Parametric echosounder SES-2000 compact measurements of reflections from buried object sounding pulses – their recognizability and visualization

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Parametric echosounder SES-2000 Compact measurements of reflected from buried object sounding pulses - their recognisability and visualization.

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Contents of presentation:

- Introduction
- Measurement equipment
- Stationary trials
- Results of measurements
- Conclusions

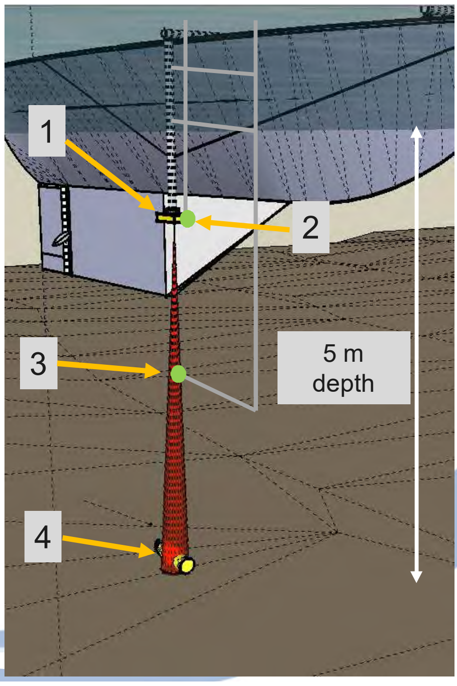
Introduction

Detection and localization of objects located on or under the sea bottom surface is a challenge for researchers interested in exploring the seabed. Finding such objects is the subject of interest for a wide group of professionals, including archaeologists, marine safety specialists, and the military responsible for defending coastal waters. One of the currently developing non-invasive remote sensing methods consists of the use of phenomena accompanying nonlinear propagation of elastic waves. Hydroacoustic examination of the seabed layers requires echosounder which can generate low frequency sounding pulses with very narrow transmitted beam width, no side lobes in order to minimize sediment reverberation and possibility of usage compact transducer. Solution for such exercise is to use the parametric echsounder SES-2000 Compact, which results of soundings focusing on object detection will be presented in this article.

Measurement equipment

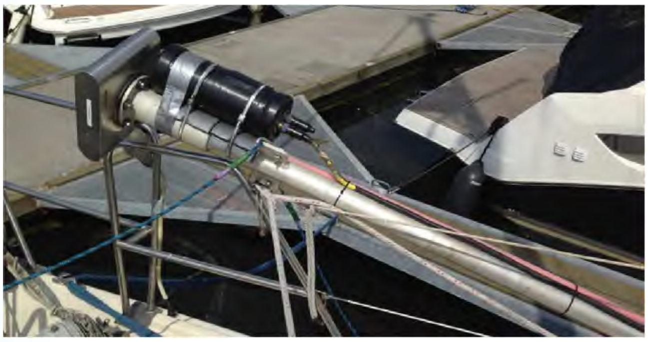
The measurement base was placed on board of small research vessel s/y Windspeel.

1. SES – 2000 transducer
2. Receiving hydrophone for HF
3. Receiving hydrophone for LF/HF
4. Sounded object



Measurement equipment

- Transducer array was mounted on an adjustable aluminum arm on the starboard, 0,85 m below sea surface.
- The device that complements the correct operation of the system was the motion sensor SEATEC MRU-H.
- The location of the sensor above transmitter minimizes the error associated with the sensor's inaccurate calibration by having to orient its position relative to the antenna.
- Due to stationary research, the use of a satellite navigation system was not necessary.



Measurement equipment

Laboratory station localized below the deck.

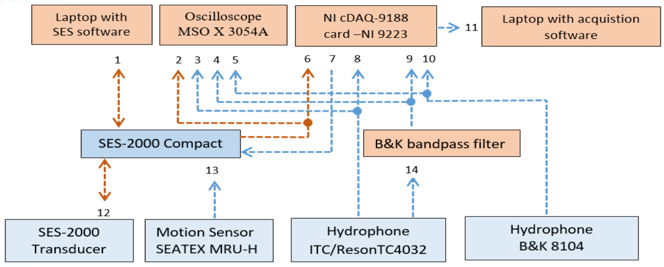


Diagram of connections between devices used during trials.

Parametric echosounder main unit with used all input/output sources.

