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METHOD OF DIGITAL PRESENTATION OF THE RELIEF AND DYNAMICS OF THE SEA BED IN THE LITTORAL ZONE

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Abstract:

The authors submit their proposal for a new method of presenting the relief of the sea bed in the littoral zone and its changes, consisting in the substituting of isobaths by digital symbols containing data on the mean depths of elementary fields. Basing on the photommetric method, where the measurement of optical density on a photograph is used to define depth, the construction of the microphotometer was improved, thus enabling direct input to a computer, which, in turn, enables the printing of a digital bathymetric chart. This affords automation of photointerpretation, calculation and cartographic work related to the area investigated.

Introduction

Deteiled investigation of the sea bed morphology, together with data as to its variability and sediment dynamics, are extremely important in all research conducted for both practical purposes and to determine the general regularities of processes and the laws ruling the dynamics of the littoral zone.

The present-day rate of collecting data on objects investigated in the zone in question, in the form of recorder graphs, read-outs etc., requires labour-consuming processing, in which man is increasingly frequently substituted by computers. Apart from the elaboration of programs, however, this necessitates the preparation of data in digital form on punched or magnetic tapes. Thus increasing numbers of measuring instruments have attachments giving the values measured in this form. The arduous task of reading-out, recording and then coding of data is then avoided.

In view of the high variability of bottom relief in the littoral zone, the rapid processing of data available and frequent repetition of measurements is imperative. To do so using the classical methods would be extremely difficult, in view of the labour-consumption and slender possibility of automating the work.

The methods of presenting the bottom relief and its changes hitherto, consisted in the drawing up of bathymetric charts and bottom deformation plans / 1 /. These charts are drawn by means of isobaths based on profiles determined by echo sounding or photometric analysis of air photos / 3, 4 /.

The authors give a sample of the new method of presenting the bottom relief. This consists in the substitution of traditionally applied isobaths as information on surroundings, by information on an elementary field, contained in a digital symbol.

The Preparation of Isoline Bathymetric Charts

In bathymetric charts hitherto, the position of isobaths has been interpolated between points with known depths, assuming linear variability of the bottom surface between these points. Data about the bottom relief could be obtained by analyzing the outline of individual isobaths. The basic information about a region investigated, serving for further analysis, was the bathymetric chart and profiles from which it was drawn up. These profiles were drawn at certain intervals between which the course of the isobath - owing to a lack of data as to the true bottom shape - contained inaccuracies and errors, the greater, the breater the diatance between the profiles.

A much more accurate chart can be made by photometric analysis of air photos.

The photometric method of determining depth in the littoral zone consists in utilizing the dependences of optical densities in air photos on the water depth.[1]

Light beams represented by components of the sea's vertical radiations L_m and L^x originating from back scattering of light in the atmospheric layer / Fig. 1 /, reach an air camera fitted in a plane flying over the area investigated. The dependence between the radiation recorded by the air photo and the depth is:

$$L_f = L' \mp L'' e^{-ph} \qquad /1/$$

where: L', L'', p = parameters characterising the optical properties of the water basin, atmosphere and air camera;

h = depth of water.

After taking into account the dependence between the radiation recorded on the air photo film and the optical density of the photo which it is possible to measure by microphotometer, the depth of the basin is determined from the dependence:

$$h = -\frac{1}{p} \ln \frac{1}{L''} / n\log \frac{D_i}{\gamma} - L' / \qquad /2/$$

whers: D_i = optical density measured in the photograph

γ = air film contrast coefficient

To determine the parameters: L', L'', p, of equations /1/ and / 2 / the depth must be known in at least three points in the basin 2.

The photographs are analyzed by microphotometer along specified straight lines which are profiles. The profiles obtained in the shape of microphotograms are transformed into digital form by readout and then undergo mathematical processing to obtain the depth.

The interval between profiles can be decreased at will, thus defining the course of the isobaths, the situation of which is obtained from the profile analyses. By interpolation between the isobaths, assuming the linearity of changes, we obtain the information as to the depths of bettom elements. This is, in practice, the most accurate of the methods of drawing up bathymetric charts of littoral zones known hitherto.

