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Acoustical images of the Gulf of Gdansk

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Abstract

Acoustic images of seabed are of interest to specialists in the field of marine engineering, marine navigation, marine archeology, hydrogeology, etc. New technologies based on use of elastic waves, predominantly acoustic waves that allow detecting complexity of geometric forms of seabed, ensure progress in studying the bathymetric structure of seafloor. Use of parametric sources of waves generated by nonlinear interaction of collinear acoustic beams of little different frequencies is one of the most important factors allowing the study of the surface structure of a bottom. The paper presents the results of investigations performed in situ, for the same areas of interest, using multibeam sonar, side scan sonar and parametric sonar.

Keywords: sea bed imaging, parametric echosounder, multibeam echosounder

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1 Introduction

Investigations of sea bottom with acoustic methods has a rich history [1-7]. Especially intensive progress is connected with the use of side scan sonar and multibeam echosounders . These devices allow for obtaining a relatively accurate image of a sea bottom. This constitutes an important contribution to developing bathymetric charts of a selected basin [8].

With the increase in angular-depth resolution precision of making such charts has allowed for conducting safe underwater navigation, which is especially important in connection with objects floating underwater which can not make use of satellite navigation.

This article presents acoustic images of a selected area in the Bay of Gdańsk in the Baltic Sea.

An important extension of the issue of seabed investigations is the use of methods for non-linear generation of waves having low frequencies, referred to as parametric ones[9-11]. It includes the results of sea bed sounding with a parametric echosounder connected with an attempt to identify the longitudinal structure of the sea bed up to several dozen meters into sea bed [12-15].

2 Marine investigations methodology

The Bay of Gdańsk is part of the Baltic Sea limited only by the coastline and the line connecting Rozewie Cap and Taran Cap [16]. This the water basin whose maximum depth is slightly over 100 m. To carry out sea bed investigations an acoustic system composed of multibeam echosounder EM 3002 and parametric echosounder SES 2000 Compact was used. The localization of the area studied is shown in figure 1.

The measuring and investigation devices together with a system of electronic movement stabilization were placed in a motor-sail boat. It was equipped with a system for precise positioning allowing for an accurate localization of the sounding area on a nautical chart of the sounded area. Each of the measuring sets was powered independently.

The images obtained were placed on an underlay representing the current position of geographical coordinates using the system for precise dynamic positioning.

Fig. 2 shows the functional diagram of use of multibeam sounder SM3002 produced by Kongsberg Simrad.

