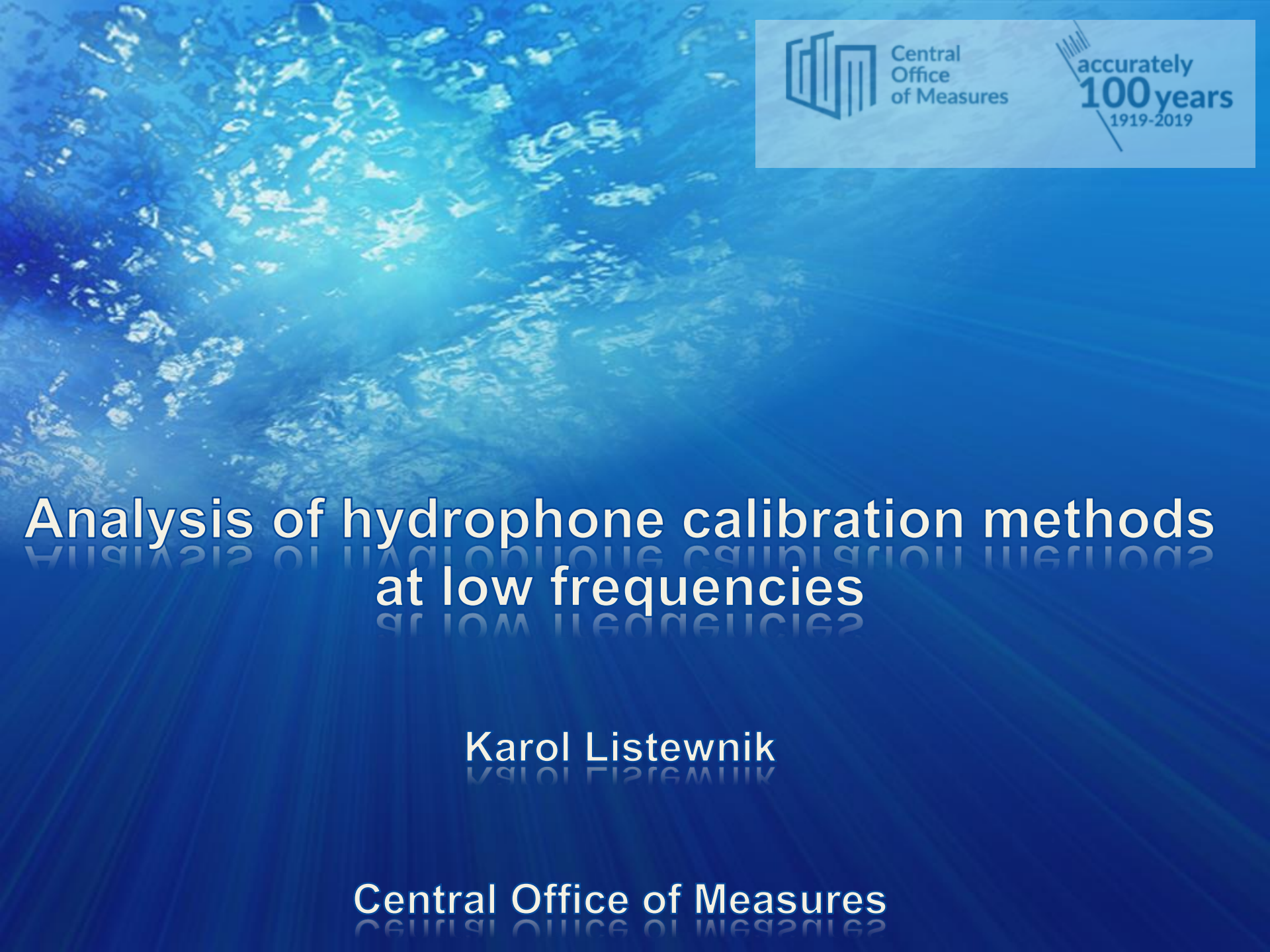


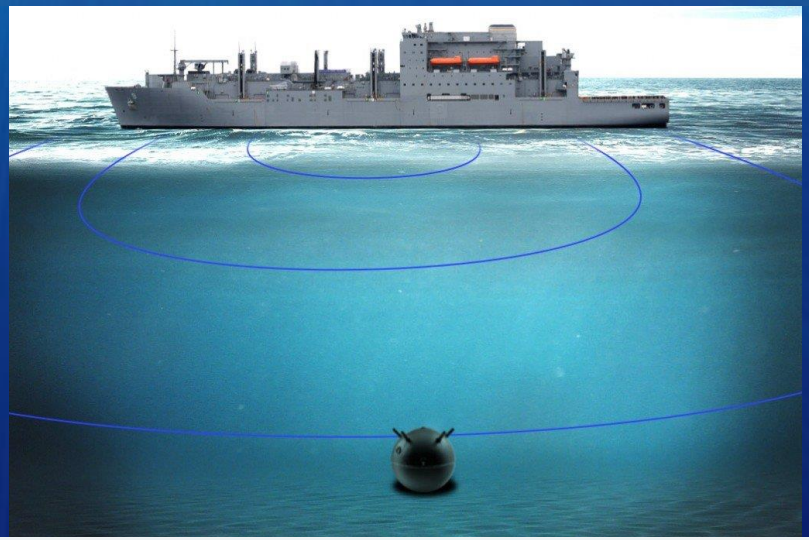
Analysis of hydrophone calibration methods at low frequencies

Karol Listewnik

Central Office of Measures

Outline

1. Introduction,
2. The analysis of current solutions,
3. The novel calibrators projects,
4. Conclusions.



triklopodia.gr/ναυτικός-πόλεμος-στο-αιγαίο-και-η-σημα/naval-mine-attracting-the-us-warship/

Standards of hydrophone calibration

PN-EN 60565:2006 Hydroacoustics - Hydrophones - Calibration in the frequency range from 0.01Hz to 1MHz

ANSI/ASA S1.20:2012 Procedures for Calibration of Underwater Electroacoustic Transducers, New York: American National Standards Institute

IEC 60565-1:2020? ED1 Underwater acoustics - Hydrophones - Calibration of hydrophones, Part 1: Procedures for free-field calibration