The Concept of Drawing up a Digital Bathymetric Chart

On the example of charting the littoral zone sea bed from air photographs, the authors attempted a new method of presenting the bottom sculpture using digits and symbols. The assumption of the method is to collect data from elementary fields, instead of the measurements of depths in profiles used hitherto. As the mean depth for a given elementary field, the data so obtained are presented as symbols or digits.

In the analysis of the graphic image, depth is not defined by interpolation between measured points, but uses the notion of mean depth of an elementary field. The defining of such a mean is possible by measuring the mean optical density of a section of an air photo, restricted by the measurements of the microphotometer aperture. The elementary fields discussed, cover the whole area investigated with a grid of rectangles orsquares.

To automate the process, the authors constructed their own attachment to a Carl Zeiss Jena G III microphotometer, which enabled them to record the optical density values for all elementary fields of the chosen area of the photograph automatically. As these values are recorded direct onto perforated tape, they can be fed directly to the computer for automatic calculation of the depth of each elementary field according to the appropriate program. Instead of depths at specific points of the profile, the results are the mean depths of elementary fields.

The measurements of elementary fields in the shape of rectangles or squares, depend upon the measurement of the microphotometer aperture, enlargement of optical system, as well as the scale of photographs and these can be changed depending upon the requirements. The aperture measurements must be so chosen as to ensure they are proportional to the measurement of the computer lineprinter keys / a x b / / Fig. 2 /.

Each elementary field mean depth calculated is given a onebit digit or symbol according to the depth scale assumed, after which the digits and symbole are printed to form a digital /lineprinter/ bathymetric chart / Fig. 3 /.

The area occupied by particular one-bit symbols corresponds in scale to the measurements of the microphotometer apperture, thus the chart printed is cartometric. A corresponding choice of scale of digits and symbols means that the chart is immediately legible and thus, from certain points of view more communicative than an isoline chart. Altgough it is cartometric, there is no need to carry out any measurements on it, as a collection of mean depths of individual elementary fields on which these can be carried out much more accurately and automatically by computer, serve this purpose.

If we draw up a second chart homologous to the first, but presenting a different bottom relief, the corresponding elementary fields will be able to be compared directly. In this manner two collections of numbers characterizing the area investigated will be obtained. Creating differences for each pair of fields, we obtain data as to the values of erosion or accumulation in the shape of differences in depths from which the value can be calculated without any difficulty. After the introduction of certain intervals in value, changes in depth or volume can be ascribed relevant symbols and charted analogically to the digital bathymetric charts. We thus obtain digital charts of depth or volume differences. Fig. 4 gives a specimen bottom deformation chart / depth changes /, with change intervals.

In view of the accuracy of determining depth by photometric method / about 10 % of the depth / and the range of its application / to about 5 metres / being restricted by the transparency of the Baltic waters, the symbols given in the legend to Figs 3 and 4 have been accepted as the depth scale. These charts contain no less data on the bottom configuration than the bathymetric charts applied hitherto. An additional advantage is avoidance of errore and immediate legibility. The chart symbols have been so chosen that the value of the digits correspond to the depth in metres, and to improve the sculpture image, intermediate symbols have been introduced. The cartometric character of these charts is the same as the traditional bathymetric charts.

Conclusions

An important advantage of the proposed digital method of presenting the littoral zone bottom relief, is the possibility of ascribing the number of the mean depth with suitable accuracy to each elementary field. The recording of all depths on perforated tape means that the data on the area investigated is easily available.

Assuming the constancy of measurements and position of the elementary fields, it will be possible to compare the digital bathymetric charts drawn up automatically at given time intervals. It is not the graphic images which are compared, but more accurate data collections about the area investigated logged on perforated tape. This improves the accuracy and rate of analysis of changes in the bottom sculpture, and enables automatic printouts of bottom deformation charts.

The following conclusions can be formulated at the present stage of research on the method presented, conducted by the authors from Gdańsk University:

1/ The method enables more extensive utilization of data contained in air photos.

2/ It enables automatization of photointerpretation, calculation and cartographic work related to the area investigated.