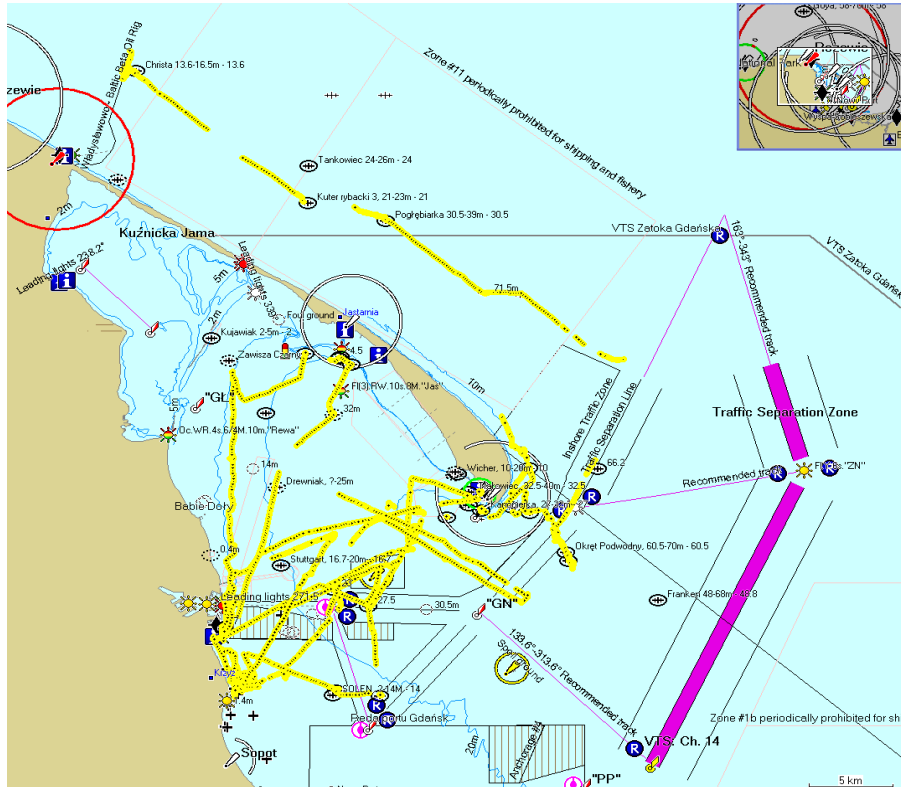


Figure 1: The area of the Bay of Gdansk covered by the acoustic investigations

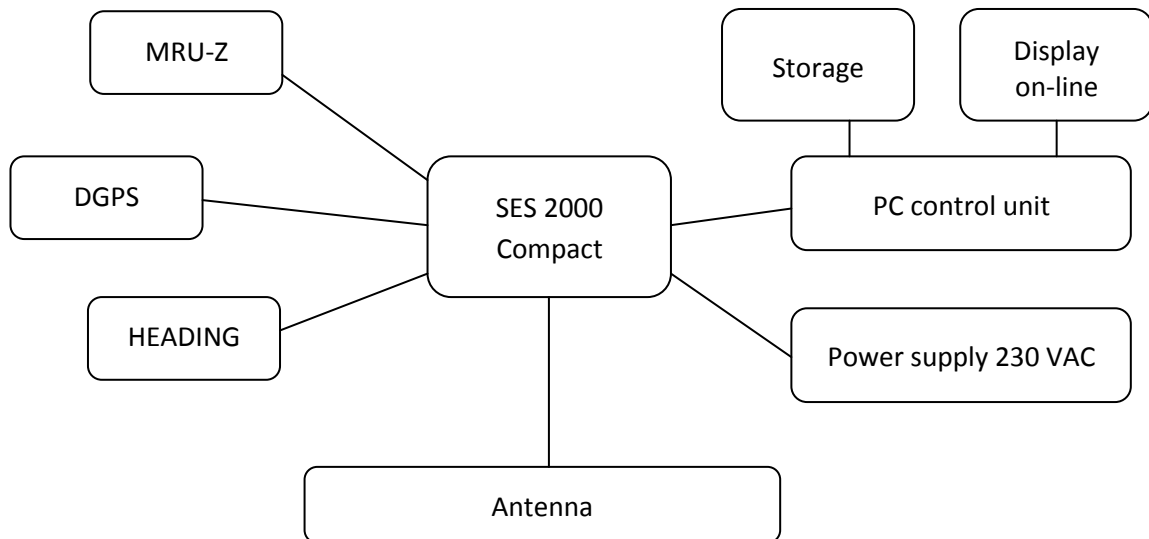


Figure 2: The block diagram of the system for determining acoustic images by means of a multibeam sounder

Together with the multibeam echosounder a parametric echosounder type SES 2000 Compact, which allows for determining the bottom sediment structure, was used.