IEC FDIS 60565-2:2019 Underwater acoustics – Hydrophones – Procedures for low frequency pressure calibration

Documents for measuring according to EU Directive2008/56/EC

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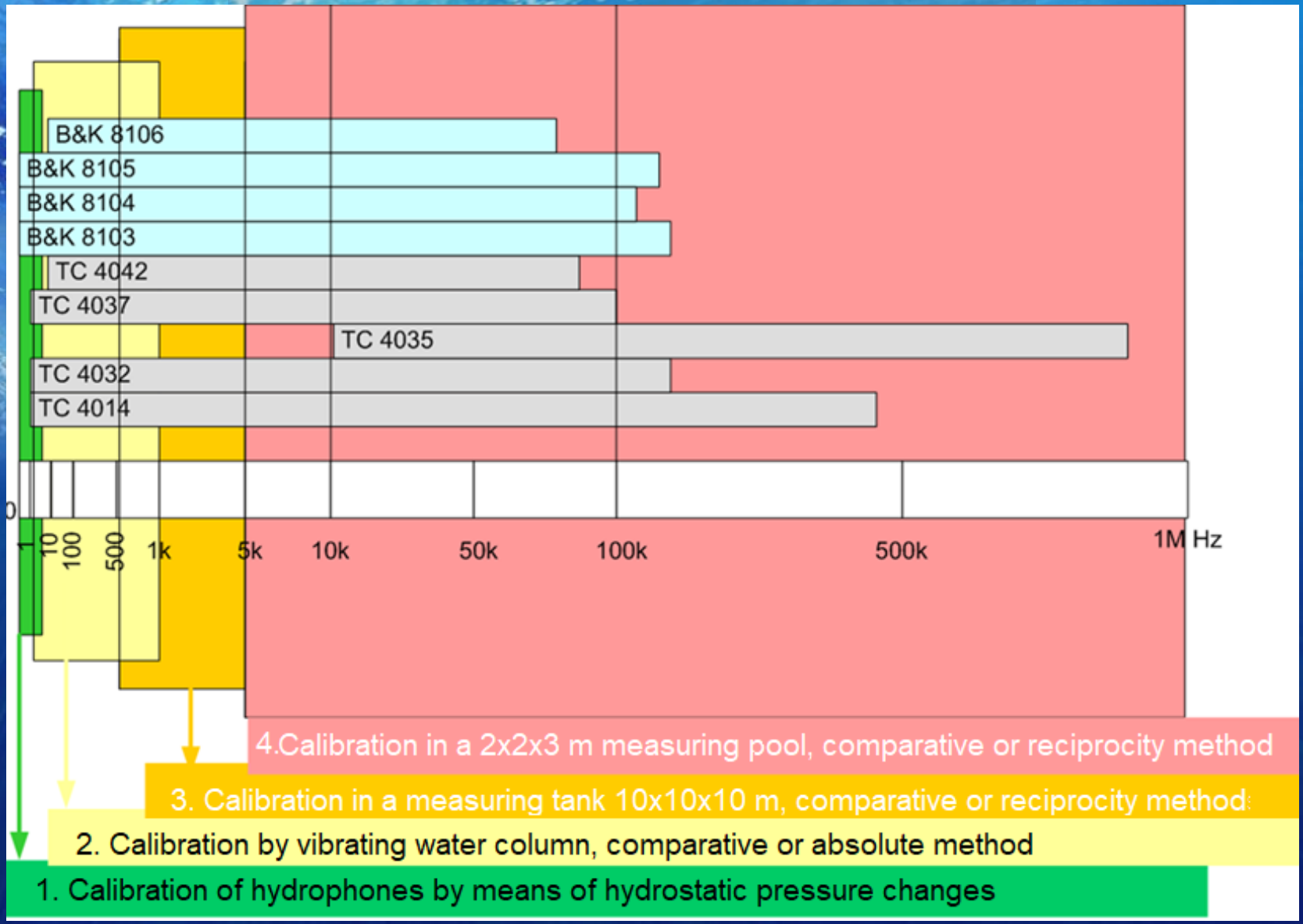
- EU Directive2008/56/EC
- Dekeling, R.P.A., Tasker, M.L., Van der Graaf, at al, ***Monitoring Guidance for Underwater Noise in European Seas***, *Part I-III*: Executive Summary, JRC Scientific and Policy Report EUR 26557 EN, Publications Office of the European Union, Luxembourg 2014
- BIAS STANDARDS FOR NOISE MEASUREMENTS, Background information and Guidelines, Amended version 2015, Project code: BIAS LIFE11 ENV /SE 841
  BIAS - Baltic Sea Information on the Acoustic Soundscape
- QUIETMED – D3.1 Best practices guidelines on sensor calibration for underwater noise monitoring in the Mediterranean Sea, Delivery date: 5th December 2018

Comparison of frequency ranges of tested hydrophones in relation to measurement methods



Frequency ranges of tested hydrophones in relation to measurement methods in NPL

NPL currently provides the following hydrophone calibration services, most of which are accredited to ISO17025:

1. Free-field calibration of hydrophones by the reciprocity method in the NPL tank facilities in the frequency range from 315 Hz to 500 kHz.

2. Free-field calibration of hydrophones by a comparison method in the NPL tank facilities in the frequency range from 1 kHz to 1 MHz.

3. Pressure calibration of hydrophones by comparison method from 5 Hz to 315 Hz.

4. Directional response measurement of hydrophones and transducers in the frequency range 1 kHz to 1 MHz over 360 degrees of rotation in both the horizontal and vertical plane in the NPL tank facilities

Other measurements include transducer electrical impedance/admittance in the frequency range 1 Hz to 20 MHz, and directional response/beam patterns of transducers and transducer efficiency.

Calibration of marine autonomous recorders
NPL also offers the only service for pressure calibration of digital marine autonomous recorders in the frequency range 20 Hz to 315 Hz.

