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The nature of the bed load transport in the mouth of the river to the non-tidal sea (the Vistula River, Poland)

Aliaksandr Lisimenka (1), Zbigniew Zwoliński (2), and Stanisław Rudowski (1)

(1) Maritime Institute in Gdansk, Dlugi Targ str. 41/42, 80-830 Gdansk, Poland (sasha@im.gda.pl), (2) Institute of Geoecology and Geoinformation, Adam Mickiewicz University in Poznan, Dziegielowa 27, 61-680 Poznan, Poland (zbzw@amu.edu.pl)

The Vistula, Poland's primary river, is the second largest river of the Baltic Sea Basin considering the average river flow and drainage area and one of the least regulated amongst large rivers in Europe. The main Vistula river mouth is a cross-cut artificial channel of about 3000 m length, 400 m width and up to 10 m depth.
Results of three measurements campaigns which were carried out in the main Vistula river mouth in October 2013, March and June 2014 are presented. The area of interest was mapped using boat mounted high-resolution Reson Seabat 7101 multibeam echosounder system (MBES). River flow field information was obtained with Rio Grande 1200 kHz Acoustic Doppler Current Profiler (ADCP) along the designated 14 cross-section profiles at an interval of 250 m. Seismoacoustic measurements were carried out using Innomar SES-2000 parametric sub-bottom profiler along the longitudinal profiles at an interval of 30 m. At the end of each measurement campaign, 20-30 grab samples were collected in places chosen on the basis of current bathymetric map and were analyzed by sieving method.
The obtained results have revealed comprehensive riverbed morphology of the river channel which is characterized by presence of multiple generations of small to large sandy dunes of various orientations, whose asymmetries indicate a general seaward migration. On the basis of newly developed method for quantitative analysis of subaqueous straight-crested rippled bottom roughness with using of the 2D Discrete Fourier Transform (2D DFT) algorithm which involved a calculation of low-order spectral moments, primary parameters of the observed bedforms such as crest-line spatial alignment, wavelength and height are determined. Depth-averaged flow velocities indicate spatial variability with increased flow velocities achieve up to 0.75 m/s in the mainstream. Analysis of the seismoacoustic data confirms seaward migration of the observed sand dunes and shows that, in general, dynamic sediment layer thickness exceeds 3 m. In addition to, granulometry analysis indicates dominating of medium-grained sands, in average well sorted, with the small add mixture of coarsed-grained sand (mainly on the crest of dunes) and sandy muds (mainly in the hollows).
Field and computer analyzes indicated on the hydrodynamic conditions of water discharge in the mouth of the Vistula River in the longitudinal and transverse profiles, variations of bed load facies and variations of morphodynamic zones in the river channel. Despite the large internal dynamics of the river channel, analyzes show the relative spatial stability of that channel, independent of seasonal variations. This demonstrates the inertial character (stable) of depositional environment in estuary section of the Vistula River.