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The 10th EAA International Symposium on Hydroacoustics Jastrzębia Góra, Poland, May 17 – 20, 2016

The 10th EAA International Symposium on Hydroacoustics, which is also the 33rd Symposium on Hydroacoustics in memory of Prof. Leif Børnø organized in Poland, will take place from May 17 to 20, 2016, in Jastrzębia Góra. It will be a forum for researchers, who are developing hydroacoustics and related issues. The Symposium is organized by the Gdańsk University of Technology and the Polish Naval Academy.

The Scientific Committee comprises of the world – class experts in this field, coming from, among others, Germany, UK, USA, Taiwan, Norway, Greece, Russia, Turkey and Poland. The chairman of Scientific Committee is Prof. Eugeniusz Kozaczka, who is the President of Committee on Acoustics Polish Academy of Sciences and Chairman of Technical Committee Hydroacoustics of European Acoustics Association.

The Symposium will include invited lectures, structured sessions and contributed papers covering almost all major topics of hydroacoustics. Structured session will be devoted to:

- underwater acoustics in security systems,
- seafloor scattering,
- satellite methods in marine ecosystem research,
- underwater communication in confined and shallow waters,
- noise monitoring in European marine waters,
- ultrasonic applications,
- sound propagation in the sea and modelling,
- sonar signal processing,
- sound propagation in the sea and modelling.

More than 90 scientists have already registered to the Symposium representing research centers mainly from Poland but also from other countries including Israel, Canada, USA, with 5 invited papers:

- Prof. Chi Fang Chen: *Review on the Development of Underwater Acoustic Propagation Models*;
- Dr. Ing. Tanja Grießmann *et al.*: *Application of Bubble Curtains to Mitigate Hydro Sound Levels at Offshore Construction Sites*;
- Dr. Christopher Jenkins: *Backscatter from Intensely Biological Seabeds – Benthos Simulation Approaches*;
- Prof. Eugeniusz Kozaczka: *Technical Support for National Border Protection on Vistula Lagoon and Vistula Spit*;
- Prof. Andrzej Nowicki *et al.*: *Estimation of Radial Artery Reactive Response using 20 MHz Ultrasound*;
- Prof. Jerzy Wiciak: *Advances in Structural Noise Reduction in Fluid*.

All accepted papers will be published in the periodical "Hydroacoustics".

Abstracts

Review on the Development of Underwater Acoustic Propagation Models

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Underwater acoustic propagation modeling began with two-dimensional (2D) approach by treating the ocean as range-dependent medium and neglecting the azimuthal variation. Later the azimuthal variation is taken into account by Nx2D approach, i.e. dissect the space into azimuthal sectors and treat each sector with 2D approach. However the ocean is 3-dimensional; we cannot neglect the true ocean physics. This motivated model developers to develop model(s) to treat the 3D ocean physics realistically. This was how the FOR3D (which stands for Finite difference solutions for an Ordinary differential equation using the Rational function approximations for 3Dimensional wave propagations problems) was developed. In 1990s, FOR3D was first introduced to the underwater acoustics community to treat ocean as a three-dimensional medium with variations in range, depth and azimuth. This was the pioneer work in three-dimensional underwater acoustic propagation.

In the last decade, the three-dimensional research attracted more interest as the computational power and speed were greatly improved and advanced. In this paper,

we will review the recent works in the field while FOR3D continues to be one of the commonly used models.

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Application of Bubble Curtains to Mitigate Hydro Sound Levels at Offshore Construction Sites

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The acoustic noise caused by piling of offshore foundations of wind energy converters has an impulsive character and generates sound pressure levels, which are potentially dangerous to marine life. Without mitigation measures, the single piling event reaches values, which exceed the limit values at a distance of 750 m (160/190), established in the German regulations since 2010. To minimize impact on the marine environment, effective sound reduction techniques have to be provided. This talk presents the results of applications of the mitigation concept bubble curtain in the German North Sea within different national research projects during the last decade.

To gain deeper insight into the physical effects of bubble curtains, measuring-setup, methodology as well as spectral results of a parameter study from an onshore test campaign in a lake are presented and discussed. Bubble curtains produced with rubber membranes are found to unfold the best sound attenuation effect compared to conventional construction types – especially in the frequency range from 100 to 400 Hz, where the spectral analysis of typical piling noise close to the source delivers maximum energies.

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Acoustic Backscatter from Intensely Biological Seabeds – Benthos Simulation Approaches

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Divergences between the results for backscatter mapping of the seafloor, and ground truthing observations are often likely from biological factors in the seabed. Most models do not deal well with biology. This talk discusses the issue and illustrates a different approach with box simulations of biological seafloors, which are then numerically insonified to gauge acoustic response. Simulations are able to handle organism shapes and arrangements, population changes, and effects of 'engineering species' on the seabed. In these modern times large online databases provide enough information to reliably construct simulations for special areas.

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Technical Support for National Border Protection on Vistula Lagoon and Vistula Spit

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Border areas, especially the aquatic, are on the one hand, subject to the overwater observation in the case of good visibility in daytime. For the night time, thermal cameras can be successfully used. In case of fog, radar is an additional device allowing observation of the inspected area. On the other hand, more complex situation occurs if underwater area is under supervision.

Vistula Lagoon is a specific water environment, characterized with little depth and generally muddy bottom.

The propagation of acoustic waves is specifically – characteristic for the propagation of acoustic waves in plano-parallel waveguide. Under such circumstances, the detection of both surface and underwater targets is spatially reduced.

It seems that the use of passive observation is more effective solution.

Active location methods can be used in relation to specific conditions, as for example the application of acoustic antenna on fairway.

These specific conditions create a complex methodology of observation system for the previously characterized water region.

In the paper functional solutions and system design made in the frame of the research project founding by the National Centre for Research and Development will be presented.

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Estimation of Radial Artery Reactive Response using 20 MHz Ultrasound

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Preceding atherosclerosis is endothelial dysfunction. There is therefore interest in the application of non-invasive clinical tools to assess endothelial function. There are commercially available ultrasound scanners to estimate Brachial Artery Reactive Response BARR by measuring the flow-mediated vasodilatation (FMD) of the brachial artery using 10–12 MHz linear array probes; however the precision in estimating of artery dilation does not exceeds 0.2 mm, far beyond the required one.

We have introduced a high frequency scanning schemes; 25–35 MHz encoded (Golay) wobbling type imaging without Doppler (uScan developed in our lab, thick film wide bandwidth transducer, 50 microns axial resolution). In the second approach we have used 20 MHz linear scanning with 20 MHz pulsed Doppler attached to the linear array. Instead of brachial artery we have examined the radial artery where Radial Artery Reactive Response RARR was measured.

The radial artery FMD were normalized using AUC of shear rate at the radial artery wall. The precision of the radial artery diameter measurements is over two times better using 20 MHz US instead of 7.5 MHz used for brachial artery FMD.

The measured initial internal radial artery diameter was in range of 1.59–2.35 mm, the maximum diameter 2.01–2.60 mm was observed 40 to 55 seconds after releasing the cuff. In a limited number (14) of examined young,

healthy patients the FMD_{SR} were in the range from 7.8 to 9.9 in arbitrary units. In older patients with minor cardiac history the normalized FMD_{SR} was clearly lower, 6.8 to 7.6.

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Advances in Structural Noise Reduction in Fluid

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The sea is a complex acoustic transmission medium. The acoustic field that exists in its interior comprises natural and artificial sources with wide range of frequencies – from fractions of hertz up to few hundred kilohertz. The artificial disturbances contain a number of discrete components originating from the submarines and ship's hull and equipment connected to hull. Structure vibrations and structural noise caused by hull, cylindrical shell or plate structures may be reduced by passive and active isolation, by passive and active vibration and sound absorbers or by active control. Recently there has been considerable development in the area of construction and application of the intelligent materials for the structural vibration and noise damping.

The article presents the application of piezoactuators, bubble metascreens and topological insulator for structural vibration and sound reduction in fluid.

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Analysis of Hydrodynamic Pressure Field Motorboats and Pontoons in Shallow Water

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Using the boundary methods of flow modeling around the small motor boats and pontoons, will be calculated dimensionless characteristic of **h**ydrodynamic **p**ressure **f**ield (HPF) in the lower hemisphere. HPF will be presented at the deep water depth ($H \geq 10L$, L – length of motorboats) and shallow water with a depth comparable to the length of the vessel ($H \sim L$).

It will be submitted to the impact of shallow water on the HPF as a function of Froude dependent on depth (Fnh) in the range of values [0.5, 1].

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Calibration of Precipitation Estimation Algorithm with Particular Emphasis on the Pomeranian Region using High Performance Computing

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Fast and accurate precipitation estimation is an area of atmosphere monitoring systems as it allows i.e. to correct short time weather forecast and predict several types of meteorological threats. The paper presents methodology for calibrating precipitation estimation algorithm based on MSG SEVIRI sensor and Optimal Cloud Analysis product available via EumetCast transmission. Calibration is performed in predefined coastal zone area and the parallelized gradient computing method was used. In order to perform and validate results of estimation, reference weather radar data provided by Meteorology and Hydrology Research Institute (IMGW) is used. The research is conducted using high performance computing environment of Gdańsk University of Technology Tryton supercomputer.