Different underwater noise recorders

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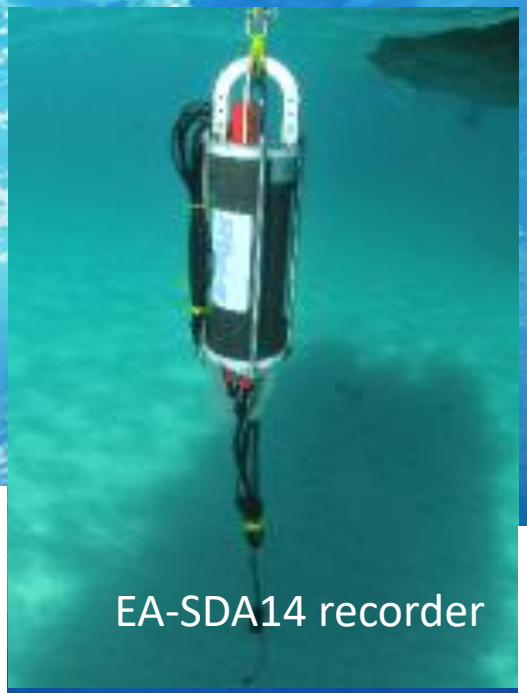
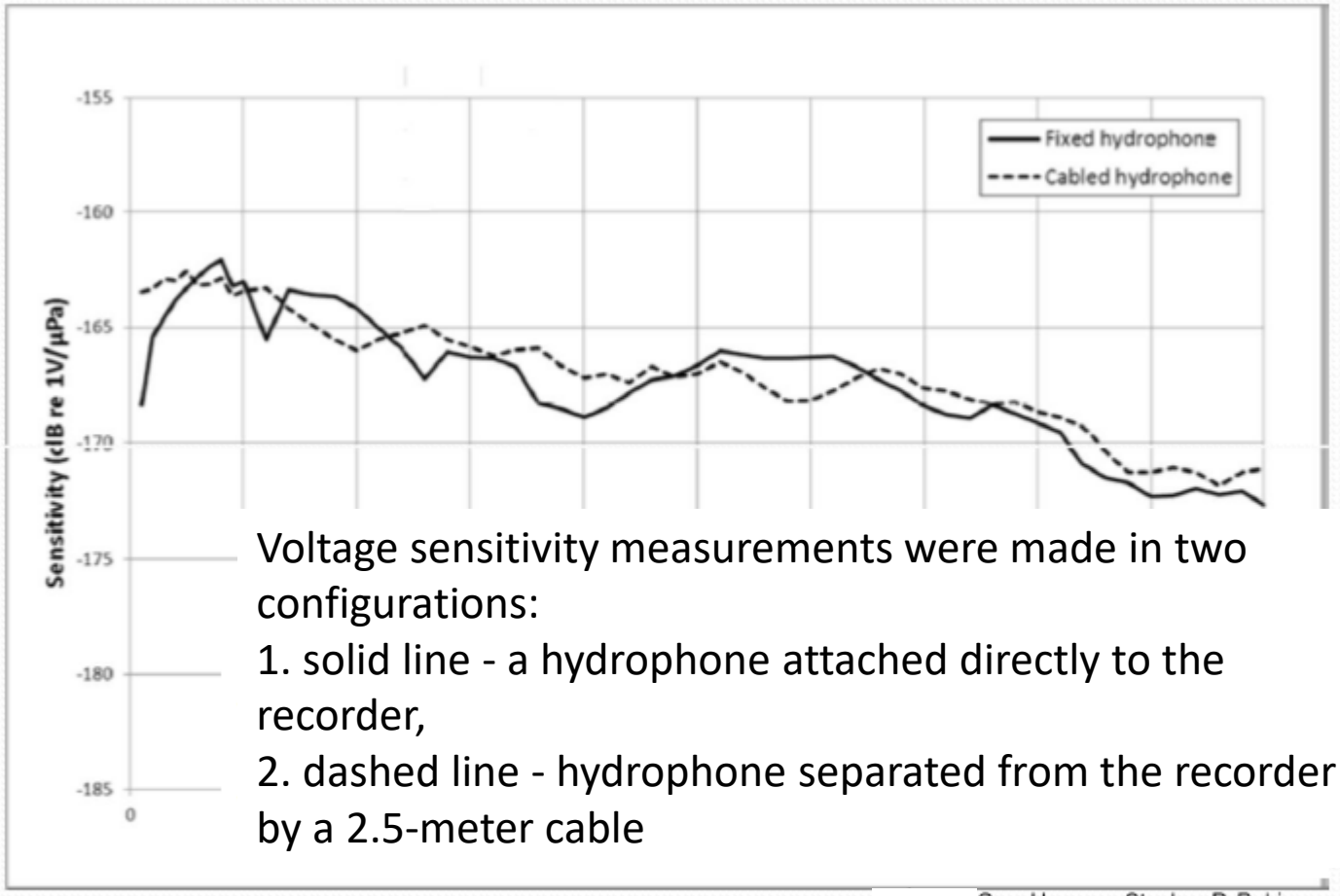


EA-SDA14 recorder

Acousonde™ 3A.

IGLOO System
(Polish Navy)