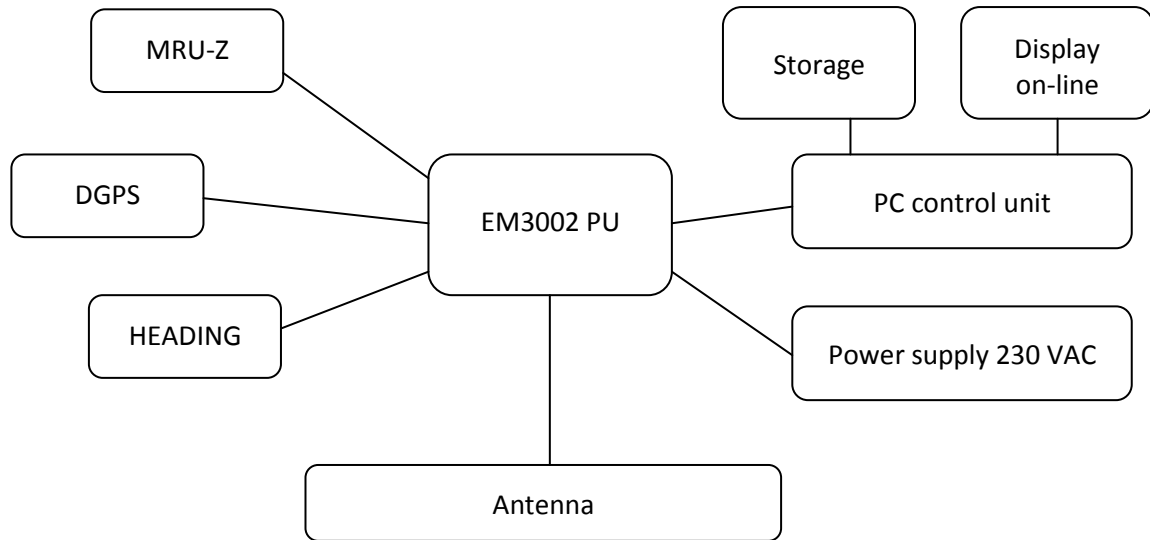


Figure 3: The Block diagram of the system for determining acoustic images of bottom sediments using SES 2000 Compact produced by Innomar

Using the measuring-recording sets presented above several acoustic images of the sea bottom were recorded as well as images of sea bottom structure cross-sections.

3 The investigation results

Below presented are examples of acoustic images obtained as a result of sounding. They are illustrated in the bathymetric form in relation to the sounding with the multibeam sounder and fragments of sea bottom stratification when the parametric sounder was used.

Fig. 4 shows an acoustic image of a ship covered by bottom sediments

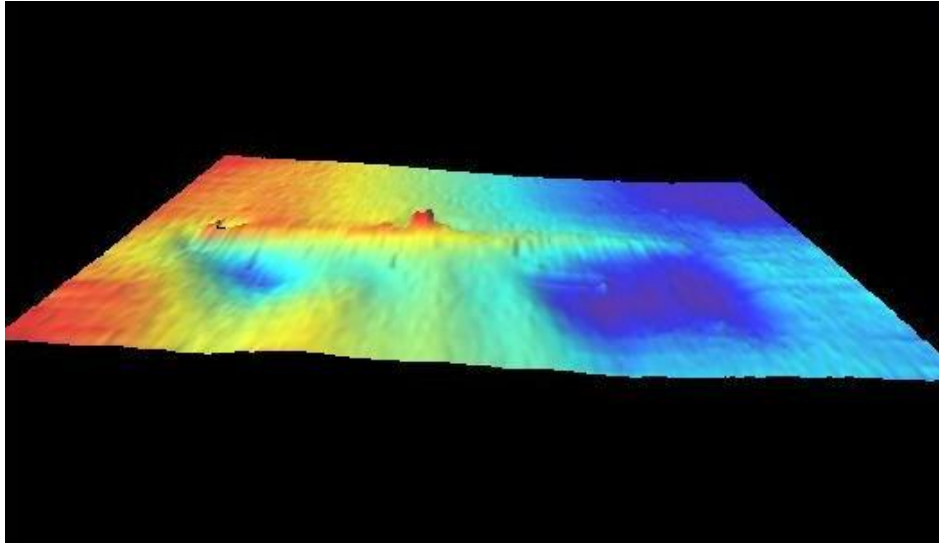


Figure 4: The acoustic image of a ship covered by bottom sediments resulted from bottom load movement

The following picture shows an acoustic image of the bottom with elements markedly protruding above the bottom surface obtained as a result of the multibeam sounding.

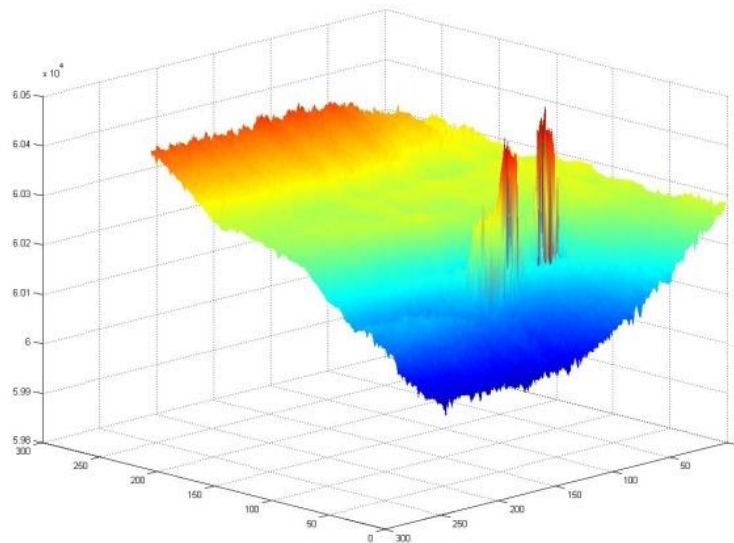


Figure 5: The acoustic image of the bottom with a clearly diverse surface

The next picture shows a combination of acoustic images obtained through using the multibeam echosounder and the parametric echosounder whose acoustic beam runs through the protruding objects shown in fig. 5.

