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THE RELIEF OF THE OFFSHORE SEA BOTTOM AT KARWIA–CHAŁUPY, POLISH BALTIC COAST

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Abstract. Morphology of sea bottom of the Władysławowo area, from Karwia to Chałupy, has been studied based on the detailed digital bathymetric map prepared in a scale of 1:25 000 with isobaths every 0.25 m. A significant differentiation of the bottom relief has been observed, with the level changes up to 1–3 metres, mostly connected with the occurrence of specific systems of ridges and runnels. They are probably partly relict forms (fluvial and/or coastal?), changed to certain degree during the rapid stage of the Litorina transgression, and in partly forms created by the recent waves. Several types of the sea bottom surface, differing in pattern of morphological forms, have been recognised within inshore, near shore, and open sea (above 16 m depths) areas. The full knowledge of the origin and development of these relief forms requires further specialised research, currently carried out. Nonetheless, the already obtained picture of the sea bottom relief indicates an intensified abrasion of the offshore sea bottom, and an intensive, irreversible sweeping out of the sediments from the shore to the open sea, most probably by rip currents, at a distance up to several kilometres from the shore. It is in accordance with the results of a former large-scale (1:500) study of the sea bottom at the test field at Chłapowo, performed with the use of an integrated system of non-invasive and direct methods.

Key words: sea bottom relief, offshore, hydroacoustic methods, Polish Baltic Coast.

INTRODUCTION

This work is based on the detailed bathymetric map in the scale of 1: 25 000 of the sea bottom area from Karwia to Chałupy, with isobaths drawn every 20 metres (Fig. 1). The map has been constructed in GIS system to form the database for integrated management of the shore zone, as an introductory project carried out in the Władysławowo area (Gajewski, Stachowiak, 2000). A significant density of sample lines together with precise positioning (better than 1 m for horizontal co-ordinates and better than 10 cm for the depth) allowed to construct a map with isobaths drawn every 0.25 m. This is the first so detailed bathymetric map of a considerable sea bottom area of the Polish part of the Baltic Sea. The obtained image of the sea bottom relief is much more diversified than it has been presumed, though with relatively small changes of level (mostly 1–3 metres). The full recognition of the sea bottom relief character requires further, specialised research. It was observed through very detailed (1: 500 scale) examination of the sea bottom, carried out on the test field in Chłapowo (Rudowski, Gajewski, 1998) that there exists even greater local diversity of the relief. This fact enriches the actual knowledge of the near shore sea floor structure, and of the hydrodynamic processes taking place in the shallow-water sea zone. The presented analysis of the sea bottom relief does not fully explain its character. Nonetheless, it constitutes a necessary basis for further research, indicating places and tasks that need to be attended to first, as well as pointing out the type and manner of the research. This paper is a result of the entire team of the Department of Operational Oceanography co-operation. The authors wish to express their gratitude to all the co-workers.

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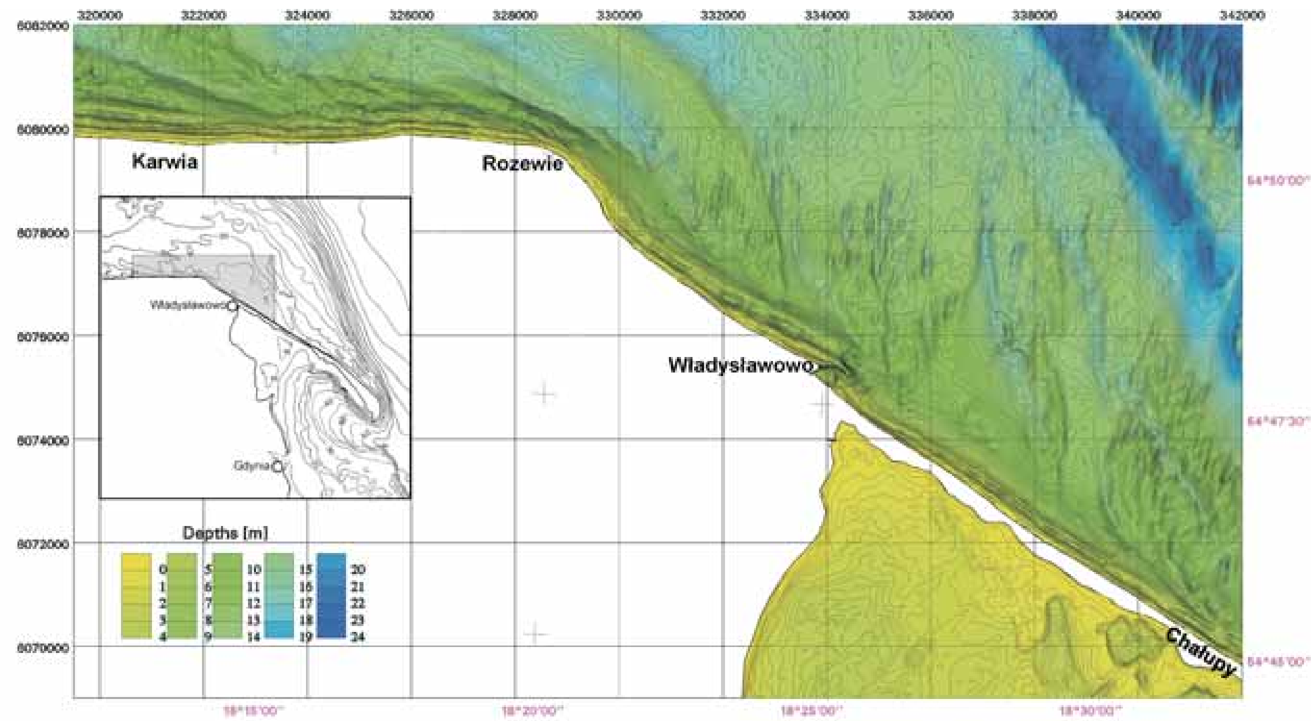