Comparison method of hydrophones calibration

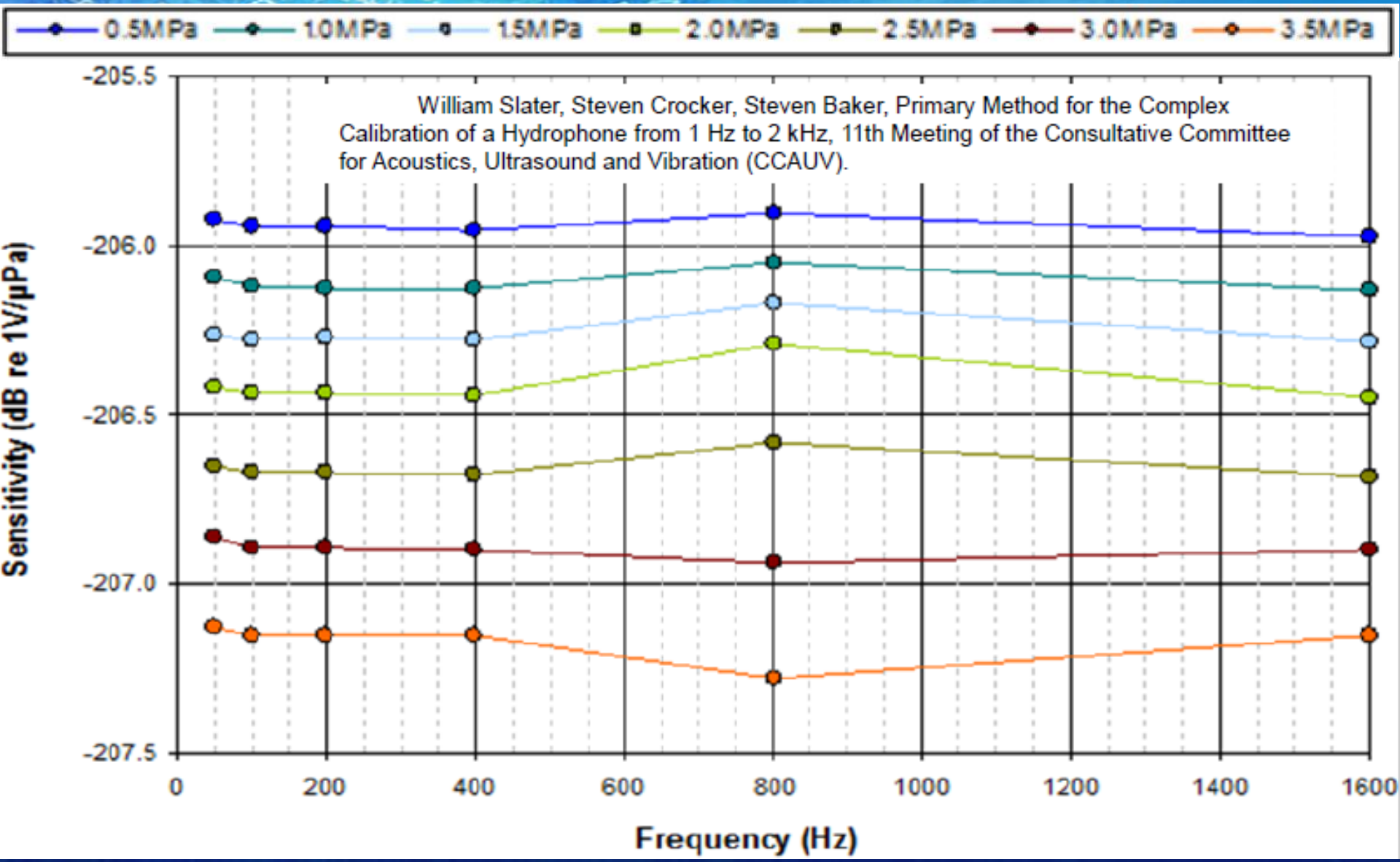


Voltage sensitivity measurements were made in two configurations:

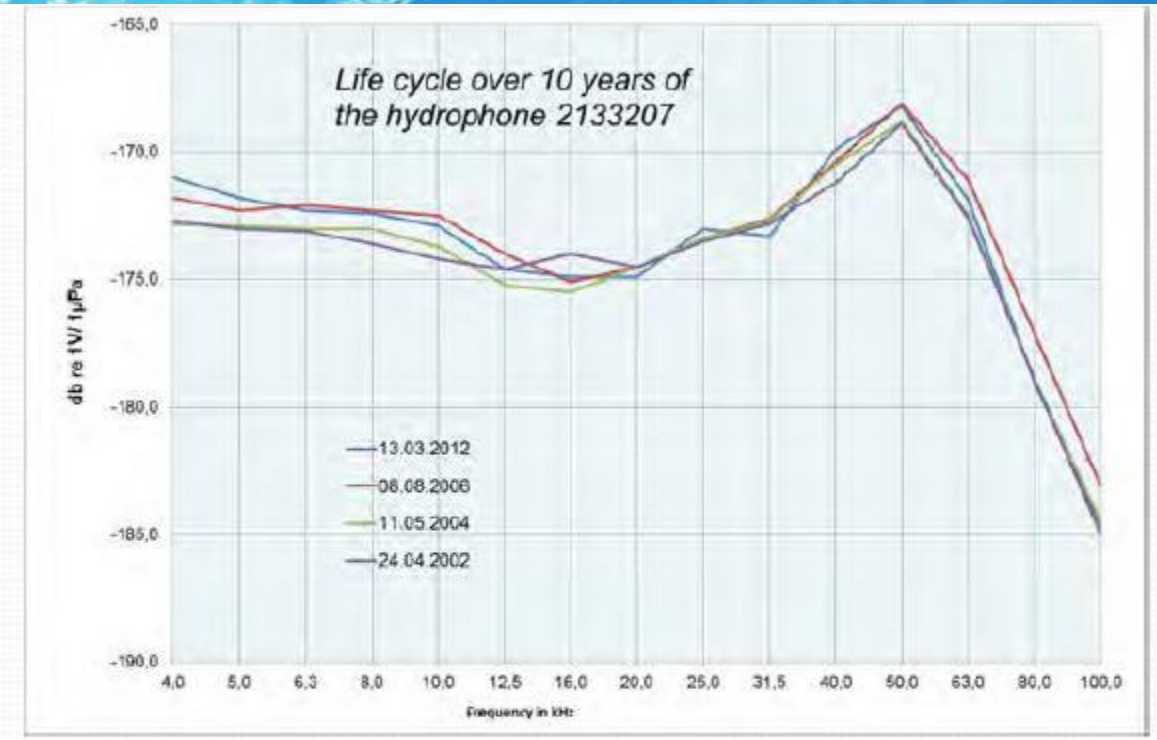
1. solid line - a hydrophone attached directly to the recorder,
2. dashed line - hydrophone separated from the recorder by a 2.5-meter cable

Gary Hayman, Stephen P. Robinson, Paul A. Lepper, THE CALIBRATION AND CHARACTERISATION OF AUTONOMOUS UNDERWATER RECORDERS, UA2014 - 2nd International Conference and Exhibition on Underwater Acoustics, Grecja.

Comparison method of hydrophones calibration



Comparison method of B&K hydrophones calibration



Stefan Schael, ADULTERATION OF UNDERWATER ACOUSTIC MEASUREMENTS, UA2014 - 2nd International Conference and Exhibition on Underwater Acoustics, Grecja.