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Signals Parametrization Method of Sailing Vessels

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The development of maritime transport is directly connected with increased risk of appearance of unidentified vessels approaches to ports, wind farms and other sensitive places in the water body.

Creating a database of sailing objects parameters based on dynamic recording physical fields specified disorders aims to increase security within the strategic offshore.

The article focuses on the signals parameterization from the hydroacoustic sensor, magnetometer and a pressure sensor. Presentation of the above mentioned signals in the form of a set of parameters increases the possibility of creating and managing the database of various objects moving on the body of water surface near the underwater measurement module. Used sensors, were part of multisensor underwater measurement module. Simultaneous observation using the Automatic Identification System (AIS) allows to determine the trajectory of the object and its basic parameters required to create new and filling previous records. The obtained data set will be used to develop methods for classification and identification of vessels.

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Model of Multipath Propagation of Ultrasonic Pulses Generated in Soft Tissue-Like Media by Linear Arrays

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Arrays of ultrasonic transducers used in medical diagnosis for safe and non-invasive imaging of the inside of human body usually consists of many elementary piezoceramic transducers. In case of commercial linear arrays used in ultrasound scanners particularly important is a careful selection of elementary transducers regarding repeatability of electromechanical parameters in order to ensure possibly the highest quality of imaging. The creation of crosstalk can be observed in a form of propagation of an electric voltage and mechanical vibration on neighboring elements while activating individual transducers in such an electromechanical construction of the array. It leads to the distortion of a generated acoustical field and in consequence reduces the quality of achieved medical images. Complexity of the problem rises rapidly in case of arrays which uses ultrasonic beamforming.

In this work, authors developed numerical amplitude-phase model of multipath propagation of ultrasonic pulses generated in water or in a water-like media (homogeneous soft tissue) by such arrays. The model allowed for the simulation of acoustic field distributions and for the examination of the influence of the transmitting mode beam focusing on these distributions, taking into account electrical and mechanical crosstalk.

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Comparison of Direct and In-Direct Methods of Multi-Resolution Satellite Observation of Coastal Zone Area

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The Earth Observation satellite imaging systems have known limitations, especially regarding their spatial and temporal resolution. In this context, the approaches based on subpixel mapping of the Earth environment are of high interest. Multi-resolution data fusion allows for utilization of the advantages of various types of observation sensors. The paper presents the approach to downscaling the land surface temperature (LST) products for coastal zone derived from low resolution imagery acquired by the Advanced Very High Resolution Radiometer (AVHRR) using direct and indirect methods. Effective emissivity derived from Corine Land Cover database is used as a quantity describing thermal properties of the coastal zone area in higher resolution and allowing the downsampling of low spatial resolution LST images. The authors propose inverse problem approach for downscaling AVHRR imagery and utilize the Tikhonov regularization method for finding an optimal solution to the defined problem. In the paper, comparison to other known methods of direct observations i.e PBIM, was presented. It has been shown by examples that apart from global optimization, the obtained results are also good in local scale and can be used for relatively small areas, much smaller than the entire satellite imagery scene, depicting diverse surface conditions.

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Potential of Polish R&D Industry in the Context of Prototyping, Design, Development and Control of Dedicated National Satellite SAR System for Marine Ecosystem Monitoring

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Space technology is currently one of the most important elements in the advance of information societies and knowledge-based economies all over the world. The European Space Agency (ESA) is in the focal point of the European space activities while the European Union provides strong financial support for the development of space technologies and applications in its flagship programs. In domestic scope, Polish Space Agency (POLSA) is a national aeronautics entity responsible for activities related to development of technologies of national space sector. Recently, one of the activities of POLSA aims to establish, is the programme of building the system of satellite SAR observations dedicated for Polish users such as administration, civilian services and Polish scientific and research entities that would expand potential use of satellite technologies among numerous Polish beneficiaries. The paper describes architecture and functional components of exemplary satellite SAR system along with the potential of Polish entities to develop such technology. Potential advantages and benefits of using SAR satellite for marine ecosystem observations and maritime industry is presented.

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Local Group Delay Estimator for the Time-Frequency Reassignment by Example on Sonar Sounding Signals

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In this paper, a local group delay estimator dedicated for the time-frequency reassignment is proposed. The main estimation based upon the numerical derivation of the phase of the discrete Fourier spectrum with respect to frequency is preceded by its additional modulation. Then the local group delay is estimated as the argument of the product of modulated and not modulated, conjugated spectra. In this stage, the carrier should have a really small constant frequency. This simple approach can led to increasing the final precision of the energy localization in the reassigned spectrogram in comparison to the methods which use adjacent spectrum stems. The proposed method is tested by finding the accurate delay of sounding pulses usually used in the sonar technique.

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MEMS Technology Quality Requirements as Applied to Multibeam Echosounder

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Small, lightweight, power-efficient, and low-cost microelectromechanical system (MEMS) inertial sensors and microcontrollers available in the market today help reduce the instability of Multibeam Sonars. Current MEMS inertial measurement units (IMUs) come in many shapes, sizes, and costs – depending on the application and performance required. Although MEMS inertial sensors offer affordable, appropriately scaled units, they are not currently capable of meeting all requirements for accurate and precise attitudes due to their inherent measurement noise. The article presents the comparison of different MEMS technologies and their parameters regarding to the main application namely Multibeam Sonars (MBS). The MEMS parameters quality are crucial for further MBS records processing, the article presents the results of undertaken researches in that area.

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EGNOS Based GNSS Receiver for Precise Positioning in Restricted Areas of Continental Shelf

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Positioning accuracy is very important in many areas, whereas typical GPS receiver accuracy often is not sufficient. The European Geostationary Navigation Overlay Service (EGNOS), Europe's first venture into satellite navigation, improves the open public service offered by the Global Positioning System (GPS). As a satellite navigation augmentation system, EGNOS improves the accuracy of GPS by providing a positioning accuracy to within 3 meters. In this paper we presented prototype of GNS receiver based on EGNOS dedicated for precise positioning in restricted areas of continental shelf.

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In-Situ Acoustic Seabed Characterization

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In a defined area, from a close location to another, seabed response to acoustics is a continuous uncertainty. Current methods to determine first layer seafloor characteristics such as sub bottom profiling, cone penetrators and core sampling as their advantages and limitations.

Sub bottom profiling will provide a nice image of the seafloor but keeps uncertainty on the type and homogeneity of the type of seafloor. Core sampling is demanding in infrastructure and removes seabed from its ins-situ location, which can interfere on its comportment; whether than cone penetrators shall not provide acoustic related information.

INSEA approach lays is an innovative in-situ measurement system for sediment characterization using acoustics. It aims to provide an accurate in-situ information on the acoustic characteristics of the first layer of the sediment, avoiding core-sampling.

The INSEA is composed of an autonomous compact device 200 meters depth rated, equipped with four emitting and receiving broadband transducers that transmit sounds in multiple geometrical configurations in the sediment. Transducers integrated in the stakes emit and receive at multiple frequencies in the band from 50kHz up to 270kHz. Each one of the 4 stakes emits and then receives a sequence of consecutive signals covering all the frequency range. Time delay and attenuation of the signal from emission to reception provides quantifiable information of the sediment.

This paper will present the development and results achieved using this technology.

Then, it will focus on current evolution of this methodology and device with aim to gather additional information such as video, attitude, and lower frequencies transducer for S-waves or P-waves.

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Utilizing Comparison Magnetic Resonance Imaging and Acoustocerebrography Signals in the Assessment of Focal Cerebral Microangiopathic Lesions in Patients with Asymptomatic Atrial Fibrillation (Preliminary Clinical Study Results)

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Background: Acoustocerebrography (ACG) is a novel, noninvasive, transcranial ultrasonic method that measures a set of data variables obtained from the transmission of multispectral ultrasound signals that are propagated through the brain tissue, including: absorption coefficient, frequency – dependent attenuation, speed of sound and tissue elasticity. ACG and Magnetic Resonance Imaging (MRI) results were compared in a clinical study assessment of focal white matter lesions (WML) in the brains of patients with asymptomatic atrial fibrillation (AAF).

Methods: The clinical study included 55 patients with AAF; the study population had a mean age of 66.1±6.7, a CHA2DS2 VASc of 2.5±1.3, and a mean HAS-BLED of 1.65±0.9. According to MRI data the patients were assigned into four groups based on the number of lesion: "L0" – 0 to 4 lesions, "L5" – 5 to 9 lesions, "L10" – 10 to 29 lesions, and "L30" – 30 or more lesions.