3/ Apart from its cartographic character and legibility, as compared with the isoline chart, the digital chart contains more information about the area investigated, stored on perforated tapes.

4/ This method enables rapid processing of information by computer.

5/ The application of the notion of elementary field and its mean depth, enables the automatization of calculations related to the area and comparative analysis of changes.

N o t e s

[1] The bases for the photometric method in this paper were taken from papers / 3, 4 /.

[2] Applying the multispectral photography method, it is possibls to determine parameters without knowing the depths at the control points.

R e f e r e n c e s

1. Furmańczyk K., Musielak S., Metody przedstawiania dynamiki dna morskiej strefy brzegowej z wykorzystaniem zdjęć lotniczych. / Methods of presenting sea-bed variations in the shore zone using serial photographs /. "Fotointerpretacja w Geografii" Vol. 9, Gdańsk 1975.

2. Furmańczyk K., Musielak S., Próba cyfrowego przedstawiania rzeźby i dynamiki dna morskiej strefy brzegowej / Attempt of digital presentation of the bottom configuration and dynamics in the littoral regions /. "Archiwum Hydrotechniki" Vol. 22, no 3 - 4, Warszawa.

3. Primenenie aerometodov dlja issledovanija morja / Using aero-methods in studies of the sea /. Moskva 1963.

4. Woźniak B., Furmańczyk K., Wensierski W., Optyczne aspekty fotometrycznej metody określania głębokości morza w strefie brzegowej., cz. 1. Fizyczne podstawy kształtowania się oddolnego strumienia światła naturalnego nad płytkim akwenem morskim / Optical aspects of the photometric method of determining depth in the littoral zone. Part 1. The physical bases for the shaping of an upwelling light flow over a shallow sea basin /. "Zeszyty Naukowe Uniwersytetu Gdańskiego, Geografia" Vol. 5, 1976 / in print /.