Comparison of voltage sensitivities of hydrophone Reson TC-4032

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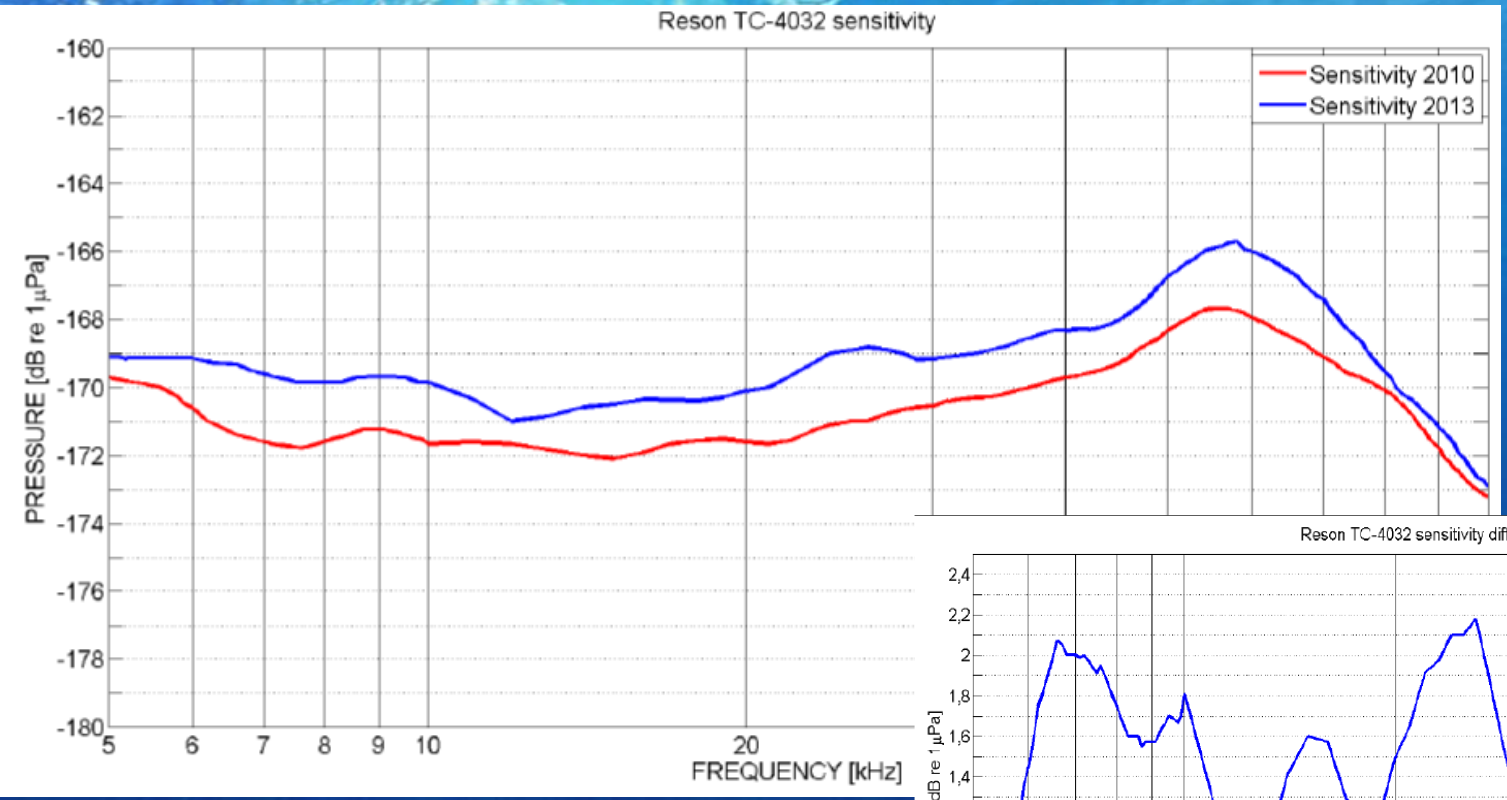