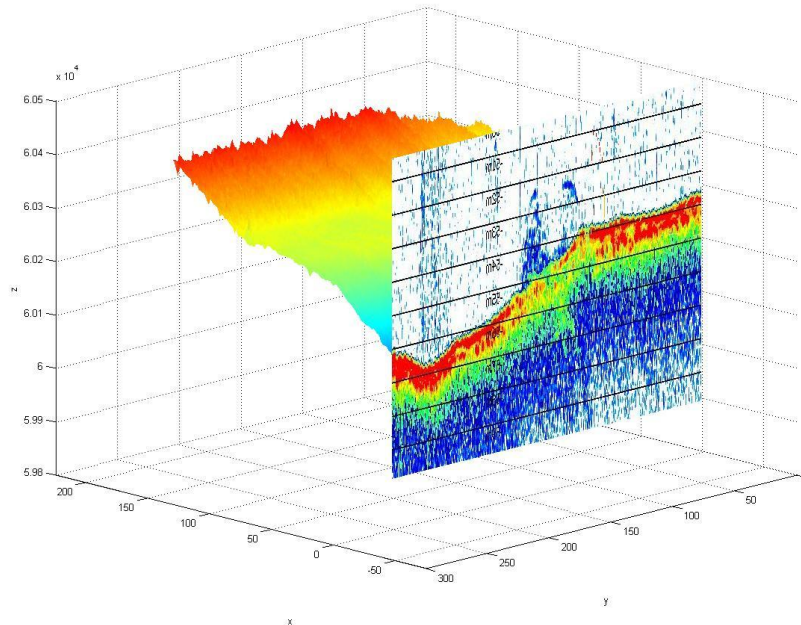


Figure 6: The composition of acoustic images obtained from the multibeam echosounder and the parametric echosounder

The next acoustic images showing large objects buried under the sea bottom are shown as a set of two images (figure 7). The upper one is a ship covered by bottom sediments (silt) The lower one shows a cross-section of the upper layer of sea bottom with clearly visible elements of a ship's hull.

A simultaneous use of two kinds of sounding allows for more accurate interpretation of acoustic images, which may be more effective in the case of archeological studies, but not only in such a case.

The use of parametric echosounders has several limitations related to the range of sounding. Classical one-beam parametric echosounders offer small areas of sea bottom observation, but they show the structure of the upper layer of a bottom up to the depth of a few dozen meters. This, obviously, depends on the density of these layers and their absorption of an acoustic wave.

Connecting the surface sounding (bathymetric) carried out with a multi-beam echosounder and plunge sounding carried out with a parametric echosounder offers much higher credibility in evaluating the results of sea bottom measurements. Fig. 8 presents an acoustic image of sea bottom taken with a parametric echosounder. It shows an almost step change in acoustic properties of the sea bottom and the cross-section of the sea bottom with a three finite change in physical properties of the materials forming the top layer of the bottom.