Results: It was proved that the ACG method could clearly differentiate a group of WML patients with 0 to 4 lesions (L0) and a group of patients with 30 and more lesions (L30). Fisher's Exact Test shows that this correlation is highly significant ($p < 0.001$), (Fig. 1).

Conclusions: ACG is a new, effective method for detecting WML in patients with AAF. The ACG measurement methodology may become increasingly useful to diagnose and to stratify patients with AAF in order to individualize their treatment and importantly to reduce their risk of stroke.

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Detection of Variations in Random Characteristics of Scattering Medium by the Wavelet Analysis

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The main idea of this research is to show the capacity of the wavelet analysis to the differentiation of randomness of backscattering structures. Simulated ultrasound backscattered signals are obtained under real conditions imposed on the incident field generation and properties of the actual ultrasound transducers. It is assumed that the scattering volume, i.e. region of interest, is composed from a sum of two random media occupying the neighboring locations. The considered media are equal in size but they consist of backscattered with different random distributions or different physical properties. As an example, particular structure of the complex random scattering volume is considered. It consists of the ensemble of spheres randomly shifted from the center of cubic cells with the shift distributed uniformly and normally with different characteristics for each of two sets. It will be seen in what a way the two randomness impact on the features of the wavelet spectrogram of RF signals in which not only the variations in randomness but also the location of the border between two random parts is noticeable.

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Spatiotemporal, Multidimensional GIS for Pelagic Fish Biomass Estimation

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Various methods of pelagic fish biomass estimation provide information about quantity of fish in a specific geographical location. Analysis of the consequent measurements for the same area over extended period of time can help in explaining the changes occurring in the environment (migration etc.). Moreover, pelagic fish biomass estimation compared with fishing data can help in effective fishery planning. Modern Geographical Information System (GIS) technology can provide easy to use, near real-time solution to aforementioned problem. Multidimensional GIS systems are especially designed to acquire, distribute, analyze and visualize complicated temporal data.

In the article, authors present an idea for multidimensional GIS for pelagic fish estimation analysis and discuss possible benefits, architecture and applications.

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A Novel Algorithm of Spectral Analysis for Passive Sonars

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A problem of significant importance in various areas of science and technology is an effective detection of a short duration harmonic signal embedded in noise and in the presence of slowly varying disturbance.

Short duration is understood here as time instant from a to several (less than 100) of periods of the harmonic signal sought.

This is, among other the scenario in passive underwater location, where the goal is to detect the periodic signal of the submarine propeller.

The main idea of the algorithm consists in chopping the analyzed signal into a number of adjacent subintervals of the duration equal to the assumed period of the signal to be detected. This, thru averaging, enables an improvement of signal-to-noise ratio and provides some flexibility in choosing metric for most robust determination of the number frequency of the harmonic signal to be identified.

The goal of this paper is to discuss the available metrics and their performance in identifying the harmonic signal vs the performance of standard Fourier analysis.

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Effect of Water on Acoustic Properties of Ionic Liquids

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Ionic liquids are considered to be a novel and attractive huge class of chemical compounds with unique properties such as negligible vapour pressure, a broad liquid temperature range, a high chemical and thermal stability. Thus they are becoming a new green solvents.

The measurements of speed of sound in ionic liquids have been undertaken, either to study the nature of molecular interactions, structure and packing effects or to obtain thermodynamic quantities for applications in chemical and industrial process. The presence even a small amount of water in ionic liquids may affect many of their properties. Therefore speed of sound, density, acoustic impedance, isentropic compressibility, and isobaric thermal expansion were determined for solutions of water in 1-ethyl-3-methylimidazolium ethyl sulfate and 1-octyl-3-methylimidazolium chloride within the temperature range from 278 K to 343 K.

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Development of a High-Resolution Real-Time Capable 3D Sonar Camera for Deep Sea Operation

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The deep sea and especially the seafloor constitute an increasingly attractive field for different scientific and economic interests. In order to accomplish a comprehensive exploration as well as an efficient economic utilization of the deep sea, visualization tools which provide images of reasonable quality within an acceptable period of time are required. Since the commonly used optical imaging systems are restricted in the seafloor area, a high-resolution real-time capable sonar-system is required to ensure an adequate visualization for exploration and process monitoring

purposes. The aim of the project is the development of a sonar camera system which is able to provide real-time 3D images with a sufficient spatial resolution in a deep sea environment. Within this work we present a first experimental setup of the camera system consisting of a 1024 element matrix array antenna together with a 128 channel beamforming system including an 8:1 multiplexing device. While the basic concept for this camera system was developed in previous stages, this work deals with the construction of the antenna, the description of the electronic beamforming device as well as first measurement results under laboratory conditions.

The measurement results are used to verify the former simulations concerning the antenna's sound opening angle, the attainable spatial resolution and a proof of concept for the entire system. Here, the focus is on the particular transmitting and receiving modalities since the beamforming device allows an adjustable defocused sound field of the antenna. Furthermore, a statistical investigation of the antenna's elements is presented in order to show their electrical and acoustical performances and uniformity. The cross coupling between the single antenna elements as well as their spatial displacement and vibration modes have been investigated using a laser-doppler vibrometer. Finally, the generation and transmission of frequency coded signals for matched filter usage are presented and discussed.

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Acoustical Properties of Tissue Phantoms with Different Stiffness and Water-Like Absorption

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Poly(vinyl alcohol) cryogel, PVA-C, is produced as a soft tissue-mimicking material, suitable for application in ultrasound imaging. A 10% by weight poly(vinyl alcohol) in water solution was used to form PVA-C, which is solidified through a freeze–thaw process. The number of freeze–thaw cycles affects the properties of the material, particularly the mechanical stiffness. The ultrasound characteristics were investigated using 3 different cylindrical samples of PVA-C produced by 1, 2 and 3 cycles of freezing-thawing process. The speed of sound was found to range from 1502 to 1522 m s^{-1}, and the attenuation coefficients were in the range of 0.085–0.124 dB/(cm MHz). The structural heterogeneities are visualized by Nakagami maps and it is shown that the range of Nakagami parameter characterize the differences between samples. The samples are structurally different in the regions close to the surface from the internal regions. This is probably caused by the spatial heterogeneity of the solidification process . The thickness of the boundary layer is also measured from Nakagami maps and it is shown that it is also linked to the type of samples. The elastography maps (measured by the commercial quasistatic strain imaging system ...) are compared with Nakagami maps. The question arises, in what circumstances parametric estimation of spatial structure variations by Nakagami maps are linked to the spatial variations of local stiffness?

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Situational Analysis of Underwater Noise Issue in the Area of the Central and South Baltic Sea

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The issue of the noise control in the atmospheric environment has been developed for several decades. As a result, certain legal acts have been constituted, together with a number of quantitative norms regarding both the workplace, and the spatial areas, in particular the urbanized regions. The areas of heavy traffic, such as motorways, highways or thoroughfares, have also been the subject of interest.

In case of the underwater environment the situation is unfortunately heavily underestimated. Human factor is commonly known as highly influencing on the so called marine acoustical climate, as well as, environment.

The main source of the underwater noise is commonly understood maritime transport. There are fairways where shipping traffic is very intense, like on highways. Unlike in gaseous environment, it is hard to imagine constructing acoustic screens in the sea. Thus the noise in the range of small and medium frequency bands propagate in sea over long distances from their sources with far less natural attenuation than in the air. Moreover, the structure of the water environment creates a kind of waveguide with conducing conditions for noise propagation over long distances.

Apart from the maritime transportation noise, new sources of the underwater noise, such as offshore wind farms, occur. The industrial activity in the coastal areas can be also named as additional one.

There have been works in the EU region on the legislation as well as research – measurement activities for several years. Basically, the current situation can be considered as at an early stage, however, there are efforts made in order to reduce the noise level in the sea.

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Acoustic Climate of the Gulf of Gdańsk in Years 2000–2010

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The conditions of the acoustic wave propagation in the southern Baltic are much more complex than in other shallow waters. In the typical shallow water seasonal changes in acoustical conditions in the upper layer of the depth of about 60–70 m are observed. They are caused by variation of the annual meteorological conditions. Most often, in the deep water layer acoustical conditions are stable throughout the year. However, in the Southern Baltic they change

during the year also in the deep water layer. They depend on the inflows of highly saline water from the Northern Sea through the Danish Straits, which evoke dense bottom current increasing the salinity at the bottom. The vertical sound speed distribution in the Southern Baltic strongly dependent on the hydrological conditions.

In the paper the characteristic elements of acoustic climate of the Southern Baltic will be considered basing on data concerning the Gulf of Gdańsk. Averaged characteristics for years 2000–2010 as well as anomaly have been determined.