Fig. 1. Bathymetric digital map of the sea bottom at the Władysławowo region (scale 1:25,000) with isobaths every 0.25 m. Location of the study area is presented on the inset batimetrical map "Sea Bottom Relief", Plate I (Mojski, 1995)

METHODS AND MATERIALS

In spring and summer of 1999, the profiles were taken from the shipboard of „Dr Lubecki" every 100 m in W–E direction (azimuth 90°). The echosounder DESO 15 was used, with the DGPS positioning system adjusted to the antenna of the ship and to the navigation system HYDRO. The collected data were digitally processed in the HYDRO system. The measurement accuracy of a given point position on the sea bottom was higher than 1 m, and the accuracy of the depth measurement was higher than 0.1 m. A map in 1:25 000 scale was constructed in GIS technology using the ESRI ArcInfo system. Projection system based on WGS 84 ellipsoid in so-called '92 Transverse Mercator' was used, with the axis meridian 19°. A part of the sea bottom of about 1 km^2 of the test field, between Rozewie and Władysławowo, has been recognised and examined in detail at the scale of 1:500 by Rudowski and Gajewski (1998). A modern system of non-invasive methods was used there. This included a detailed registration of the sea bottom with multibeam echosounder (model SeaBat), a side-scan sonar, and images from an underwater TV camera.

Results of the core and bore samples analyses were used for the identification of the different types of sea bottom. The subbottom profiler was used to

define the subbottom structure. Finally, aerial photographs taken in 1996 were used to examine the relief of the shallowest part of the sea bottom.

RESULTS

High resolution and precision of the constructed map enables good recognition of diversity of the sea bottom morphology, generally slightly sloped seawards (at the angle of below 1°). There are systems of extended elevations (ridges) and depressions (runnels) with small level changes, usually 1–3 metres. Relatively homogeneous, even, and flat bottom exists only at the depth greater than 14–15 meters. There are several distinctly different areas on the image of the sea bottom relief (Fig. 2): inshore (up to 6–8 m b. s. l.), nearshore (up to 14–16 m b. s. l.), and the open sea (more than 16 m b. s. l.).

The final recognition of the sea bottom forms, their origin and development requires further research. Partly, they may be relict forms (fluvial and coastal) and/or partly they may be forms created by current waving related processes.