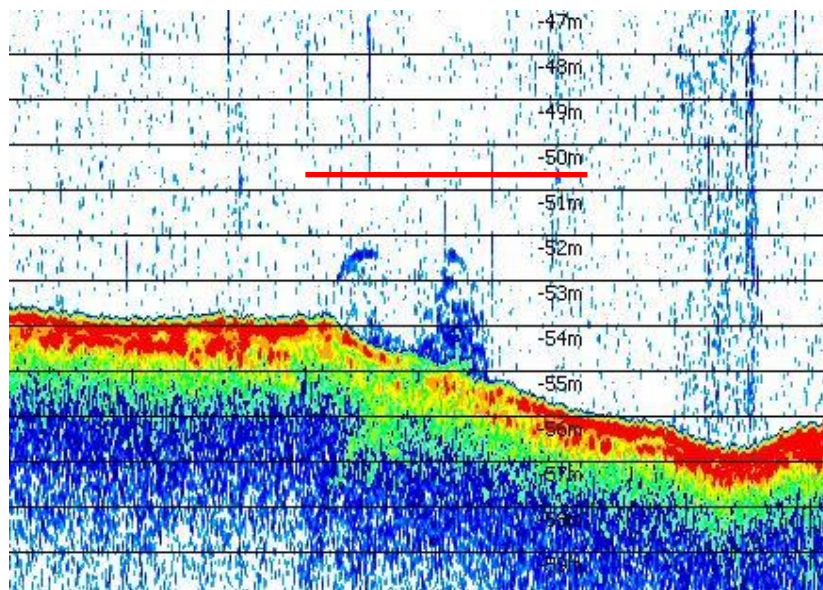
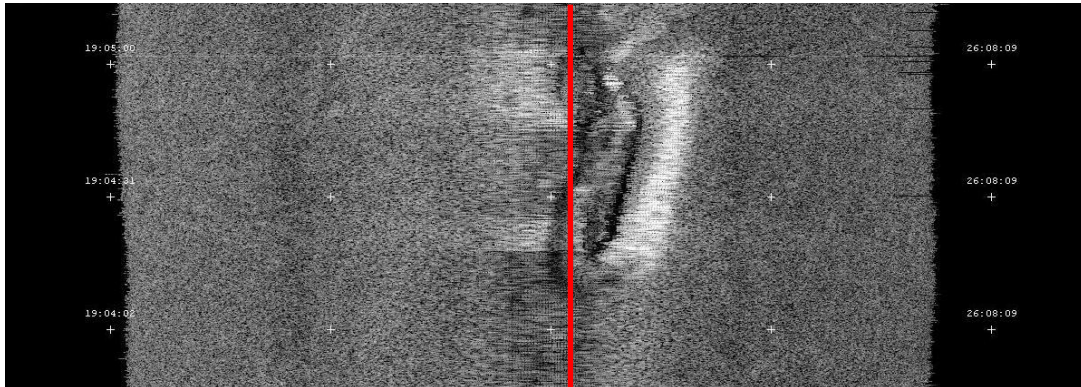


Figure 7: The set of images of the buried ship; red lines indicate the same section

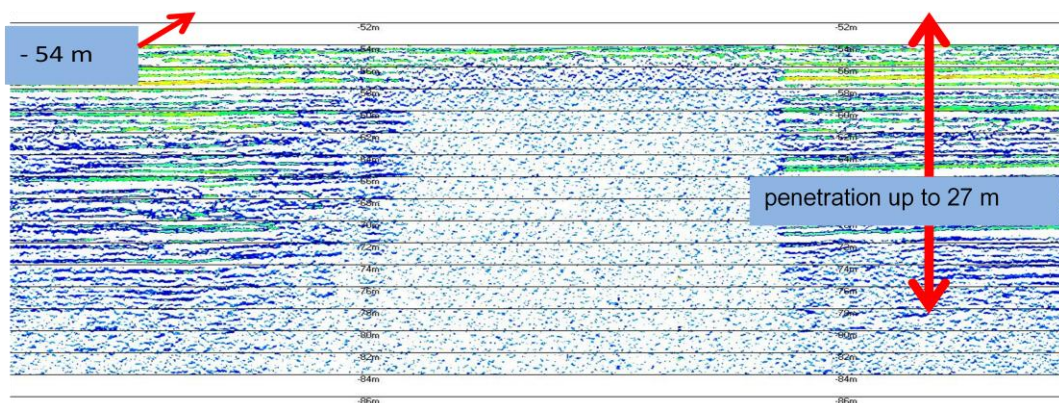


Figure 8: The image of the sea bottom in the area of clearly visible change in the properties of the bottom sediments

Referring to the properties of sea bottom sounding by means of a parametric echosounder it can be stated that capabilities of generating very narrow propagation characteristics increase surface resolution of the observation field. However, the possibility to regulate frequencies of a differential wave allows for significant increase in the depth of an acoustic beam penetration inside bottom sediments. Fig. 9 shows an example of acoustic energy penetration in the function of wave frequency for the same bottom structure. These changes are clearly noticeable. The range of changes in differential frequency is associated with the possibility to regulate primary waves within the frequency range of primary resonance sources.