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Diffraction of Sound Pulses on a Spherical Target Submerged in an Oceanic Waveguide Covered with Ice

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Sound propagation in an oceanic waveguide covered with ice has been studied by many authors as opposed to the problem of acoustic scattering by a target imbedded in such a waveguide. This paper is devoted to modeling of the pulse scattering by a spherical target immersed in a homogeneous waveguide covered with ice. For calculating the echo signal in the frequency domain we have followed the Hackman and Sammelmann's general approach. The arising scattering coefficients of a sphere were evaluated with the use of the normal mode method. The amount of normal modes forming the backscattered field is determined by the given directivity of the source. The emitted signal is a pulse with a Gaussian envelope. Computational results are obtained in a wide frequency range 8–12 kHz for water depths equal to several hundreds of m, and distances between a source/receiver and a target from 1 km up to 10 km. A target is assumed to be acoustically rigid or fluid. In particular, the properties of the ice cover and a scatterer may coincide. The obtained analytical expression for the backscattered field in the time domain is applied to evaluate its dependence on depth of a water layer, bottom and ice properties, and distance between the source and obstacle.

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Investigation of Acoustical Spectrum of Underwater Propulsion Systems

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In this paper, prediction of acoustic behavior of underwater propulsion systems were investigated through test-case validations which were performed using finite volume based solver. Test-case study consists of determination of frequency spectrum around cylinder and aeroacoustics of automobile A-pillar raingutter. Although the medium is different, the experiments can be good validation reference for the current study. Frequency in spectrum and magnitude range is the main comparison between those cases. URANS and LES formulations were both implemented to compare solution time, errors and applicability. At each step during flow calculations, acoustic sources around moving parts and wake were stored to couple them with acoustic solver. Instead of direct solution of wave propagation, it is modeled using FWH method (Ffowcs-Williams and Hawkings) based on Lighthill acoustic analogy. FEM/BEM solver was also used for the purpose of observing differences between FWH analogy and FEM/BEM solver. Blade passing frequency and its harmonics on tonal and broadband noise around a propulsion system were given using the computation of the turbulence quantities and the radiation of sound waves to the pressure sensors. Test-case results show good agreement with the experimental data: Frequency spectrum, magnitude of amplitudes and tonal harmonics for farfield and nearfield were predicted for cylinder and raingutter. The same schema and methodology was implemented to the underwater propulsion case in order to predict noise spectrum. Due to the effect of coupling method, FWH analogy and FEM/BEM solver were compared between each other. The results show that noise prediction can be obtained by using hybrid acoustic method.

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Modelling of Acoustic Backscattering by Southern Baltic Herring

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Hydroacoustical abundance estimation of Baltic herring, economically and ecologically significant species, has been performed in different parts of the Baltic sea since the eighties. The reliable *TS(L)* model (TS is the target strength of herring individual and L is its total length) is crucial for the higher estimation accuracy. Taking into account the geographic dependence of the *TS(L)* model for Baltic herring, the ICES Working Group of *Fisheries Acoustics, Science and Technology* recommends the study of the *TS(L)* model for different subdivisions of the Baltic Sea. It motivated the detailed analysis of the relationship for herring from the southern Baltic ICES Subdivisions 24, 25, 26, in which Poland is responsible for the hydroacoustical herring abundance assessment.

In order to understand the mechanisms of backscattering of sound by herring individuals, model analyses on the backscattering characteristics of individual specimens, as well as average backscattering characteristics, was performed. To describe the backscattering of acoustic waves on the body and the swimbladder of fish, the Modal-Series-Based Deformed Cylinder Model (MSB-DCM) was used. The detailed shape of the swimbladder of herring individuals was considered. As input data for the model, the morphometric data obtained from X-ray images of herring individuals from the Polish coastal zone (ICES 26 subdivisions)

in November 2011 were used. The study was done for the statistically representative fish collection (74 individuals).

The sensitivity of the backscattering properties of the herring to the parameters of the orientation distribution of fish in the aggregation was analyzed. It was confirmed that the target strength of southern Baltic herring is significantly higher, compared to the values obtained based on the *TS(L)* relation, which is currently recommended by ICES for hydroacoustical assessment of herring stock in the Baltic sea.

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Sea-Bed Scattering and Reflection Contributions to the Short-Range Acoustic Impulse Response: Measurements and Modelling

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Sea-bed and sea-surface scattering, as well as multipath arrivals, make the underwater sound-propagation impulse response complicated. Special techniques must be applied to handle the complex impulse response in underwater communication and sonar detection algorithms, for example. The present paper reports results from a short-range experiment in shallow-water, under well controlled conditions, designed to assess the various contributions to the impulse response. A sound source mounted at depths between 5 and 25 m emitted FM and short CW pulses, centered at 25 kHz, that were registered by an array at depth 7.5 m some 50 m away. The water depth at the source and receiver location is 29 and 16 m, respectively. Geologically, there is a transition of bottom type from clacial clay at the source to crystalline rock at the receiver. The impulse response recordings show initial isolated peaks followed by long decaying tails. A 3-D ray model, Rev3D, is used to model the measured time traces. The initial peaks are identified as direct and multi-path arrivals of various types, while the decaying tails arise from bistatic reverberation involving the sea bottom in an elliptical area with the source and receiver positions as focal points. Using beam-forming with the receiver array, efforts are made to locate the parts of the bottom with the most significant contributions to the impulse response and to determine reflection coefficients as well as scattering-kernel values. Rev3D modelling with energy-density maps for selected time intervals and time traces for energy-weighted averages of various parameters, such as the emission angles from the source, is also applied for this purpose.

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Underwater Noise Properties in Waterways Areas of the South Baltic Sea

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Results of underwater noise registrations completed with single and multi-hydrophone systems performer in the shallow water in the vicinity to waterways to the Tricity (Gdańsk/Gdynia) and Świnoujście harbours are presented in this paper.

Due to the fact that the bottom properties, bathymetry, and temporally varying sea surface alter the original sound spectra generated by a ship and reduce the acoustic energy, the sound transmission losses have been modeled and source levels of passing ships have been predicted.

The used sound propagation model – the KRAKEN-C illustrates the problems of the recognition of sources noise spectra on the basis of the measurements performed in a far zone from the sources.

On the basis of the ship density data received from the AIS system the potential ecological effects of anthropogenic underwater noise on fish and marine mammals including their behavioral responses are given for the Gdańsk and Pomeranian Bights.

In the paper, some examples of algorithms recognizing the ship noise are presented.

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Influence of the Benthic Microalgae Photosynthetic Activity on the Energy and Spectral Characteristics of the Signal Reflected from Southern Baltic Sandy Sediments

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The use of hydracoustical techniques to classify benthic fauna and flora and to study benthic biological processes is one of the important challenges in the present marine research. The understanding the microphytobenthos photosynthesis impact on the characteristics of the signals backscattered by the sea floor is crucial for the Baltic Sea where the hydroacoustical classification techniques are actively developed now. This motivated our study.

In order to understand the impact of the photosynthetic activity of the southern Baltic benthic microalgae on the signal, reflected by sandy sediments, the backscattering data collected in the frame of the grant of the National Science Centre, Poland (No. N306 773940), were analyzed. These data were acquired in the aquarium with sandy bottom under controlled constant temperature and salinity conditions, typical of the Baltic Sea, during eleven days laboratory experiment changing the light conditions (light/dark photocycles). The data, collected over the band with the central frequency 280 kHz, were proceeded.

It was studied how different characteristics (the energy and spectral density) of the signal, reflected by Baltic sandy sediments, are sensitive to the microphytobenthos photosynthesis within the considered frequency range. The statistical correlation between hydroacoustical data and the oxygen content, simultaneously monitored in the experiment, was analyzed in order to understand the mechanism of the microphytobenthos photosynthesis impact on the echo signal.

It was shown that the diel variation of the spectral density due to the photosynthetic activity of the southern Baltic benthic microalgae depends on the frequency and at some frequencies is more significant than the echo energy

changes. Some recommendations for the further study of the mechanism were done.

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The Properties of Silent Sonar with MLS+HFM Sounding Signal

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An FM-CW type sounding signal is used in the classical solution of silent sonar. The such a signal provides a relatively simple implementation of digital signal processing, ensures good detection conditions, but unfortunately, in the presence of Doppler effect, distance measurement result is burdened with a very big error. This is due to the fact that the received signal momentary frequency value is dependent both on the distance to the object and its speed. Sounding signal, patented by the authors, is a combination of pseudo-random sequences MLS type and elementary signals HFM type. The structure of this signal is aimed at minimizing the above-mentioned measurement error. The article presents the idea of a sounding signal MLS + HFM type and the results of computer simulations.

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Harmonic Antibubbles

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We study the sonication of stable particles that encapsulate a liquid core, so-called antibubbles. Acoustically active antibubbles can potentially be used for ultrasound-guided drug delivery. In this presentation, we derive the oscillating behaviour of acoustic antibubbles with a negligible outer shell, resulting in a Rayleigh-Plesset equation of antibubble dynamics. Furthermore, we compare the theoretical behaviour of antibubbles to that of regular gas bubbles. We conclude that antibubbles and regular bubbles are acoustically active in a very similar way, if the liquid core is less than half the antibubble radius. For larger cores, antibubbles demonstrate highly harmonic behaviour, which would make them suitable vehicles in ultrasonic imaging and ultrasound-guided drug delivery.