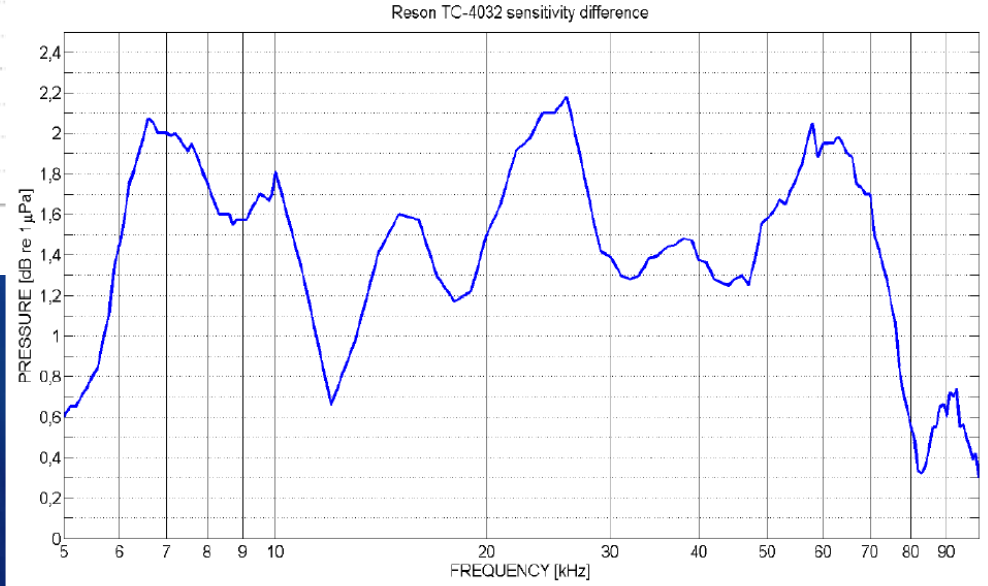
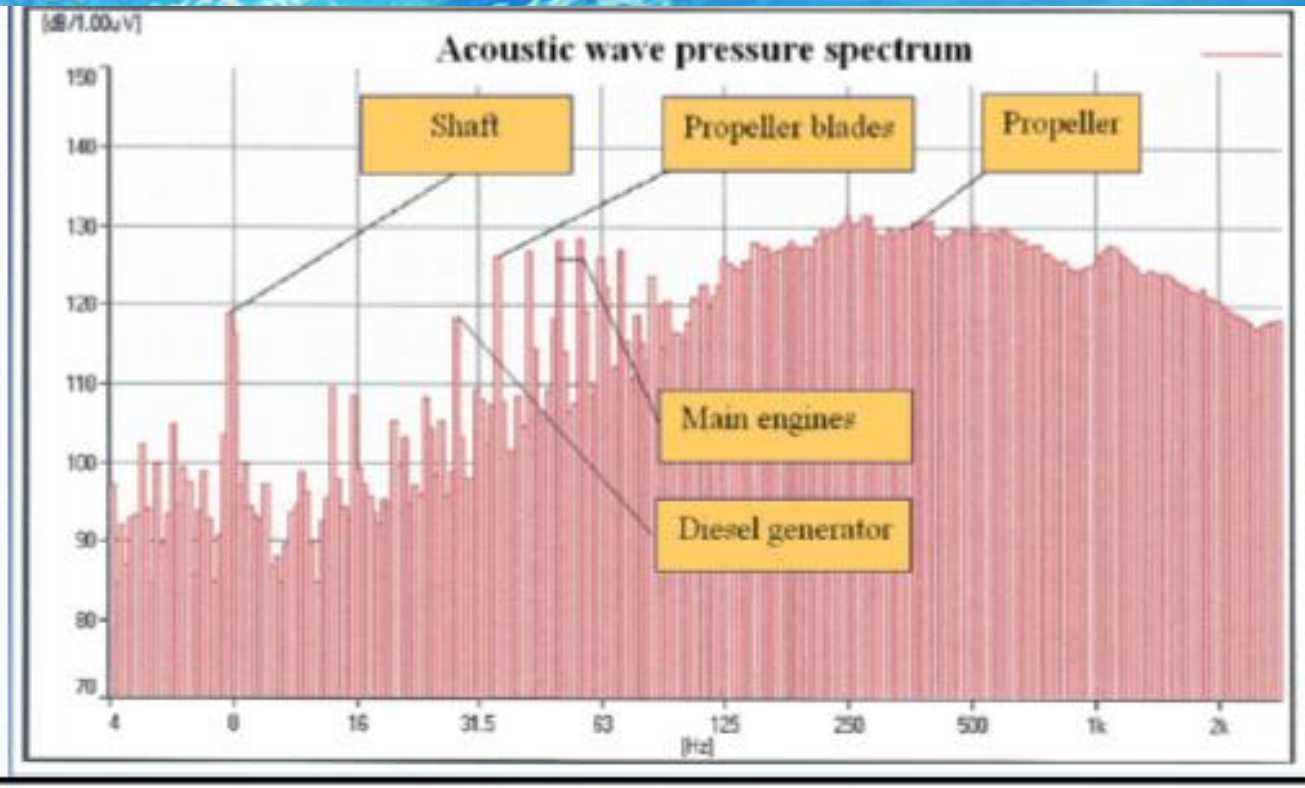
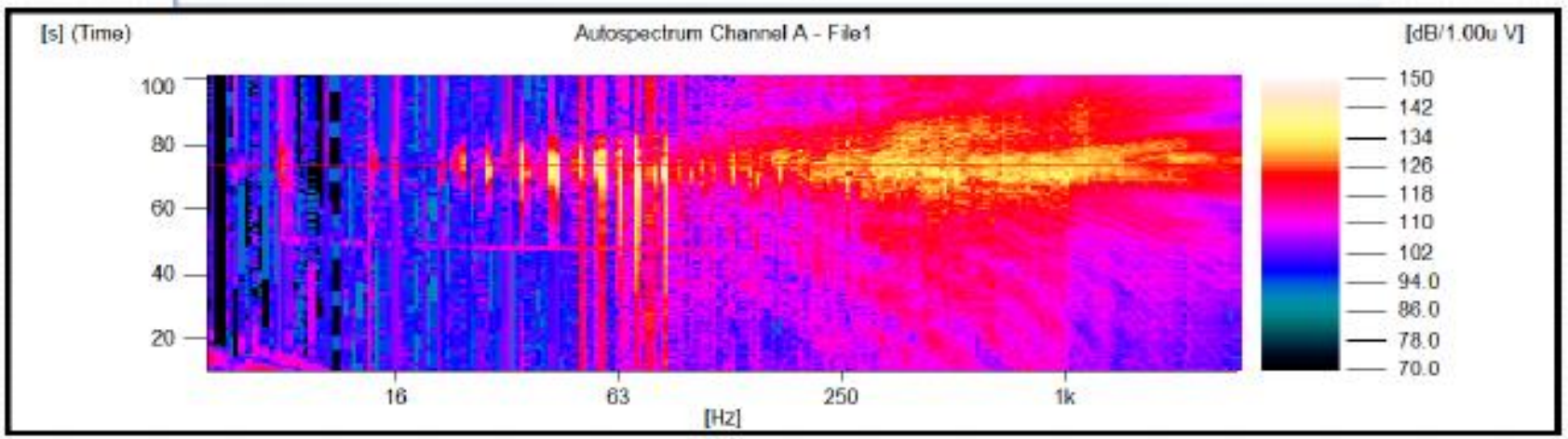