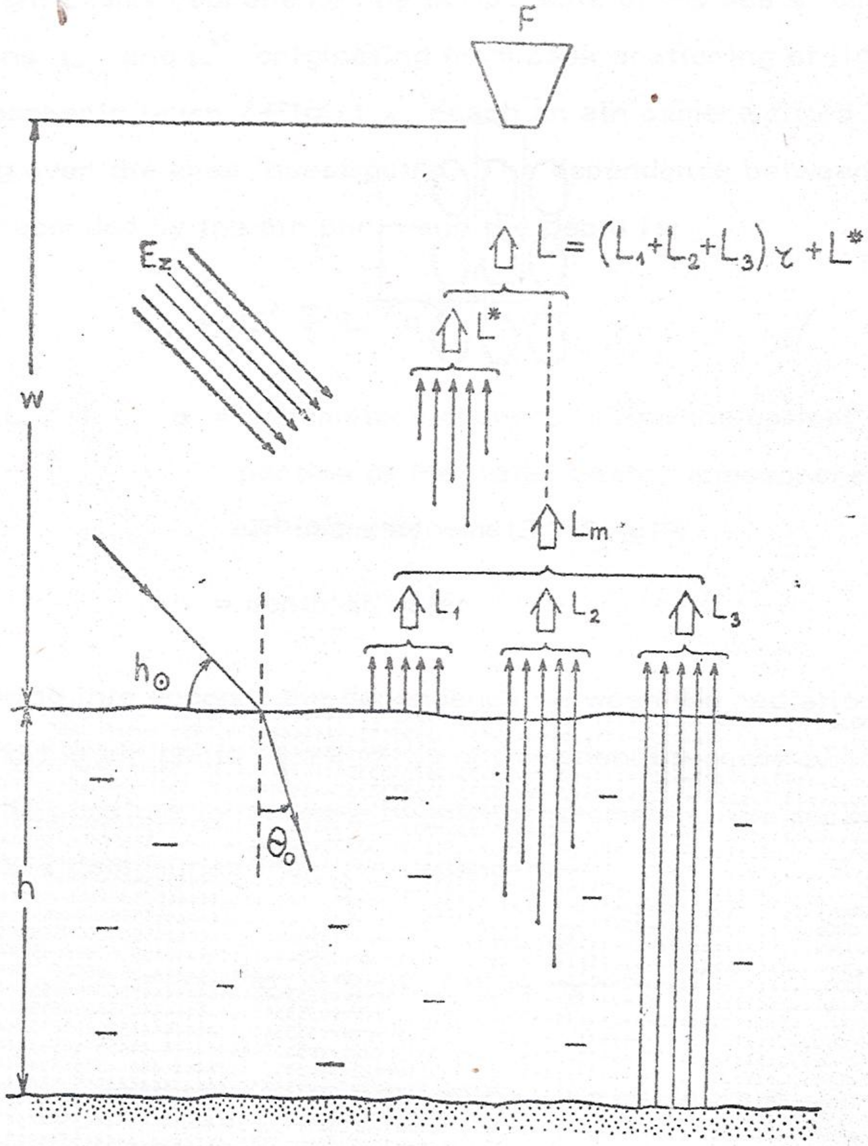


Fig. 1. Diagram of the forming of an upwelling stream of radiation over a shallow sea basin.

F = aerial camera

Ez - external irradiance

Lm - sea radiation:

L_1 = component formed as the result of light reflected from the water surface

L_2 = component formed as the result of back-scattering of light in the water layer between the sea surface and bottom

L_3 = component representing light reflected from the bottom of the basin

L^x = vertical radiation as the result of back-scattering of light in the atmospheric layer

w = flight altitude

h = depth of basin

= coefficient of sea radia..on transmission in the atmospheric layer

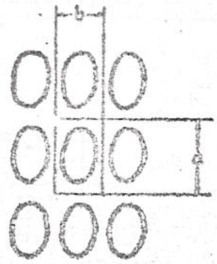
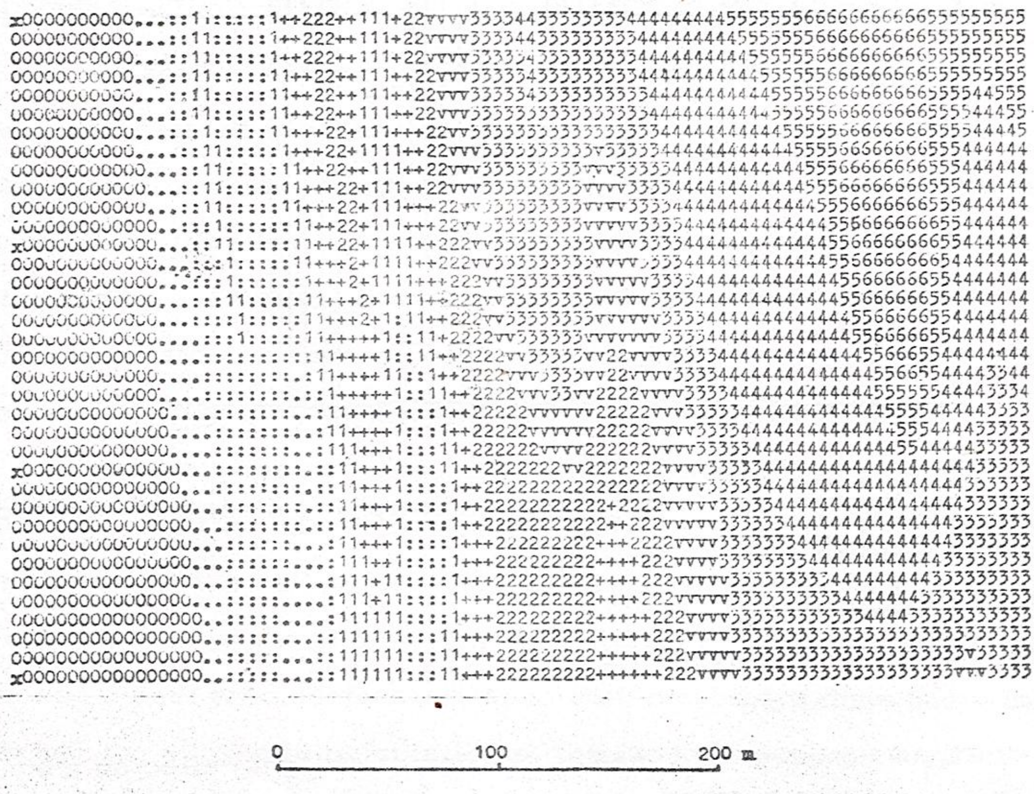


Fig. 2. Elementary fields.