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New Type of High Power Ultrasonic Generator for Welding and Cutting Processes

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The paper presents a new type of high power ultrasonic generator for welding and cutting processes developed by Tele & Radio Research Institute. The new generator cna provide up to 5 kW of electrical power to ultrasonic transducer in frequency range from 16 kHz up to 40 kHz with regulation step down to 0.1 Hz. The device utilizes innovative microcontroller with built-in high resolution timing blocks that enable direct synthesis of control signals for generator's resonant converter without the need of external DDS unit or programmable device. This new approach to designing ultrasonic generators can benefit in greater flexibility and reliability of the device. New algorithms with cycle by cycle parameter control and precise regulation of output frequency and power delivery have been developed. Various parameters of ultrasonic stack such as impedance and resonant frequency are measured by the generator in real time and can be used to diagnose the stack and detect its damages.

In addition, the newly designed generator is equipped with 7 inch, high resolution color display with touch panel which allows for clear presentation of data gathered by the device including impedance curves of ultrasonic stack, output power curves and easy setup of desired parameters. Gathered data can also be transferred to computer via USB Device interface, over local LAN network using built-in Ethernet or WiFi module or stored to Flash Drive via USB Host interface. The generator can also be connected to PLC controller via RS485 interface, digital or analog in/out control signals and can also measure external parameters such as temperature or horn vibration amplitude by built-in analog inputs.

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Application of Ultrasound to Noninvasive Imaging of Temperature Distribution Induced in Tissue

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Therapeutic and surgical applications of High Intensity Focused Ultrasound (HIFU) require monitoring of local temperature rises induced inside tissues. Guidance of the HIFU beam is of crucial importance. It is needed to appropriately target the focal plane and hence the whole focal volume inside the tumor tissue prior to thermo-ablative treatment and beginning of tissue necrosis. Currently, the Magnetic Resonance Imaging technique, relatively expensive and rather inconvenient in practice is used. In this study we present an ultrasound method, which calculates the variations of speed of sound in the locally heated tissue. Changes in velocity correspond to temperature change. The method calculates 2D distribution of changes in the sound velocity by estimation of the local phase shifts of RF echo-signals backscattered from the heated tissue volume (the focal volume of the HIFU beam) and received by an ultrasound scanner. Further, the method combines the advantages of Synthetic Transmit Aperture and phase shift detection techniques to improve the spatial resolution and minimize the overall uncertainty in temperature estimation. The technique enabled temperature imaging of the heated tissue volume from the very inception of heating. The results indicated that the contrast sensitivity for

imaging of relative changes in the sound speed was on the order of 0.06%, corresponding to an increase in the tissue temperature by about 2°C.

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Sound Field Fluctuations in Shallow Water Due to Mode Coupling in the Presence of Moving Internal Waves

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In the paper sound field fluctuations are analyzed in shallow water in the presence of nonlinear (intense) internal waves moving approximately along acoustic track. In this case, reason of fluctuations is mode coupling, depending on angle between direction of acoustic track and wave front of internal waves. Experimental data presented obtained in experiment ASIAEX 2001 where solito-like internal waves were registered, traveling from the source, radiating signals with frequency 224 Hz, to receiving vertical line array at the distance about 35 km. Results of experiment are in good correspondence with theoretical estimations.

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Experimental results on Networking in Underwater Acoustic Communications using Evologics Modems

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Paper presents the development of a digital underwater acoustic network, in which connection delays and connection disruptions in data transmission between network nodes are allowed. The technology enables data transfer in networks of arbitrary topology, which network nodes are spatially separated so that the possibility of data transmission directly from source to destination can be absent. The number of intermediate nodes between source and receiver may be fixed or non-fixed. This transmission route can be static or dynamic.

Implementation of the digital underwater acoustic network represents a program framework – the stack of network protocol, each of which is designed to solve the problem of data transmission under certain conditions of underwater acoustic environment.

The program framework is accompanied by open source code, enabling any adaptation of the framework to operate on different hardware platforms, in particular, the operation on the hardware platform (i.e. "on board") of the underwater acoustic modems built upon the S2C technology, manufactured by Evologics. With this framework, the underwater acoustic modem of the S2C technology represents an experimental platform allowing to combine the existing network protocols, as well as to integrate additional custom protocols (stack of customized protocols developed by modem users).

The framework of network protocols developed for underwater acoustic environment obtained the name EviNS. It is a novel framework for underwater acoustic networks and positioning systems designed as lightweight efficient and easily extensible tool. Currently EviNS includes several routing solutions. These are static routing and flooding based protocols, such as Sequence Number Controlled Flooding (SNCF), Dynamic Probabilistic Flooding (DPFlood), Information Carrying Based Routing Protocol (ICRP), Evologics Path Finding Protocol (EVOPF) and Dynamic Path Finding Protocol (DPF).

The use of flooding based protocols considers a transmission of broadcast messages, what can lead to multiple data collisions in the network. The solution for decreasing the collisions was the integration of an additional MAC layer to the network stack of EviNS framework thus providing an extra control over the channel access. EviNS media-access-control layer acts as an additional layer to S2C modem firmware data-link layer and had the same interface as with D-MAC protocol. EviNS contains such implemented media-access-control solutions as CSMA-Aloha, DACAP and T-Lohi.

Also, to ensure the transmission of data in tricky conditions of underwater acoustic environment there has been developed (as a part of the EviNS framework) and implemented a protocol of the transport layer, tolerant of delays and connections disruptions, in particular, DTN – Delay Tolerant Network.

Paper presents the experimental results on the operation of network protocols of the EviNS framework on the hardware platform of the underwater acoustic modem in tricky underwater acoustic environments, causing delays and connection disruptions between the network nodes. Experimental results justify the possibility of using digital underwater acoustic networks for fast transmission of short messages (commands), and undamaged transmission of large amounts of data.

The results have been obtained during REP14 sea trials, organized and carried out by Center of Maritime Research and Experimentation (CMRE, La Spezia) in July 2014 in the Atlantic Ocean near the coast of Portugal.

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Limitations of WSSUS Modeling of Stationary Underwater Acoustic Communication Channel

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Performances of underwater acoustic communication (UAC) systems are strongly related to specific propagation conditions of the underwater channel. Due to their large variability, there is a need for adaptive matching of the UAC systems signaling to transmission properties of the channel. This requires a knowledge of instantaneous channel characteristics in terms of specific parameters of stochastic models. The wide-sense stationary uncorrelated scattering (WSSUS) assumption simplifies calculations of terrestrial wireless channel transmission properties. Although UAC channels are hardly ever WSSUS, the rationale of such a stochastic modeling is that over a restricted period of time and for limited frequency range this assump-

tion is sometimes reasonably satisfied. The limits of application of the local-sense stationary uncorrelated scattering (LSSUS) model are determined by the stationary time and stationary frequency parameters. The paper presents the results of LSSUS model analysis for UAC channel measurements gathered by the WTD71-FWG, during the SIMO experiment in the Bornhom Basin of the Baltic Sea.

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Propeller Noise Investigations

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The analyses of hydroacoustics are of high interest at the moment due to strong impact of hydroacoustic phenomena on marine environment; the noises, generated e.g. by marine traffic, may be harmful for sea life. The presented analyses are focused on one of main sources of noises generated by ships, i.e. cavitating propeller. The goal of the work is the assessment of the cavitation phenomenon, carried out with the standard commercial tool. The computational model is based on unsteady Reynolds-Averaged Navier-Stokes (RANS) flow model. The analysis started with elaboration of the method for modelling the propeller operation behind the hull by proper setup of the inflow conditions based on the results of full scale CFD wake analysis and self-propulsion model tests. The numerical analyses were carried out also at model scale so as to enable direct verification of the results on the basis of model tests carried out in the cavitation tunnel of Ship Design and Research Centre (CTO) S.A. Two loading conditions were considered. Good correlations of both kinds of results have been noticed and highlighted.

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Mobile Inventory System for Hydrotechnical Objects using Data from Multiple Sensors Operating Simultaneously

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The knowledge of the location, shape and other characteristics of spatial objects in the coastal areas has a significant impact on the functioning of ports, shipyards and other water infrastructure facilities, both offshore and inland. Therefore, measurements are taken of the underwater part of the waterside zone, which means the bottom of water and other underwater objects (eg. breakwaters, docks, etc.), and objects above the water, such as the above-water part of the waterside, breakwaters, hydraulic constructions and other objects of waterside infrastructure.

In this paper project of mobile inventory system for hydrotechnical objects using data from multiple sensors operating simultaneously will be presented. The aim of the project is to elaborate a mobile underwater water scanning system which could be applied in various works requiring precise, detailed and coherent underwater and above water measurement, especially in areas associated with surveying, inspection and monitoring of objects in coastal areas will be presented.