Measurement equipment

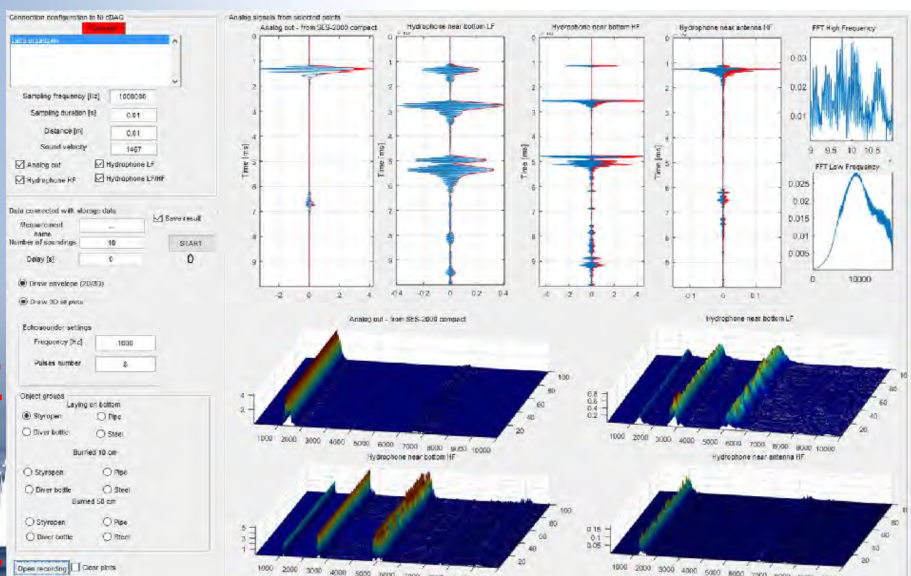
Matlab software was used to write program acquiring data from A/D converting unit.
Software gave possibility of:

- Set parameters of A/D cDAQ unit
- Presenting signals in real time
- Plotting 3D echograms
- Recording data with predefined scenarios

Laptop with SESwin software and PC with Matlab program

A/D card parameters

Object types and localization



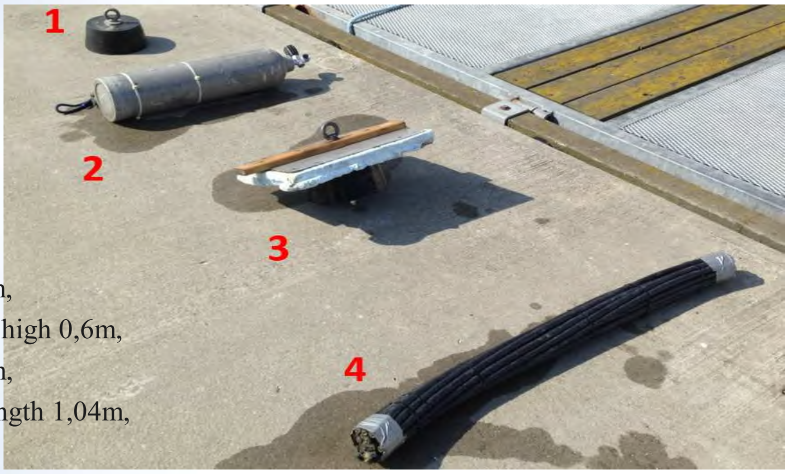
2D signals presentation

3D echograms plotting

Written program for signals from hydrophone recording

Stationary trials

Selected objects:

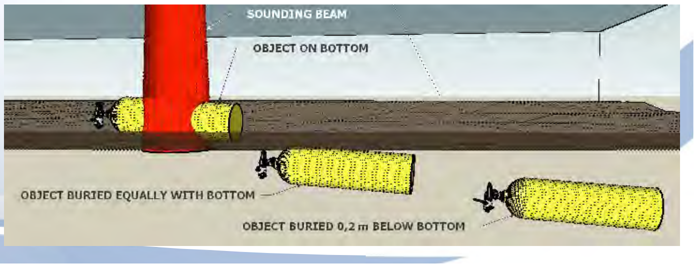


1. Lead weight: diameter 0,2m high 0,1m,
2. 12 liters diver bottle: diameter 0,15m, high 0,6m,
3. Styrofoam: 0,42mx0,31m, high 0,05 m,
4. Group of cables: diameter 0,085 m, length 1,04m,

Investigation was carried out using selected frequencies from 10 kHz to 15 kHz focusing on 1,2 and 3 periods