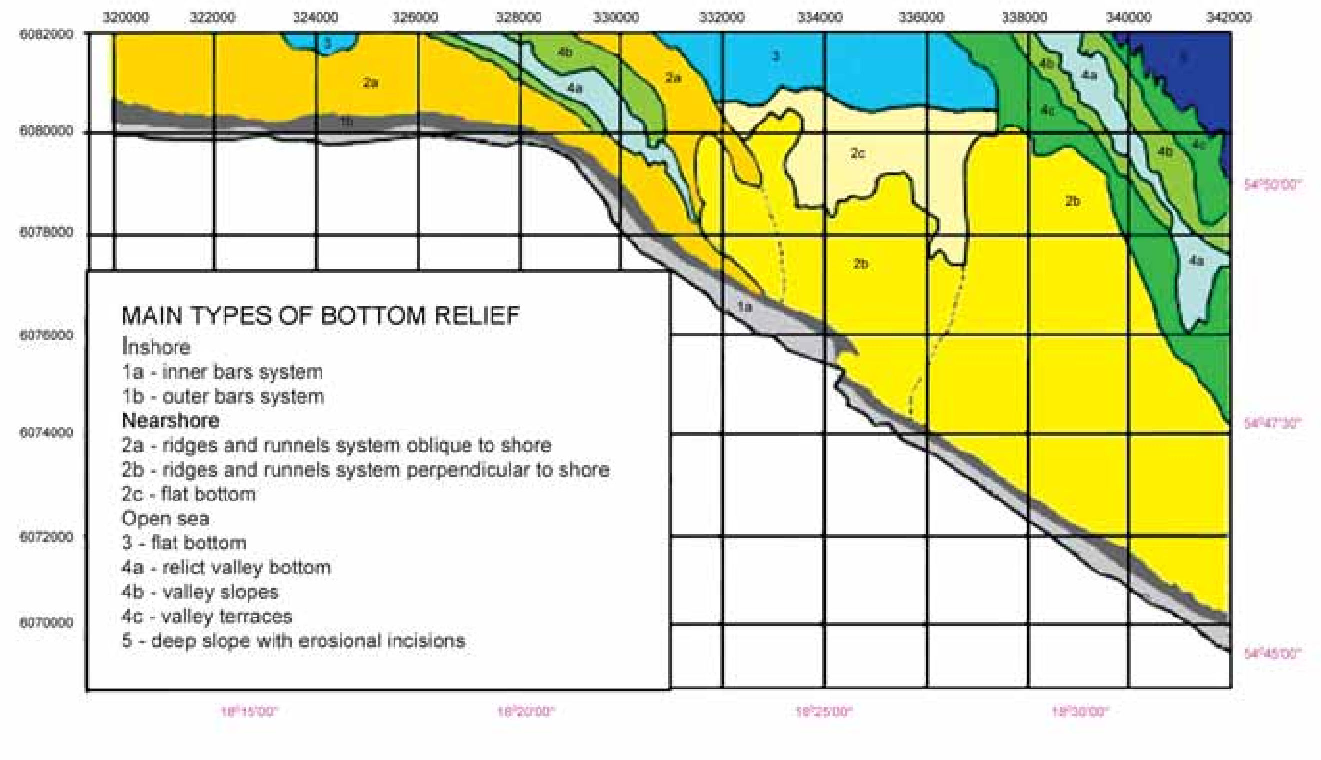

Fig. 2. Main types of sea bottom relief

Several types of the sea bottom areas were determined, based on differences in the relief form character (Fig. 2).

The inner and outer bars systems were identified within **inshore** (*sensu* Rudowski, 1986) areas. **The inner bars system** consists of two ridges separated by runnels with their level changes up to 2 m. It runs along the coast to the depth of about 4–5 m. The bars are usually parallel to the shore, but there are also systems of bars oblique to the shore. The bars ridges level changes slightly along the length of the ridges (undulations). There occur gentle depressions and elevations with the altitude variations up to 0.5 m, with gaps in the ridges extension, and even with a seasonal disappearance of bars in some places (e.g. by the Rozewie promontory).

Under conditions of weak waving, especially in the final phase of storm, there might appear three bars, the one of which located in the shallowest area is an ephemeral form with a very diversified shape and position, often connected with the shore. This part of the sea bottom is the most dynamic zone of the offshore area, and the forms existing here undergo fast transformations with every change in the waving.

The inner system of bars is usually 250–300 m wide. Only in the area west of the Władysławowo harbour, the bar system is about 500 m wide which is caused by the anthropogenic accumulation of the sediment (breakwater). By the Rozewie promontory exist ephemeral, poorly formed bars of that system, about 100 m wide only, due to the protective embankment (concrete wall and a pile of stone).

The outer bars system contains more permanent forms than the systems discussed above. There occur one or two bars, usually solidly built during the strong waving. These bars are usually relatively parallel to the shore, but there also appear bars oblique to the shore. The ridges are usually elevated 2–3 m above the bottom of the runnels. A long seaward slope of the deepest bar reaches the depth of 6–8 m. The outer system of bars is usually 300–350 m wide. The weaker bars appear on the slope of the spit at the harbour breakwater, on the east side of the harbour, and on the Rozewie promontory.

Ridges and runnels system oblique to the shore was encountered in the western part of the map. It is a distinctively separated system of forms, relatively similar in shape, and bent westward. From the east this system is restrained by a distinctly visible slope 2–3 m in height (max. up to 6 m in N part) and inclination of 1–2°. In this case, ridges and runnels are slightly sloped forms (up to 1°) with level changes not bigger than few metres. These forms are of considerable length, even up to several kilometres. They are the recent forms, created by the activity of wave related currents, covering partly the land and coast relict forms.