To elaborate the concept of the system analysis concerning existing methods of precise underwater and above water measurement as well as measuring equipment available was carried out. The results of the research was used to develop the concept of the mobile system equipped with underwater laser scanning and acoustic positioning. The technology demonstration is developed using specially built laboratory environment that simulates hydrotechnical infrastructure with access to GPS data. The final stage of the project will consist of testing the system in open waters.

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Methods for Quality Improvement of Multibeam and Lidar Point Cloud Data in the Context of 3D Surface Reconstruction

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Point cloud dataset is the transitional data model used in several marine and land remote sensing applications like seabed surface and underwater object shape reconstruction from multibeam sonar data as well as land surface topography elements detection, recognition and mapping using laser scanning measurements. During further steps of processing the transformation of point cloud spatial data to more complex models containing higher order geometric structures like edges, facets etc. may be possible if an appropriate quality level of input data is provided. Point cloud datasets usually contain a considerable amount of undesirable irregularities, such as strong variability of local point density, missing data, overlapping points and noise caused by scattering characteristics of the environment. For these reasons, processing such data can be quite problematic, especially in the field of object detection and three-dimensional surface reconstruction. This paper is focused on applying proposed methods for reducing the mentioned irregularities from several datasets containing 3D point clouds acquired by multibeam sonars and LiDAR scanners. The article also presents the results obtained by each method and discusses the advantages and disadvantages of several approaches.

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Web-Based 3D Processing and Dissemination of Multibeam Sonar Data

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The continuous detailed surveys of the various water bodies over time leads to a large and ever-increasing volume and density of underwater sounding data. Being three-dimensional in nature, data such as water-column and bathymetry is quite complex to manage, and thus the growing number of data increases the pressure on development of new solutions dedicated to processing it. A major source of three-dimensional underwater data are multibeam sonars, which produce high resolution data on a local scale.

This paper presents a concept system for web-based dissemination of multibeam data in a geographic context. In order to maintain an easily accessible user interface, processing and distribution of such datasets in a web environment requires the data to be converted into a file format which is fit for processing via a web browser. Because of this, the presented system uses the emerging 3D Tiles open standard for serving multibeam point clouds alongside reconstructed three-dimensional models of shipwrecks to remote users. The system provides presentation of the data in a web environment by means of Cesium, an open source Web-GIS library for 3D visualization of geospatial data.

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The Acoustic Camera in Research of Windows Sound Insulation

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The paper shows the result of using an acoustic camera to visualize the sounds passing through the window type partition. The camera was used in the reverberation chambers, as checking the possibilities of this tool when testing acoustic insulation of the large 3 wing window. Due to the construction of the camera and reverberation chamber it was necessary shielding noise in the receiving chamber. We present the discussion of the results in comparison with standards and vibroacoustic studies of windows.

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Time-Domain Evolution of Coupled Dynamic States in the Vicinity of Primitive Acoustic Sources

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Two types of primitive sources are able to induce a linear disturbance chain in a fluid, originally at rest. One injects a surplus of fluid matter into adjacent particles, thus initiating their elastic strain. The other exerts a force onto particles, modifying their inert motion. A secondary disturbance accompanies instantaneously the primary one, exerting simultaneously a counterwise action onto it. The two actions, although sequential, take place at the same time at the same infinitesimal particle volume, the simultaneity being proper to circular feedback actions. An adequate application of Euler's first-order relations describing mutual influence of elastic strain and inert motion, to a given physical feedback loop leads to a second-order relation being physical wave equation related to the primary quantity, coupled with a complementary Euler's relation describing the accompanying quantity. Such a pair of formulae fully characterizes the disturbance induced by a given source as a two-fold dynamic state. Its two components are internally coupled, and from the very start play each a distinct role enforced by the source at its vicinity, next conserved as pressure-and-velocity or velocity-and-pressure "wavefields" wherever and whenever the disturbance propagates through homogeneous medium. The paper illustrates directly in the time domain, in both the elementary cases of spherical disturbance spread, the evolution that takes place from much complex relations between pressure and velocity in the area close to the source, to the well-known simple proportion between these quantities far-away from the source. Pressure and velocity timeforms of a few signals representative for communication and technical acoustics are calculated analytically, showing how the otherwise known pulses can in source vicinity be different from what is expected at a "normal" distance where the disturbance is treated as classical wave, and how, additionally, the difference depends on the type of source.

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High-Resolution Bearing Estimation for Active Sonar with Cylindrical Array Performed by Equivalent Linear Form

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The article presents a method for improving the accuracy of bearing in multibeam sonar with a cylindrical array. Non-Linear shape of antenna, and thus uneven sampling of the signal in space, prevents the direct use of known methods of high resolution spectral analysis. In order to apply algorithm from this group it is first necessary to produce virtual linear antenna. The paper presents the technique of mapping a cylindrical array to the equivalent linear form. The simulation results presents the accuracy of bearing estimation in the presence of white noise. Furthermore the limitations of the method are discussed and practical aspects of the application in a real sonar system.

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Evaluation of Marine Coastline Monitoring Methods using SAR Satellite Data

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Coastline and coastal areas are not only the fundaments for local economics based on fisheries and agriculture, but also, a source of food and energy. Apart from offering diverse opportunities for recreation and tourism coastal zone areas provide protection against storms and other meteorological perturbations. Environmental information concerning marine areas is also a big importance because of direct influence on marine economy. Keeping coastal communities, economies and ecosystems healthy requires keeping track of sea and coastal areas – monitoring and assessing how these areas are changing. The paper presents method and a concept of the system that provides efficient means of automatic analysis of spatial data provided by satellite observation systems (Landsat 8 and Sentinel 1) in order to monitor and detect changes in coastline. The proposed methodology is based on a set of algorithms that enable to trace and detect changes in coastline shape and eventual damages to maritime infrastructure such as breakwaters,

peers, damns, etc., basing on satellite high resolution observational products. In the paper, the comparison of aforementioned observational products to official vector spatial database managed by maritime administration is also presented.

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Stationary Underwater Channel Experiment: Acoustic Measurements and Characteristics in the Bornholm Area for Model Validations

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The wide-sense stationary uncorrelated scattering (WSSUS) assumption is used for the statistical description of signal transmissions in the GSM passband systems, simplyfing the communication channel model. For underwater acoustic applications such as detection, navigation and communication, this approach provides only limited *a priori* knowledge for adaptive algorithms of digital transmission. FWG collect since 2001 phase-accurate channel measurements from different sea areas in different times and application scenarios with moving and stationary, submerged participants. The paper presents a SIMO experiment from 2010. During this trial two stationary ground nodes measured the transmission path in the Bornholm Basin of the Baltic Sea, with high precision decoupled the water surface in an eleven hours observation period. The stationary measurement has shown that even slightly move of the flow of water column causes the stationarity and non-correlation of the scattered signal components is not guaranteed. The effect is enhanced in the mobile underwater communications. A classification of local-sense stationarity and non-stationarity, and quasi-correlated regions of time-frequency characteristics of the communication channel model should be considered. Local-sense stationary uncorrelated scattering (LSSUS) approache is outlined and discussed in the second part.

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Generation and Measurement of Acoustic Streaming in Limited Space

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The aim of this work was to use the streaming related blood to assist clots dissolution in blood vessels. Such treatment is called sonothrombolysis. Acoustic streaming is a steady flow in a fluid driven by the absorption of the ultrasonic wave. It is a non-linear effect and it depends on ultrasound intensity and sound absorption in the media.

The source of ultrasound was the flat piezoceramic disc generating a continuous wave at 1 MHz frequency and 0.2 W/cm^2 I_{sata} acoustical intensity. The streaming was generated in the limited space inside the 10 mm diameter silicone tube positioned perpendicular to ultrasonic beam. The tube was filled with a mixture of water, glycerol, and starch with acoustic properties similar to blood. The streaming velocity was recorded either by the Siemens Acuson Antares ultrasonic scanner operating in the color Doppler mode at 10 MHz or by the custom built 20 MHz pulsed Doppler flowmeter.

The results obtained using both systems were very similar. At the depth of 7.5 mm below the anterior wall of the silicon tube the maximum streaming velocity was up to 20 mm/s. The results obtained confirm the developing of the streaming phenomena even very close to the source in the limited space. This effect will be explored in in-vitro experiments of blood clots dissolution within the tube simulating a blood vessel.

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Bioacoustic Range Equation

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Water medium, with a biological structure submerged in it, in a transmission system consisting of two ultrasonic transducers can be described as a bioacoustic link. The range of such a link is defined as the largest distance between the sending and receiving transducer that still allows ultrasonic signal to be transmitted. The range of the bioacoustic link depends on the parameters of ultrasonic transducers as well as the parameters of water and biological medium.

In order to describe and analyse the bioacoustic link the authors of this study used a modified range explicit equation formulated for hydroacoustic link. The equation makes it possible to design a bioacoustic link by assuming a given study range in a biological medium and estimating the required power ratio or power level drop (taking into consideration all factors that have the most significant effect on sound velocity and attenuation in the biological medium) and then selecting a value for the ratio by means of ultrasonic transducer parameters.