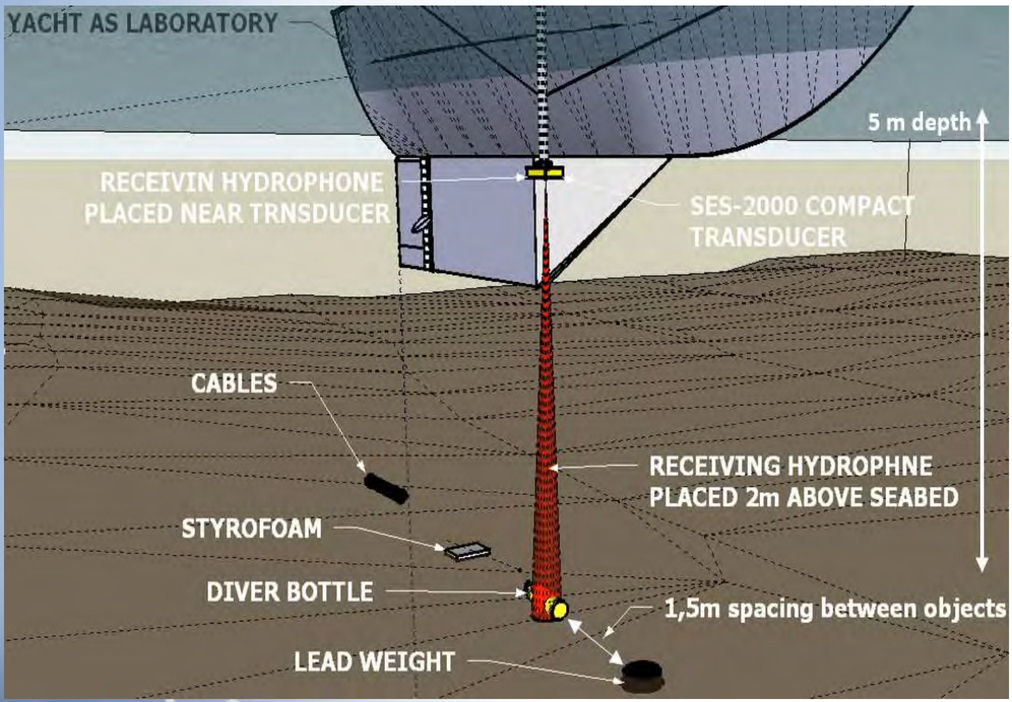
Three scenarios of objects configuration: on the bottom, buried equally to the bottom, buried 0.2 m below the bottom.

Frequency	Number of pulses/pulse length [m]		
15 kHz	1p λ=0,098	2p λ=0,196	3p λ=0,293
12 kHz	1p λ=0,122	2p λ=0,245	3p λ=0,367
10 kHz	1p λ=0,147	2p λ=0,293	3p λ=0,440



Stationary trials

Visualization of measuring polygon.



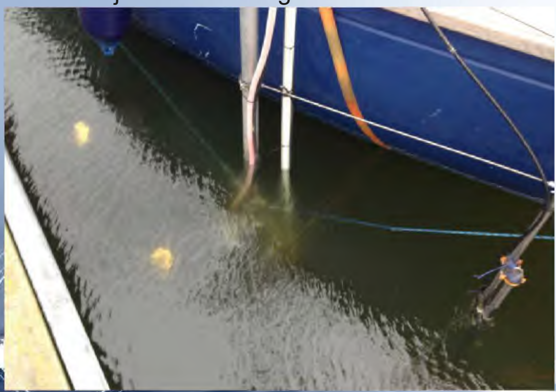
Four objects were located on bottom at the same time with 1.5 m spacing. Presented figure keeps the scale which shows the difficulty of central sounding objects with main lobe at the sea bottom.

Stationary trials

- Burial of the objects was accomplished using a diver.
- The assumed depth of burial of the 0.5 m target beneath the surface of the bottom proved to be unworkable due to the consolidated structure of the main layer - 0.3 m under the clay layer occur sandy bottom.
- Finally objects were buried 0.2 m under the sea bottom surface.