Ridges and runnels system perpendicular to shore covers most of the eastern area. These are gentle forms, with level changes up to a few meters and with slightly inclined slopes (up to 1°). One can distinguish three parts of this area (marked by dashed line in Fig. 2): western, central (north of the harbour), and eastern. According to the authors, the forms occurring here are most likely caused by the influence of the rip currents (*sensu* Gruszczyński *et al*., 1993), reaching far into the nearshore area, even up to several kilometres from the shore. The western part of the described area contains the old relict forms that are being at present exposed due to the abrasion of the sea bottom. It is well documented by the detailed examination of the sea bottom within the test field Chłapowo (between Rozewie and Władysławowo). There occur columns, ridges, runnels, and other incisions cut into the Miocene mud-sand formations, forming abrasive monadnocks with level changes up to 2 m and perpendicular slopes (Rudowski, Gajewski, 1998; Rudowski, Kramarska, 1998).

Flat sea bottom in the nearshore zone was specified because of its position at the depth of less than 16 m and the existence of waves activity. The sea bottom is almost flat, muddy, with signs of waving on its surface, and with the visible deposition and/or redeposition processes.

Within **the open sea area**, the flat sea bottom, relict valleys with slopes and terraces, and the deep slope with erosional incisions, were distinguished.

Flat sea bottom in the open sea area is marked in the central part of the map by its northern boundary at the depth exceeding 16 m. It is a flat, even, muddy sea bottom with conditions suitable for the suspension gravity sedimentation only.

The relict valleys are indicated in the NE corner and in the central part of the map.

The first valley, with its bottom 500 m wide, is located at the depth of 21–23 m. The slopes of this valley are about 4–5 m high and are slightly inclined (about 1°). On both sides of the valley, there occur relatively equal terraces located at the depths of 16–17 m on both the east and the west sides.

The second relict valley is located in the central part of the map, and runs to the NW. The width of this valley reaches 500 m.

The deep slope with erosional incisions is located in the NE part of the map at the depth over 20 m. This slope, with numerous transverse incisions, constitutes most likely another relict coast form.

CONCLUSION

The application of the modern, hydro-acoustic methods enabled detailed examination of the offshore sea bottom relief. It was recognised that the offshore sea bottom does not constitute a flat plain, as it was previously assumed, but has a diversified relief, though with small level changes of about 1–3 m.

There occur specific systems of runnels and ridges, which partly represent relict forms, transformed to certain degree by the sea processes during the Litorina transgression; partly are these forms created by the present waving related processes.

Thorough recognition of these forms character, their origin and development requires further specialised research. Presented results may be regarded as a good basis for the selection of the further test field location and for the planning the extent of further examination of the concerned sea bottom relief forms.

The already obtained picture of the sea bottom relief indicates the intensive sea bottom abrasion during the last decade, and the occurrence of an intensive transportation of the sediments seawards from the coast zone, at the distance of up to several kilometres from the shore. Those results are important in terms of methodology, the application for descriptions of the sea bottom structure and conditions, for the prognosis of the coast development in the near future, for the selection of the coast protection methods, for the modelling of the hydrodynamic processes, etc.

REFERENCES

GAJEWSKI J., STACHOWIAK A., ŻARKI I., 2000 — Database for the Purpose of Integral Coastal Zone Management. Task Quart., **4**, 1: 103–108.

GRUSZCZYŃSKI M., RUDOWSKI S., SEMIL J., SŁOMIŃSKI J., ZROBEK J., 1993 — Rip current as a geological tool. *Sedimentology*, **40**: 217–236.

MOJSKI J. (ed.), 1995 — Geological Atlas of the Southern Baltic, Plate I: Sea bottom relief. Polish Geol. Inst., Warsaw.

RUDOWSKI S., 1986 — Sedimentary environment of the barred coast tidal less sea, South Baltic coast example. [Eng. sum]. *Studia Geol. Pol*., **87**: 76.

RUDOWSKI S., GAJEWSKI L., 1998 — Classification of sea floor geology by complex acoustic methods, at Chłapowo, Poland. *Baltica*, **11**: 41–44.

RUDOWSKI S., KRAMARSKA R., 1998 — Structure and geological development of the coast at Chłapowo. In: Evolution of the Southern Baltic Shoreline. Guide Book of the Field Meeting. Poland,18–23 May 1998. (INQUA Subcommission on Shorelines of Northern and Western Europe): 33–34. Państw. Inst. Geol., Sopot.