A biological medium submerged in water between a sending and a receiving ultrasonic transducer was studied in streamlined manner as quasi-homogeneous or more specifically in the form of multilayered tissue structure with parallel border surfaces. In the paper, sample calculations of the relation between power level drop and the length of the bioacoustic link in biological media and their phantoms for ultrasonic wave frequency in the range of 1–5 MHz were performed, using a modified range explicit equation formulated for hydroacoustic link. The calculations were verified in experiments.

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Marine Mammals Acoustics and Tools for Bioacoustic and Ecoacoustic Research

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In the last 20 years the development of bioacoustic research in the marine environment has been mostly driven by the scientists' concern about the impact of anthro-

pogenic noise on marine mammals and other marine creatures. Bioacoustics and ecoacoustics are emerging tools in biodiversity science and biodiversity conservation: from the recognition and monitoring of individual species through to soundscape analysis and description, they provide new insights and approaches for science, conservation, and education.

Ecoacoustics is a recently defined interdisciplinary science, derived from bioacoustics and ecology, that investigates natural and anthropogenic sounds and their relationship with the environment over a wide range of study scales, both spatial and temporal, at individual, community and population level. Ecoacoustics operates in all types of terrestrial and aquatic (freshwater and marine) ecosystems extending the scope of acoustics and bioacoustics and providing tools for the monitoring and the management of the environment.

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Near to Far Field Numerical Simulation of Fish Target Strength by the Method of Fundamental Solutions

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Target strength measurements of swimming fish from near field to far field conditions have been numerically simulated using the method of fundamental solutions (MFS). The application of the MFS has been validated comparing the results of the numerical prediction of the TS of a prolate spheroid with those obtained by different methods previously published. The MFS offers a lower computational effort than nested methods and provides the field evolution from the scatterer to the far field. This feature allows to determine the actual far field distance of the fish. The TS measurement of dorsal and ventral aspects of salmons in sea cages has been simulated with excellent agreement with published experiments.

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Adiabatic Sound Propagation in a Sea with Curved Underwater Canyon

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The problem of adiabatic sound propagation in a shallow sea featuring a curved underwater canyon is considered. The modal decomposition is used to approximate the solution of Helmholtz equation. Under the adiabaticity assumption the equations for the modal amplitudes are decoupled. For each modal amplitude the respective horizontal refraction equation can be solved using the separation of variables. The study is concluded with a numerical example illustrating the proposed solution.

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Classification of the Breast Lesions Using Combined BIRADS and Quantitative Ultrasound

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The aim of the study was finding the relationship between the results of the histopathological examination of the breast lesions and BIRADS classification combined with shape parameters of the K-homodyne statistics of ultrasonic echoes.

200 breast lesions were examined (69 malignant and 131 benign). The ultrasonic signals were acquired using 7.5 MHz linear array. Two types of data: traditional B-mode image and set of RF echo-lines were acquired for the breast regions where the tumors were localized. The analysis method was based on the combined data from BIRADS classification and statistical distribution of US echoes.

Influence of the attenuation on the US echoes was compensated prior to the further computations. For every sub-ROI region the mean value of echo envelope was calculated. Next, the values of the envelope inside of each square subregion were divided by the mean value of envelope, which was determined for this area. In the next step each lesion was divided into N sub-ROIs covering the lesion. The number of sub-ROIs depended on the size of the lesion. The shape parameters of the K-homodyne distribution were calculated for every sub-ROI.

When only B-mode imaging was used with the cut-off at BIRADS-3/4a, all malignant lesions were diagnosed correctly; however 53 benign lesions were sent for the biopsy, unnecessarily. Combined BIRADS classification and statistics showed 91.18% of sensitivity with specificity equal 93.13%, resulting in the decreasing of number of lesions which were biopsied from 53 to 9.

Combining of the quantitative ultrasound with the BIRADS classification seems to be encouraging. Analysis of the 200 breast lesions showed that use of the quantitative parameters together with BIRADS classification categories improved distinguishing the benign from malignant lesions, and allowed us to reduce the number of biopsies comparing to the procedure based on the B-mode images only.

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Acoustical Monitoring of Caged Bluefin Tuna Subjected to Ship and Offshore Wind Farm Operational Noises

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The behaviour of captured bluefin tuna (Thunnus thynnus) in sea floating cages was continously monitored during

six weeks with a synchronize system of IP video camera and a 200 kHz echosounder. The usual behaviour of the tuna showed variations between day and night in terms of average school depth and school density. The school anticipated the daily arrival of the feeding boat, changing its vertical distribution, before of the actual ship approach.

During a three days experiment the tuna were exposed to different acoustic stimuli (including off shore wind mail recordings) emitted by a broadband underwater low frequency projector. The animal showed an evident elusive reaction to long and high enough emission levels of windmill operational noise emissions, including school depth variations, change of swimming's direction and individual disorientation. Repetition of the stimuli revealed a high level of adaptability and a increasing delay in the reactions. A quantitative analysis of echograms revealed a posteriori more subtile reactions to short emissions of pure and synthetic noises.

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Organization Performing of Passive Linear Towed Array Sonar Consoles

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The operators experience, collected over several years after the passive towed array sonar upgrading, enabled the development of the concept of new forms of sonar imaging and optimization tasks performed by the sonar operators. This concept has been implemented and tested successfully during naval exercises. Optimization tasks consists generally on a clear separation of the main sonar operator – "Sonar Supervisor" and tracking operator – "Acoustic Detection Tracker". To facilitate the execution of their tasks, displays rearrangement and expansion of interaction between screens were performed. The article discusses in detail the above ventures and the achieved results.

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Studies of the Acoustic Noise Correlation Properties in Shallow-Water

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This article attempts to examine the correlation properties of acoustic noise occurring in shallow waters. Knowledge of these properties is very important from the designer point of view for passive and active hydroacoustic systems. In sonar systems, signal processing algorithms operate on both, useful acoustic signal and accompanying noise. Quantitative estimation of the correlation properties of acoustic noise enables accurate determination of detection conditions. This will verify the validity of simplified models commonly used in simulations of hydroacoustic systems. The article presents construction of the measurement system, processing algorithms, discusses and presents the results of research.

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Digital Microcontroller for Sonar Signals Generation

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The generation of sounding signals is essential for the operation of the active sonar. The system dedicated for this purpose must be characterized by high reliability. In order to obtain high reliability the system should have the appropriate architecture, the efficient communication with connected devices and properly constructed self-tested software. Presented in the article system is responsible for the generation of sounding signals and ensures proper interaction of power amplifiers and power supplies. The structure of the system allows very stable generating of complex sounding signals in form of the linear frequency modulated pulses LFM, hyperbolic frequency modulated pulses – HFM continuous transmission wave with increasing frequency – FMCW. Implementation of any other signals is also possible. Therefore it flexible enough that can be used in sonars for various purposes. The article describes the chosen technical solutions and sounding signals possible to use.

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The Development of Underwater Telephone for Digital Communication Purposes

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The underwater telephone HTL-10 has been designed to provide voice and telegraphy communication between helicopter and submarines using acoustic waves, as the main task. It works in half-duplex mode and uses analogue power-efficient modulation in the form of single sideband and suppressed carrier according to STANAG 1074, in a wide range of frequency. It makes a generation of the transmitted signal and analysis of the received signals only in digital technology. Although it was designed about a few years ago, the flexible structure of the underwater telephone ensures a convenient platform for the implementation of various types of communication as well as for the tests. This ability is due to the particular characteristics of the digital signal processing module, of which I am the author in both parts of hardware and software. In this module are the main elements: fixed point signal processor and an additional floating-point digital signal processor with high performance. This article presents the possibility of adapting it for the implementation of digital communication in the shallow waters with reliable and robust low data rate spread spectrum approach.

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On Measurements of Internal Wave Parameters in the Sea Using ADCP

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The main purpose of Acoustic Doppler Current Profiler (ADCP) is a measurement of three components of current

in the marine environment. However, the possibilities of this device are not limited by measurements of currents. In particular, we make extensive use of ADCP to study internal waves on the sea shelves. It allows us not only to observe internal waves, but also detect conditions leading to their generation. An important aspect is also possibility to measure the own parameters of internal wave: height, period, orbital currents, features of the wave profile and etc. Examples of measurement parameters of internal waves collected by us in different seas will be given. The new method will be shown how using the data recorded with four rays ADCP, passing above the internal wave once, it is possible to obtain estimates of it's phase velocity and direction of propagation.

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Autonomous Hydrophone Recorders with Internal Processing and Modem Communication for Long-Term Ambient Noise and Mammal Monitoring

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With the increasing need in getting the ambient noise trends, especially in European waters; instruments need to be deployed for long periods as well as gathering wide range of sounds in level and frequencies and gather key information. Then, being able to correlate it with the presence of marine mammal by detecting clicks and vocalization.