Diver prepared for object burial

Object with floating markers on cord



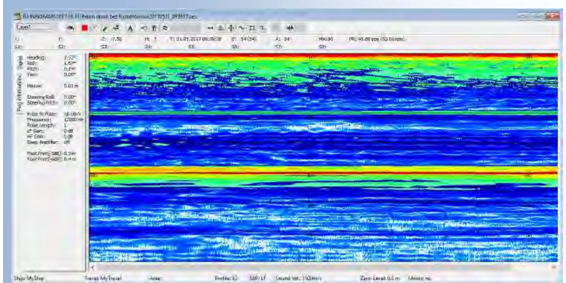
Lead weight buried equally with bottom

Results of measurements

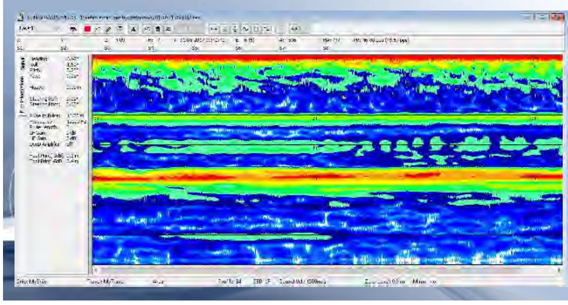
Sounding clear bottom for obtaining background data.

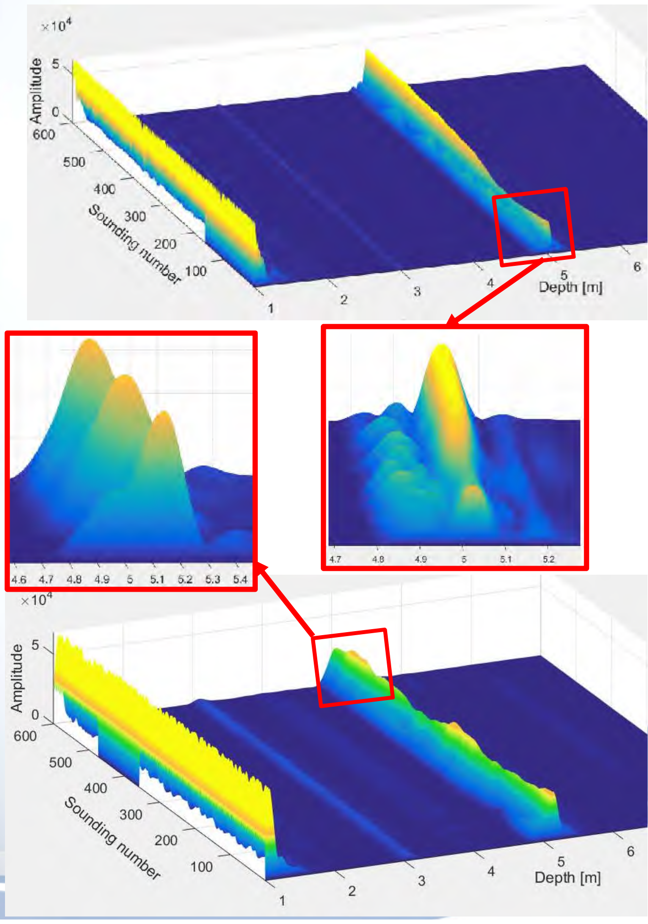
Confirmation of the homogenous structure of bottom on measurement range.

Example of data received for 12kHz 1 pulse



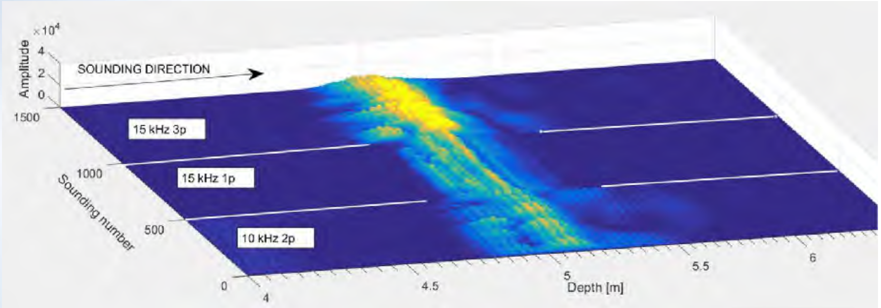
Example of data received for 12kHz 3 pulses