Differences in Receiving Sensitivity [dB re 1V/µPa @ 1m]

Typical spectrum and spectrogram for indentyfication of ships





Comparison of voltage sensitivities of hydrophones Reson and B&K

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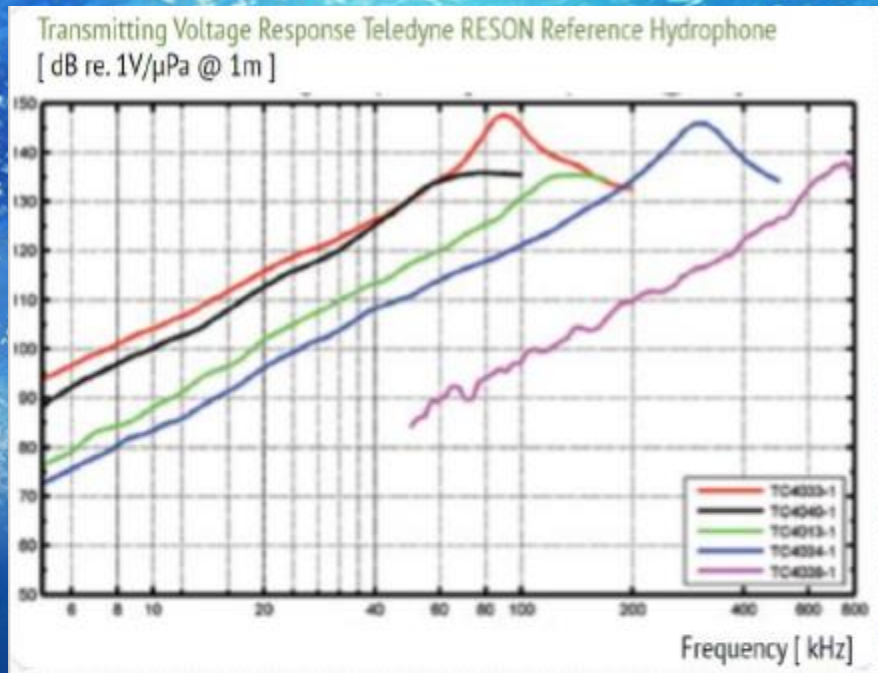
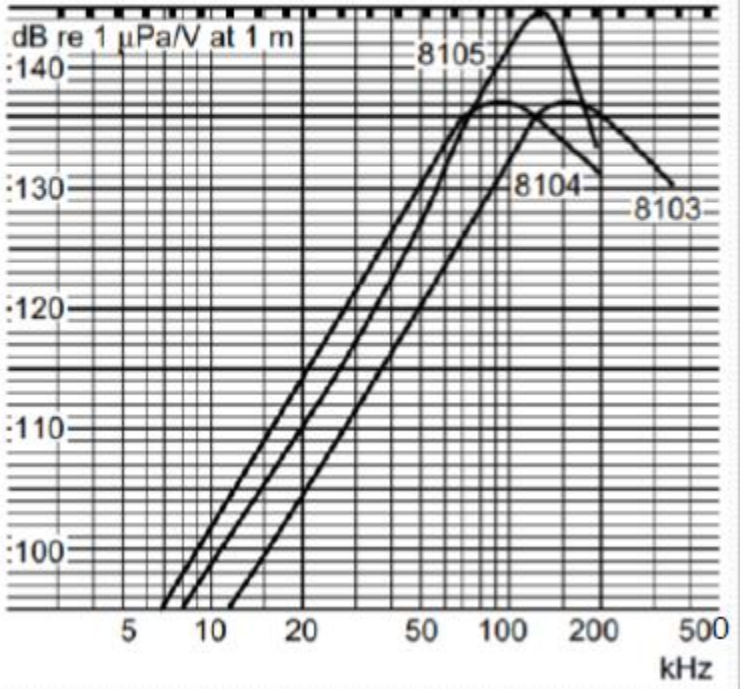
QUIETMED – D3.1





Comparison of voltage sensitivities of hydrophones

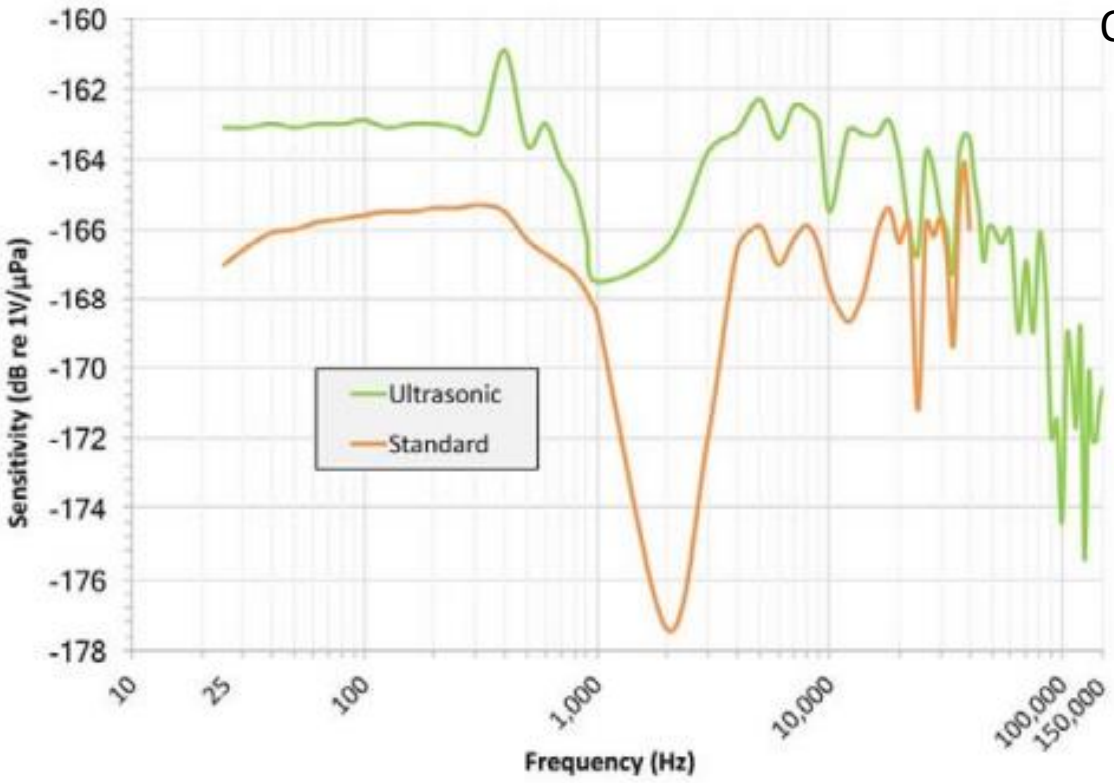


Figure 2: Example of sensitivity of 2 different hydrophones along the frequency domain [4].

Figure 2 shows an example of the sensitivity curve of a hydrophone [4], where at 1KHz it is -168 dB re 1V / µPa and at 1.25KHz it is -178 dB re 1V / µPa, a difference of almost 10 dB (orange curve). This is a good example to see that it cannot be assumed that a hydrophone is invariant with frequency. So, it is necessary to perform the calibration if the manufacturer does not give a curve like the one in Figure 2. In this case the error when supposing it will be 10 dB.