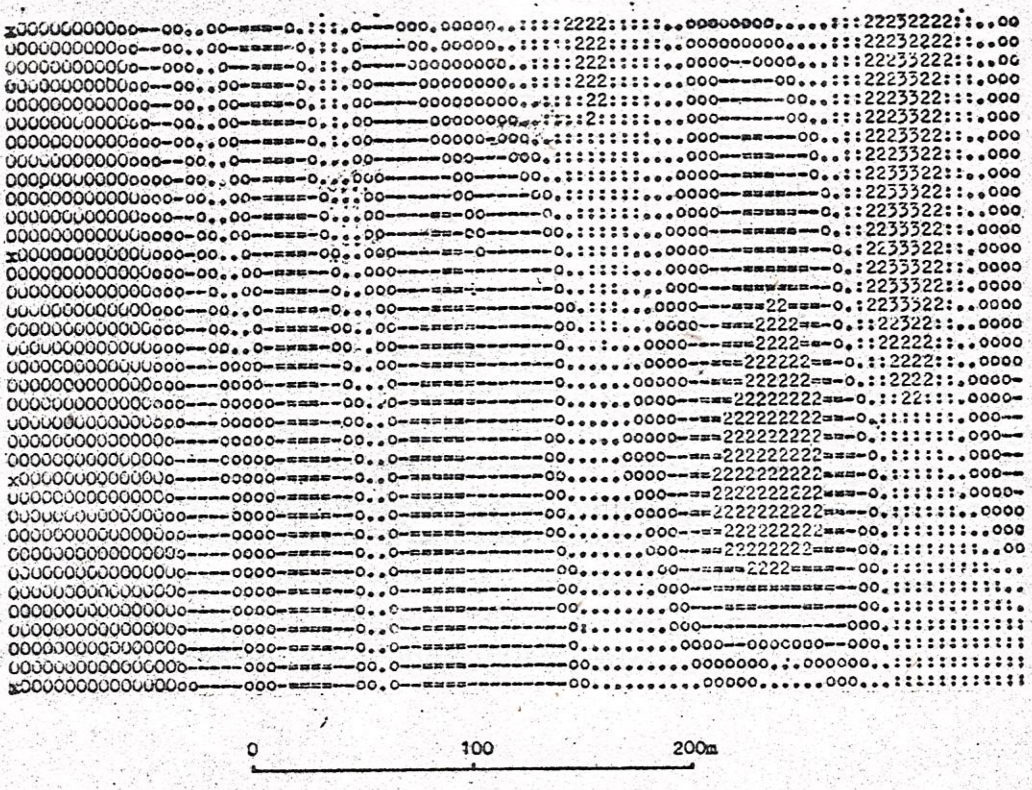


x	punkty osnowy	2	1,75 - 2,25m
0	plaża	v	2,25 - 2,75m
.	0,0 - 0,30m	3	2,75 - 3,50m
:	0,30 - 0,75m	4	3,50 - 4,50m
1	0,75 - 1,25m	5	4,50 - 5,50m
+	1,25 - 1,75m	6	5,50 - 6,50m

Fig. 3. Digital bathymetric chart

x = point of the geodesic grid

0 = beach.



x - punkty osnowy   0 - plaża

akumulacja		abrazja	
o	0,00 - 0,25m	o	0,00 - 0,25m
.	0,25 - 0,75m	-	0,25 - 0,75m
:	0,75 - 1,50m	=	0,75 - 1,50m
2	1,50 - 2,50m	2	1,50 - 2,50m
3	2,50 - 3,50m	3	2,50 - 3,50m

Fig. 4. Digital chart of depth changes in the basin / accumulation and erosion /.