecting fish habitat, delineating marine reserves, and assessing environmental changes.

The advantage of presented method – sub-bottom survey of the high spatial resolution allow to distinguish buried object that could create danger in some circumstances. Remote assessment of type of the found object needs a lot of experimental investigation and creation of base of acoustical characteristics of different targets.

AKNOWLEDGMENTS

The research was financially supported by the Ministry of Science and Higher Education, Grant No R00 0122 01.

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