Recent activities in development new hydrophone calibration method

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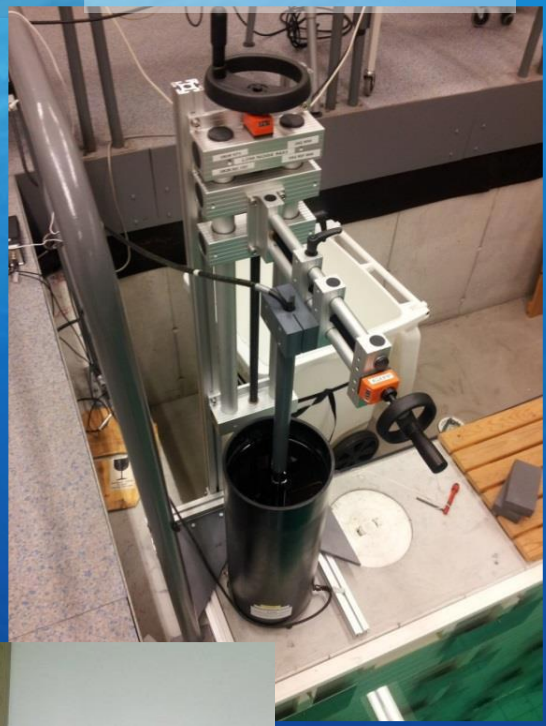
1. EURAMET EMPIR project UNAC-LOW "Underwater Acoustic Calibration Standards for Frequencies Below 1 kHz"

- frequency range from 20 Hz to 1 kHz,
- band covers the EU MSFD guideline requirements - Part I-III – which established one-third octave centre frequencies: 63 Hz and 125 Hz
- Method of calibration:
  - the air pistonphone method, frequency range of 20 Hz to 315 Hz, NPL
  - the absolute method by a laser pistonphone, NPL
  - the vibrating column method. TUBITAK



2. USA (Department of Sensors and SONAR, Naval Undersea Warfare Center)

- a coupler reciprocity - changes in frequency, temperature and pressure, very difficult to realisation, not only voltage sensitivity but phase od signal too.

Recent activities in development new hydrophone calibration method

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3. Interlaboratory comparisons carried out by the Russian Metrological Institute of Technical Physics and Radio Engineering (VNIIFTRI) and Hangzhou Applied Acoustics Research Institute (HAARI – China)

- a coupler comparative method of vibrating water column, frequency range from 30 Hz to 1 kHz.

4. At the National Metrology Center, the Science and Research Agency (NMC, A* STAR), a hydrophone calibration system based on the vibrating column method was developed

- a coupler comparative method of vibrating water column, frequency range from 30 Hz to 2 kHz.

Conclusions

A calibration methods analysis have been presented in this presentation.

In recent years, it can be observed that autonomous underwater noise recorders have become increasingly popular. In addition to previously known and improved calibration methods in the free field, there was interest in developing a method based on calibration in a coupler filled with water or air.

After analyzing the literature, the following questions arise:

1. How often should hydrophones be calibrated?
2. Where should they be calibrated?
    a. producer,
    b. an accredited laboratory (NMIs),
    c. end user,
    d. another solution.
3. What is the acceptable time of the calibration process?

Conclusions

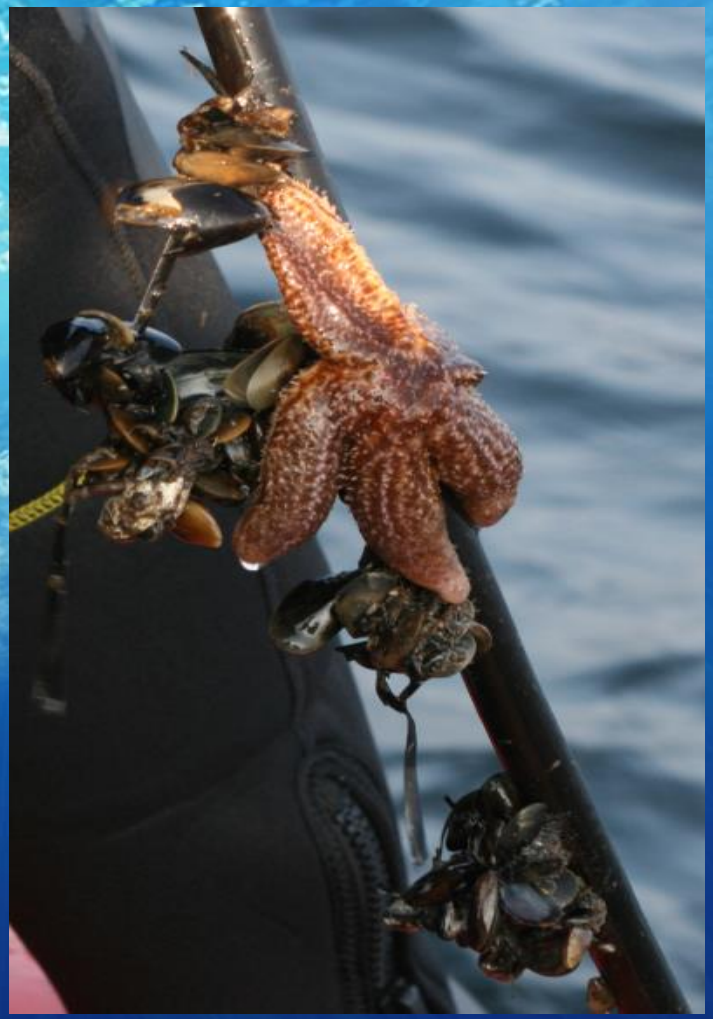
The above issues require further research or development of new procedures based on already existing research results. The authors of the studies and project participants express opinions as a summary: examine, observe and make a conclusion.

And if we invert the problem:

How to construct an acoustic recorder without the above mentioned disadvantages with built-in auto-calibration?

In my opinion, this is an idea for a new project. If interested, please write:

karol.listewnik@gum.gov.pl



Thank you for your attention