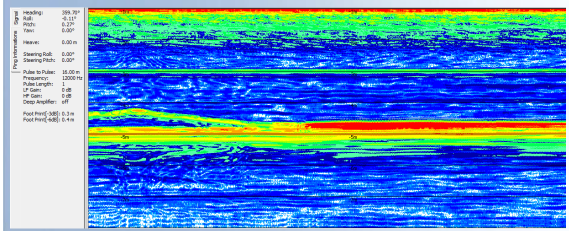


Results of measurements

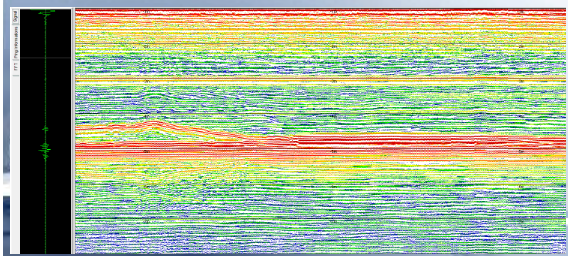
Echogram presentation of the same sounded area depends on:
- Sounding pulse frequency
- Length of signal



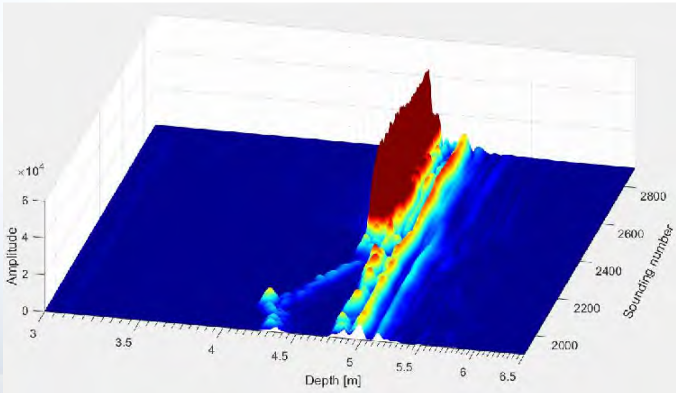
Echogram from post-processing ISE software, based on *.SES file



Echogram from post-processing ISE software, based on *.RAW file



- Presentation of echogram data in Matlab software.
- 3D plot gave possibility clear amplitude differences localization.



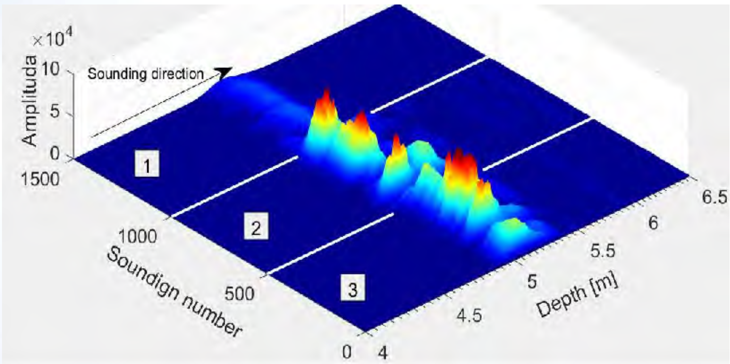
Results of measurements

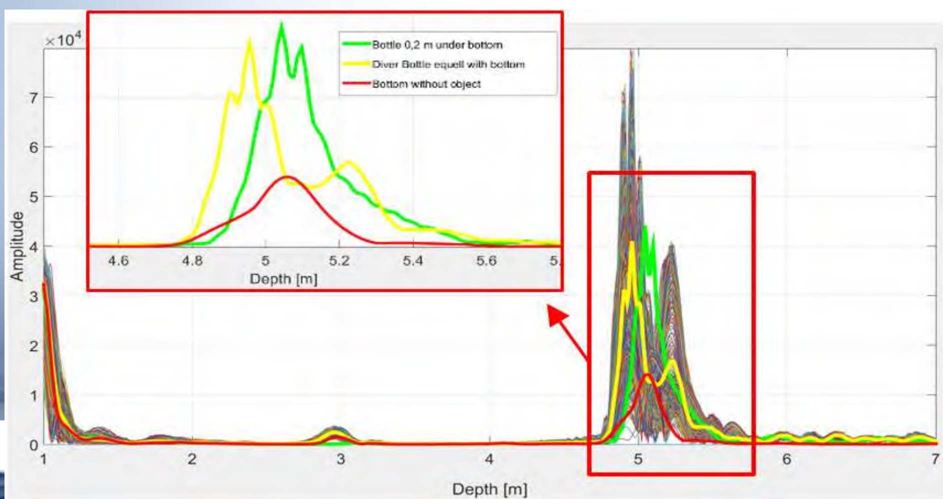
Detection

Sounding diver bottles – 15kHz 3 pulses

Straps description:

