
Dissertations

Acoustical classification of bottom sediments

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Post-doctoral thesis in earth sciences.

The post-doctoral thesis ‘Acoustical classification of bottom sediments’ was written by Dr Jarosław Tęgowski of the Institute of Oceanology, Polish Academy of Sciences, Sopot (<http://www.iopan.gda.pl>), and published as volume 19 in the ‘Dissertations and monographs’ series by IO PAS Publishers, Sopot, in 2006.

The thesis discusses the applications of acoustical techniques for characterising and classifying seabed sediments. The problems it addresses are currently among the main topics of interest in the ocean sciences, particularly to scientists studying the functioning of marine ecosystems in the face of anthropogenic threats and ever more perceptible climatic changes. 219 pages long, the thesis is richly illustrated, with many of the figures in colour. There are some 290 literature references, mostly to English-language journals.

The author takes as his theme the entire range of problems involved in describing the acoustical phenomena arising from the reflection of sound from the seabed. Besides a theoretical introduction to these problems, he presents acoustical experiments that he has carried out in conjunction with scientists from other countries. He examines the theoretical aspects of these problems in an interesting way, basing his discussion on his own materials, which are an excellent example of how assumed measurement principles should be tested in practice. The major experiments that the author undertook include the measurement of sound scattering from the phytobenthos in Puck Bay (Gulf of Gdańsk) and the wide-ranging programme to measure the properties of echoes from the bed of the North Sea. The latter region has practically become the chief area to which

The complete text of the paper is available at <http://www.iopan.gda.pl/oceanologia/>

international teams of scientists come to test a variety of measurement and classification techniques. The interpretation of results was based on the classical means of sampling of bottom sediments with mechanical dredgers.

The thesis consists of ten chapters and numerous subchapters. Theory and practice are not kept separate: rather, they have been intertwined in such a way as to make the problems under discussion readily comprehensible.

In Chapter 1 the author introduces the reader to the acoustical study of the seabed and outlines the importance of the seabed for the functioning of marine ecosystems. He places his theme in the context of world research in this field, and he makes clear the extent of his own personal contribution to the theoretical and experimental questions under scrutiny.

Chapter 2 is a general discussion of the problems surrounding the scattering of sound from the seabed: it is a neat synthesis of the theoretical descriptions relating to this question. Interesting, too, is the subchapter on the author's attempts to simulate the shapes of the envelope of an acoustical pulse scattered at the bottom.

Chapter 3 describes how the real conditions under which acoustical measurements are carried out from on board ship can affect the final results. Means are suggested of improving the reliability of these results.

Chapter 4 discusses the equalisation of the time-dependent echo envelope parameters corresponding to the path of the pulse to the seabed. This dependence on time has long been the subject of analyses, and there are many and varied ways of equalising measurements.

Chapter 5 deals with the effect of gas bubbles contained in bottom sediments on the final picture of the acoustical echo from the seabed. On the basis of studies of the vegetation zones in Puck Bay, carried out in cooperation with colleagues from IO PAS, the author has been able to explain the part played by the benthos in distorting the acoustical characteristics of the seabed.

Chapter 6 systematises the acoustical methods applied hitherto for classifying bottom sediments. The methods are described in a very understandable way, and their merits and faults are examined.

In Chapter 7 the author presents the main range of his experimental work, which entailed the development and testing of his own approach to the use of acoustical measurements for classifying bottom sediments in a selected area of the North Sea. His starting point is the result of an experiment carried out in the year 2000 by the Dutch TNO Defence, Security and Safety Institute at The Hague. The idea of that experiment was to perform acoustical measurements with single-beam probes (frequencies: 66 and 150 Hz) from two research vessels in a 10×10 nmi area of the sea

along 10 parallel transects 1 nmi distant from each other; additionally, 50 geological samples were taken from this route, which were subsequently subjected to granulometric analysis at the TNO Institute. With the aid of the taxometric triangle, this analysis revealed 15 different sediments based on the percentage relations between the main fractions of the sediments; on a grain diameter basis, they were divided into four classes corresponding to the four types of sediment – gravel, sand, mud and silt. From these data maps of the study area were drawn to illustrate the spatial granulometric distribution of grain diameters with 10, 50 and 90% contents in the mass of smaller-diameter sediment, the dominance index of a given fraction, and the distribution of the mean grain diameter showing the percentage content of the gravel fraction and of shells.

In Chapter 8 the author continues his discussion of the problem from the previous chapter by carrying out a parametric analysis of the echo for the experiment in question. He distinguished 83 characteristic magnitudes representing various aspects of the signal envelope (energetic, statistical, spectral, continuous wavelet transform, fractal for the envelope shape), which he then applied as parameters in the detailed computations.

Chapter 9 examines the application of cluster analysis and neural network analysis to the classification of the seabed on the basis of the measurements made during the same experiment. The results of the classification are listed and the various ways of interpreting the measurements are assessed.

Chapter 10 summarises the author's studies regarding the acoustical classification of the seabed. His principal achievements are:

- to have written a well-ordered monograph on the physical and mensuration phenomena associated with the measurement of echo signals from the seabed;
- to have described and compared the most important methods in the acoustical classification of the seabed, taking into account the contribution of Polish scientists in this field;
- to have analysed in meticulous detail the results of acoustical measurements from the North Seabed – this part of the work (Chapters 7, 8 and 9) provides the most compelling evidence for the author's innovative approach to his research;
- to have produced an extremely useful teaching aid.

This work is a valuable contribution to the field of the application of acoustical techniques for studying the seabed and is a worthy continuation of the research carried out in this field by Polish scientists since the 1970s.

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