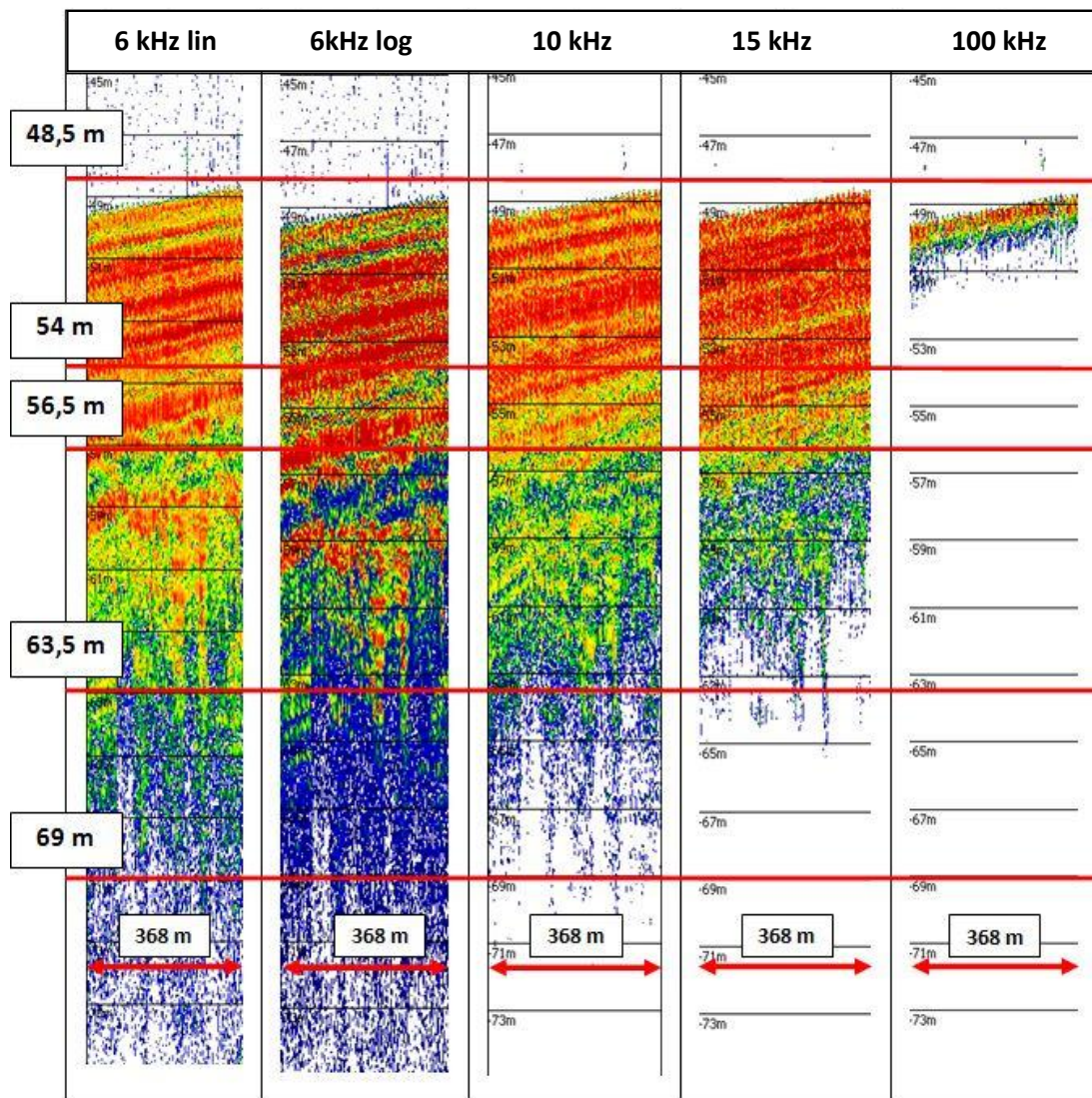


Figure 9: The depth of penetration into the bottom of an acoustic wave of a diverse wave frequency

4 Conclusions

Acoustic methods allow for remote determination of the shape of a bottom surface, taking also into consideration artificial underwater objects, such as, among others, wrecks, underwater constructions and underwater navigation obstacles. This is a teledetection method which can be very efficient and effective. Following and checking the changes in bottom configuration in areas of bottom load movement is also an important research and measuring tool. Use of sounding by means of parametric devices allows us to observe the structure of sea bottom and its stratification. Additionally, it allows for detecting objects buried or covered by silt in sea bottom. Connecting these two methods allows for obtaining a more accurate image of the surface and structure of sea bottom.

Acknowledgments

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