1. Clear bottom
2. Bottle equell with bottom
3. Bottles buried



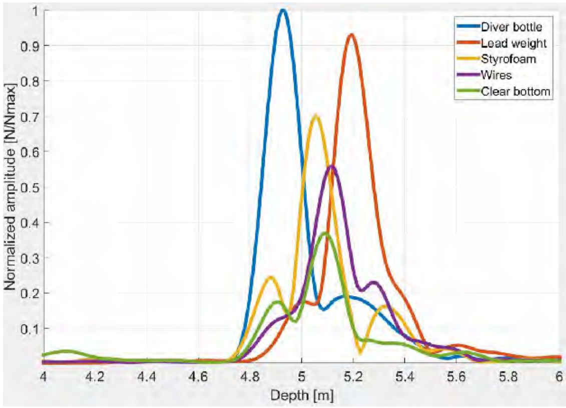


Results of measurements

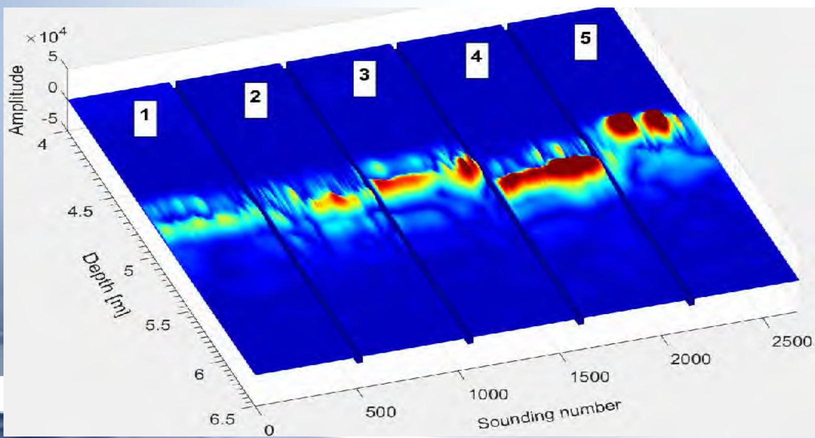
Distinguishability

Comparisons of four different buried objects and background echo sounded with 10 kHz 2 pulses.

1. clear bottom
2. wires
3. styrofoam
4. lead weight
5. diving bottle



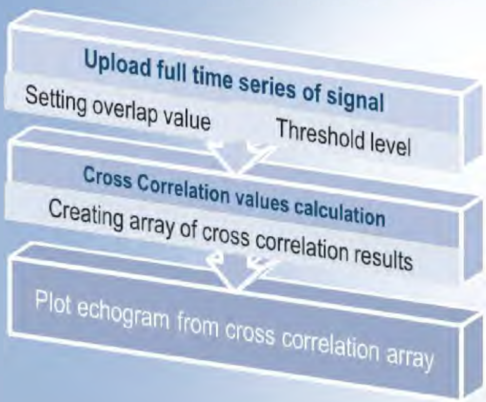
2D mean echoes amplitudes comparison

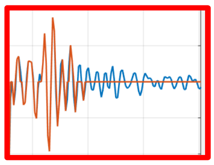


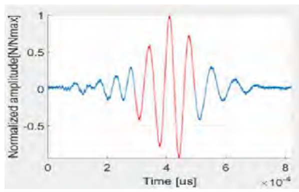
3D echograms of different object sounding comparison

