GIS, GPS AND REMOTE SENSING TECHNIQUES AS A TOOL FOR ESTIMATION DEVELOPMENT OF THE VISTULA RIVER OUTLET

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ABSTRACT

The goal of the project was to evaluate methods for recording and analyzing the geoindicators related to the coastal zone. Geoindicators, according to the definition elaborated by the IUGS, are measures (magnitudes, frequencies, rates and trends) of geological processes and phenomena occurring at or near the Earth’s surface and subject to changes over periods of 100 or less years. Shoreline changes are one of the most important geoindicators of processes on the coastal areas because of their importance to economy and nature conservation. Investigations were carried out on the southern part of the Gulf of Gdansk in the Vistula river mouth. Shoreline changes in different time scales were identified by analyses of aerial photos, analyses of digital terrain models and GPS measurements.

AREA OF RESEARCH

On the southern coast of the Gulf of Gdansk, forms and sediments occur which are related to the three mouths of the Vistula which existed in historical times. Until 1840, the Vistula flowed into the Bay of Gdansk near Gdansk. During the night of 31 January/1 February 1840, at a very high water level on the Vistula, with an ice-jam in its mouth and a high water level and a strong storm on the Baltic, the flood banks and dunes separating the Vistula river-bed from the sea broke. The Vistula formed a new mouth ca. 10 km away from Gdansk. In 1895, a new artificially dug mouth of the Vistula was opened near Swibno 20 km away from Gdansk. Since then, most of the Vistula’s water and sediment has been transported to the Gulf of Gdansk by means of this artificial canal called the Vistula Cross-cut. During the last 100 years large quantities of sediment were deposited here, which formed the currently active front of the delta and the pro-delta. The sediment of the head of the delta form a river-mouth fan and they develop mainly in the sand facies. The thickness of the sand sediment of the river-mouth fan is a maximum of 11–13 m. The sediments of the pro-delta occur on the forefield of the river-mouth ran at a depth zone of 12 - 16 m and also underlie the fan sediment (of the delta head). The thickness of this sediment ranges from 0 to about 10 m.

RESEARCH SCOPE AND METHODS

The following research was performed during the analysis of the changes taking place in the contemporary Vistula river-mouth:

• Analysis of digital bathymetric models for the Vistula river-mouth fan. The digital models were generated on the basis of bathymetric plans from 1894 and 1980 using Surfer 7.0 software and the kriging method.

• Analysis of aerial photographs from: 1947, 1958, 1964, 1976, 1997. The photographs were processed using ER Mapper 6. 0 software into a orthophotomap format. The Gauss-Krüger map projection was used on a WGS-84 geocentric ellipsoid the 1992 geographical co-ordinate system.

• Measurements of the changes in the location of the coast line using GPS equipment were performed in October 2001, March 2002 and September 2002 using Trimble’s Pathfinder ProXL equipment.
RESEARCH RESULTS

Digital area models.

In 1894, the underwater coastal slope descended up to a depth of 15 m over a section of 1500 m, which gave an average gradient of the bottom of 1:100. In 1895, a 7-kilometre canal was dug into which the waters of the Vistula were let in. In 1980, eighty-five years after the opening of the Vistula Cross-cut, the coast line had shifted by about 2,400 m, and the base of the river-mouth fan removed from the coast line in 1894 by about 4000 m. The volume of the river-mouth cone was 110 M m$^3$ and the average rate of sediment growth over the 85 years was ca.1.3 M m$^3$ per year.

Aerial photographs.

In order to calculate the changes in the land surface area of the Vistula river-mouth fan between 1947 and 1997 the territorial range covered by the 1997 photograph was assumed. The southerly range is simultaneously the range of the coast line in 1894, the year before the Vistula Cross-cut was opened. The shape and the area of the fan in individual years is shown in Table 1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Area [m$^2$]</th>
<th>Period</th>
<th>Accreted area [m$^2$]</th>
<th>Average accretion rate [m$^2$/year]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>3 019 000</td>
<td>1976-1997</td>
<td>483 000</td>
<td>23 000</td>
</tr>
<tr>
<td>1976</td>
<td>2 536 000</td>
<td>1964-1976</td>
<td>503 000</td>
<td>41 900</td>
</tr>
<tr>
<td>1964</td>
<td>2 033 000</td>
<td>1958-1964</td>
<td>312 000</td>
<td>50 200</td>
</tr>
<tr>
<td>1958</td>
<td>1 721 000</td>
<td>1947-1958</td>
<td>138 000</td>
<td>12 500</td>
</tr>
<tr>
<td>1947</td>
<td>1 583 000</td>
<td>1894-1947</td>
<td>1 583 000</td>
<td>30 400</td>
</tr>
<tr>
<td>1894</td>
<td>0</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Table 1. Changes in the area of the land surface part of the Vistula river-mouth fan

The rate of the growth of the land part of the fan depended largely on the development of the river-mouth breakwaters and on natural factors such as the variation of the amount of rubble transported by the Vistula and sea erosion.

Measurements of the change in the location of the coast line using GPS equipment.

The coast line and the scarps measured in October 2001 on the western side of the cross-cut receded a number of metres towards the land over 11 months. This could have been caused by the winter storms which took place in 2001/2002. The coast line on the eastern side of the river-mouth remained largely unchanged during the measurement period.

REFERENCES


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