A common approach to extend acquisition periods is to use recording duty-cycle to sample for example ambient and device noise regularly on a fixed schedule. This approach however is less useful for capturing uncorrelated biological acoustic events for example echo-locating marine mammals in combination with analyzing long term noise trends.

This paper will present a dual approach combined in an autonomous logger. On the one hand the research developed consists is to embed in the same low-power electronics a continuous sampling in high digitization combined with ambient noise recording. Integrated processing with traveling buffer allows real-time processing of ambient noise while raw data is stored, extracting key indicators. In parallel the 500 kHz continuous sampling integrated various frequency/level detectors up to high frequencies mammals and storing both detection of mammal and raw data of the signal.

On the one hand, it will present the development of a Modem compatibility allowing the device will be able to store raw data and send to the modem selected key information. The user at surface can then come and interrogate the unit directly from the surface without having to retrieve the device.

The abstract will also open to new research areas with aim to combine acoustic data with external sensors such as vibration sensors and physicochemical parameters.

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Measurement of Hydroacoustic Channel Impulse Response in Real Conditions

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The article will describe the method of determining the hydroacoustic channel impulse response using signals modulated by pseudo-random sequence. Determination of the hydroacoustic channel impulse response using signal similar to the Dirac delta function is impossible in practice. Signals with high energy and very short duration cause cavitation and this makes the measurement unreliable. The solution is to use the signals modulated by pseudo-random sequence. In article will be presented configuration of measurement system which allows to measure impulse response of hydroacoustic channel. There will be also described used in measurements signal. Authors conduct researches in laboratory conditions as well as in real conditions. The measurement companion in real conditions have been conducted at Kosobudno lake in October last year. The results of measurement will be presented in the paper and briefly discussed.

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Modeling of Hydroacoustic Channel using Measurements of Impulse Response

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This article presents a method of modeling the hydroacoustic channel basis on measurements of the impulse response determined in laboratory conditions. Determination of the channel impulse response and to have such a channel model can be useful to dynamically determine the propagation conditions and the construction of adaptive broadband communication systems in the aquatic environment. The article will briefly describe a method of measuring the hydroacoustic channel impulse response using signals modulated by pseudo-random sequence. Based on this method, the authors undertook researches on determining the impulse response of the water in the laboratory conditions and also performs experiments on inland waters (campaign of measurements on the lake Kosobudno in October last year). There will be presented the results and discussion of results of simulation researches on modeling the hydroacoustic channel basis on the results obtained in the laboratory conditions.

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Underwater Noise Emitted During Microscale Wave Breaking Events

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The wind speed ambient noise intensity relationships are relatively well recognised. It is established that gener-

ally, linear relation between logarithm of wind speed and ambient noise level exists. However, above mentioned dependency is clearly noticeable above the sea state 3B when bubbles, the main source of the ambient sea noise are generated due to the wave breaking. The noise generated by micro breakers during the low wind condition receive much less attention from observers of the ocean surface than plunging counterparts. Though, microscale wave breaking occurs frequently at the sea and are probably important contributors to turbulence, spray, and creation of bubble at the air-water boundary.

The paper presents results of experiments aimed at investigations of emission of underwater noise by micro- and low intensity breakers. Model experiments were performed in small tanks altering the potential energy of water involved in simulation of breaking events. The analysis include research of the underwater noise spectra under different properties of breakers and different parameters of water environment as surface tension or presence of gas bubbles.

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Noise Source Tracking using Autonomous Hydrophones Array System

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The main goal of this paper is to present solution of realization underwater, autonomous, passive system to detect and track objects moving on the surface on the water. There will be presented spacing method of hydrophones array and mechanical denouement of mobile, compact system. Analog signals from hydrophones are analyzed on the processor in module. There are two methods of determination of the angle of incidence of noise: correlation method (hyperbolic navigation) based on calculation delays between signals, and beamforming method based on received signals delays and sum to determine from which direction noise is coming. This two algorithms will be compared based on sea trials measurements done on Bay of Puck with two targets: small rubber boat with 5hp engine, RIB with 100hp engine and sailing yacht as measuring station. Synchronization of tracking system clock time with GPS time made possible comparing time series with object position and determination maximum ranges and accuracy of bearings what will be presented in the article.

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Ship Traffic Noise Distribution in the Polish Baltic Waters – Results of BIAS EU Project

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The level of anthropogenic activities in the ocean is rapidly increasing since the end of the World War II. This process is especially observed in the Baltic Sea, where the growing economy of Baltic countries have resulted in a significant increase in vessel traffic which is the basic source of chronic underwater noise of anthropogenic origin. Noise can dramatically disturb behaviour and life processes of marine mammals and fish and in some cases can lead to their death.

In order to reduce and control the underwater noise, the European Commission has recommended the monitoring of underwater noise at regional scales under the Marine Strategy Framework Directive. In the EU Life+ project "Baltic Sea Information on the Acoustic Soundscape – BIAS", six Baltic countries collaborated to deploy a total of 38 acoustic sensors throughout the Baltic Sea to measure the underwater noise levels during the whole year of 2014.

In the Polish area, 5 hydroacoustic buoys were submerged at depths ranging from 12 m to 85 m, which continuously measured the ambient noise at the sampling frequencies of 24 kHz and 96 kHz. Registered signals were filtered by one-third octave 63 Hz and 125 Hz bandpass filters for ship noise detection as required by the EU. For two deployment locations were measured also wind speed and its direction.

Moreover the information on ship traffic from AIS (Automated Identification System) and VMS (Vessel Monitoring System) systems were taken into account, which enabled the mapping of the statistical noise including shipping noise and noise generated by surface waves.

The paper presents monthly statistics and sound pressure level maps of ambient noise for the Polish part of Baltic sea together with wind speed and direction analysis.

This work has been conducted under EC LIFE+ project No. LIFE11 ENV/SE/000841 and Polish National Fund for Environmental Protection and Water Management (NFEP&WM).

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NAWIGATOR XXI Vessel Vibration and Underwater Noise Emission in Shallow Water

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Ship Design and Research Center

NAWIGATOR XXI is a research and training vessel owned by the Maritime University of Szczecin. This vessel was used as a reference ship for performing underwater noise measurements within EU FP7 AQUO (Achieve QUieter Oceans by shipping noise footprint reduction) Project. European Project AQUO is focused on finding solutions to mitigate underwater noise related to maritime transport, in order to achieve a good environmental status consistent with the objectives of the European Marine Strategy Framework Directive.

In this article measurements and measurement results of vibration related to the emitted underwater noise are presented – measurements were performed by Ship Design and Research Centre (CTO S.A).

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Acoustic Diagnostics of the Axial Pump with Magnetically Suspended and Driven Impeller

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The paper presents the results of the experimental investigation of the miniature axial pump conducted in the reverberation chamber. The principal aim of the experiment was to confirm the hypothesis that the rotor of the pump does not touch the pump duct during its operation.

The pump has been designed in Centrum Techniki Okrętowej in Gdańsk as the third generation of an implantable left ventricle assist device (LVAD) within a Polish Artificial Heart National Research Program.

Such a device characterizes with a magnetic suspension of the rotor and the application of brushless motor to generate the rotation and blood flow. The 3rd generation LVAD is less harmful for blood cells as well as less cloth susceptible however the elimination of mechanical bearings introduces the risk of the pump malfunction especially in off-design conditions. One of the unwanted effects may be the rotor precession leading to the contact between the rotor and the duct and causing substantial increase of hemolysis.

As the visual access to the pump is restricted the acoustic method seems to the most suitable and reliable method to evaluate the pump operation. The recorded and analyzed acoustic signals allowed to distinguish between two states of the pump operation: contactless rotation and contact during the rotation. The conducted research proved the expected efficiency of the rotor magnetic suspension and its usability in the LVAD application.

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A Spectral-Based Method for Tissue Characterization

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The quantitative ultrasound techniques are now widely investigated as a promising method for tissue characterization, especially in cancer detection. We propose a novel, spectral-based technique that uses the Hilbert-Huang transform (HHT) and time series analysis. We have adopted a basic idea of the HHT, originally designed to analyze nonlinear and nonstationary signals, to examine the properties of the spectra of the ultrasonic echoes backscattered in tissue. It is a well-known fact, that the backscattered echo spectra carry the information about scattering properties within the investigated tissue. They are used, for instance, to determine tissue/lesion backscatter coefficient related to local tissue structure. While the spectrum of the ultrasonic pulse reflected from a single scatterer is similar to the spectrum of the transmitted pulse, the signal resulting from the reflection on the cluster of scatterers is much more complex; the spectrum becomes less smooth exhibiting strong variability reflecting local, specific scattering conditions in the tissue. The HHT was applied to decompose the backscattered echo magnitude spectra into so-called intrinsic mode functions (IMF). Each IMF is then analyzed as a time series to assess tissue dependent features. The initial feasibility studies have shown that even such features like the zero-crossing rate of the spectrum is able to improve distinguishing one tissue from another. We believe that our novel approach can be used as a meaningful method of scattering analysis.

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