Results of measurements

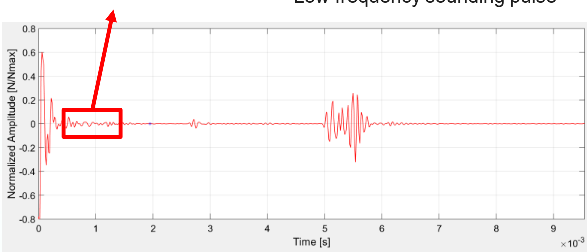
Cross correlation echogram experiment





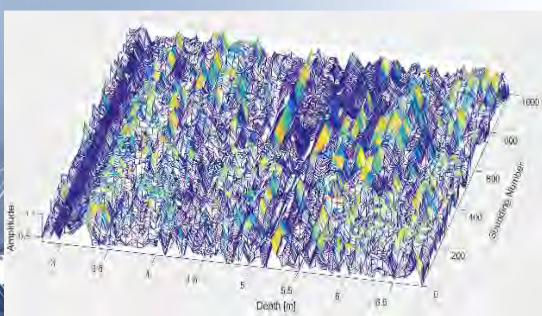


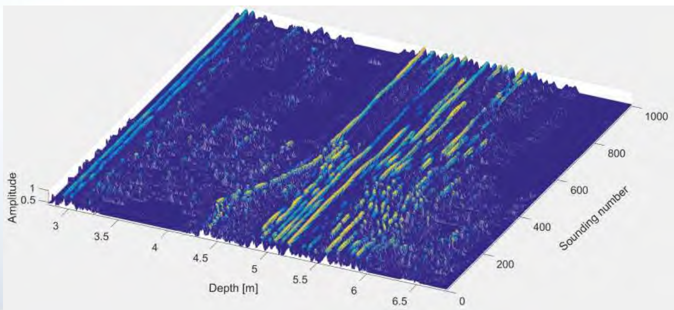
Low frequency sounding pulse



Full waveform of reflected signal

Echogram based on cross correlation – 0% overlap, no noise elimination

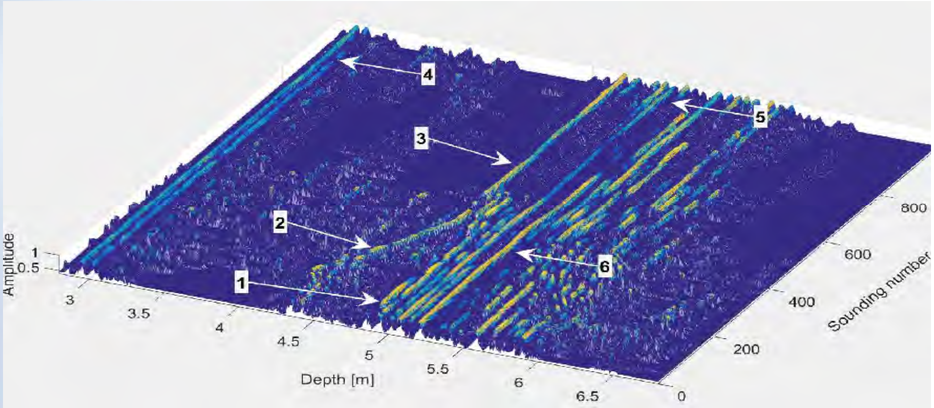




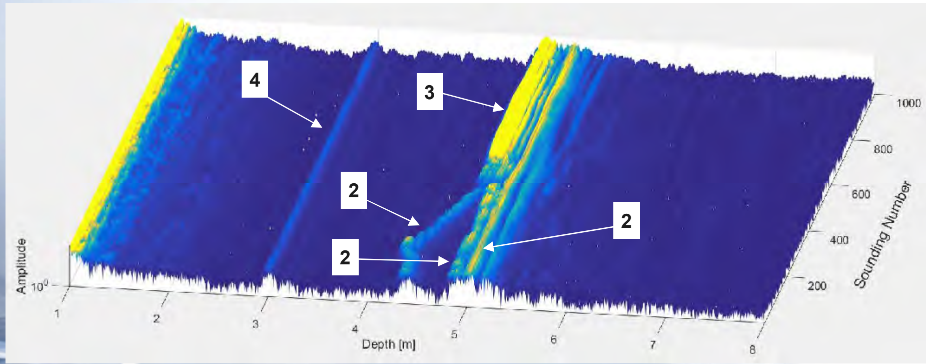
Echogram based on cross correlation – 90% overlap, noise elimination

Results of measurements

1. Clay layer
2. Floating in depth object
3. Object lying on the bottom
4. LF measurement hydrophone
5. Consolidated sandy bottom layer
6. Consolidated sandy bottom layer



Echogram based on cross correlation (90% overlap, noise elimination)



Echogram based on full waveform signals, logarithmic amplitude scale.

Conclusions

- Seabed exploration with parametric echosounder is more efficiency than traditional echosounder,
- Small objects detection is not an easy task because of:
  - rapid changes of echoes amplitudes in the target non-central soundings,
  - small number of pings per target,
  - difficult to find by operator distortion in the echogram during measurements on sea,
- Cross correlation experiment shows another way of echogram creation with satisfactory result,
- The future solution for more efficient detection could be use of multibeam parametric echosounder covering wide area of seabed.