Laboratory and Numerical Studies of Waves, Currents and Sediment Transport at the Deepwater Navigation Channel in the "Bystroe" Arm of the Danube Delta

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The construction of Deepwater Navigation Channel (DNC) in the Bystroe arm of the Danube Delta has started in 2003. The whole project provides the development of the navigation channel Danube-Black Sea in Ukraine which ensures the passage with the draft 7.2 m., that is the alternative to the Sulinskiy navigational channel on the Romanian territory. The first phase of project, that was finished in August, 2004, provides the passage with the draft 5.85 m. The second phase of the project is under preparation. Taking into account the Ukrainian public and international attention to this project provided in the area of the Danube Delta biosphere reserve, the comprehensive studies have been provided in Ukraine for the justification of the technical design of the channel and for the environmental impact assessment. The presentation describes the results of a part of such studies - the laboratory and numerical modeling of the waves, currents and sediments at the marine part of the DNC - the sea approaching channel, length 3.30 km., width by the bottom 85 m, depth 7,65 m., which is passing through the sea sand-bar at the mouth of the Bystroe arm of the Danube Delta which mean water discharge is at 1200 m^3 /sec . Within phase two the jetty will be constructed to protect the channel from the littoral drift from the North and North-East – that are main directions of the sediment transport in the area. The goals of the modeling were formulated as the selection of the most efficient jetty pattern and analyses of the channel and jetty impacts on the costal erosion of the marine side of the Danube delta at mouth of Bystroe.

A 3D scale model with movable bottom of the marine area of the mouth of Bystroe was constructed in the experimental wave tank of the Institute of Hydromechanics. The wave tank length is 43 m, width 27 m, water depth 0.9 m. It is fitted with a piston-type wave generator and with a pump to simulate the currents from the river mouth. The directions of the incoming waves can be changed by the re-location of the wave generator, The set of the automatic wave gage devices provides the measurements in the up to the 10 points of the wave tank The currents were measured by the micro-propeller meters.

The concentration of the suspended sediments in Bystroe arm within an year varies in the range 0.1-0.3 kg/$m^{3.}$ A mean grain size of the suspended sediments in the river flow is 0.02-0.04 mm. The mean grain size of the bottom sediments at the marine part of the Bystroe mouth is at 0.16 mm. The physical modeling did not consider the influence of the river sediments on the channel sedimentation, only movement of the marine bottom sands was studied. There were provided the measurements of the bottom layer aggregation in the channel under the joint influence of the waves and currents with and without the designed jetty.

The numerical modeling was provided on the basis of the 2-D hydro&morpho- dynamics modeling code COASTOX, that was used for this task as a set of the following modules.

- HWAVE – the module describing wave diffraction, refraction and transformation on bottom inhomogeneities and currents on the basis of hyperbolic approximation of mild slope equation, which is more widely appreciable than parabolic approximation and more computational efficient then an elliptic one. The numerical engine of the module is based on the 4-th order finite difference scheme.
- CUR – the module describing nearshore 2-D currents, which radiation-stress terms are calculated on the basis of the outputs of HWAVE model. The numerical engine is based on the TVD scheme, computationally efficient for the calculation of the flooding and drying of coast under long wave (tides, wind surf) impacts.
- SED - the module of the simulation of the sediment transport in which the suspended sediments are simulated on the basis of the finite-difference solution of 2-D advection –diffusion equation and the bottom sediment transport calculations are provided o the basis of a library of the most popular semi-empirical formulas.
- MORPH – the module of the simulation of the morphological transformation of coastal zone based on the mass balance equation, on the basis of the sediment fluxes, calculated in the SED module. MORPH management submodel is responsible for the execution of the model chain "waves- current- sediments – morphodynamics- waves" etc.

As the "stand-alone" modules, as whole modeling system were tested on the basis of the laboratory data and using the specialized procedures of the testing of the numerical algorithms.

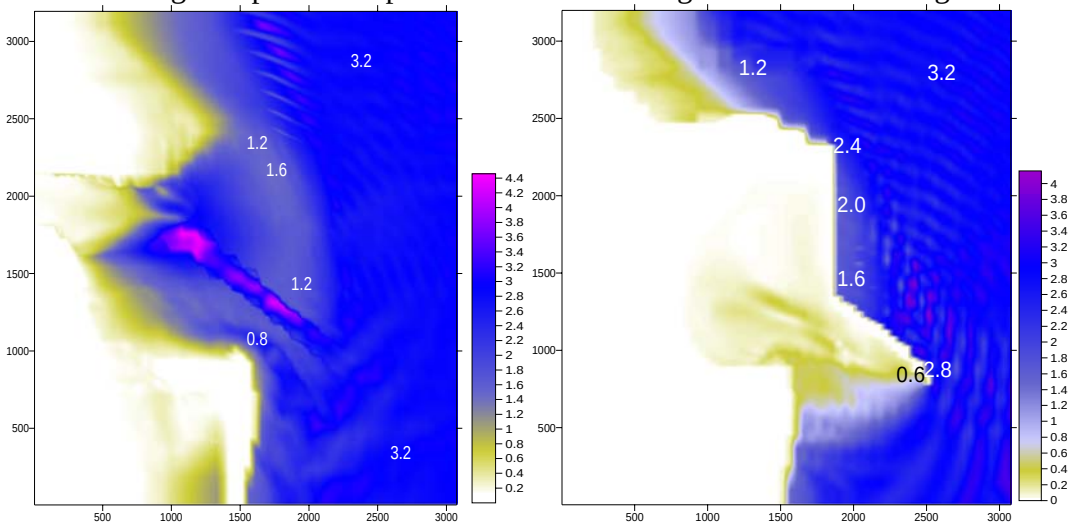

Fig.1Wave heights numerically simulated and recalculated from the measurements in the wave tank (white numbers) Incoming wave from NE (37^0), T=5.19 sec, H_0=2.9 m.. Bystroe discharge 1560 m^3/s

The measured in the wave tank and numerically simulated wave fields before and after the construction of the jetty (e.g., Fig.1), as also the fields of the wave & river driven currents are considered and it is shown that there are in a reasonable agreement. The impacts of the jetty on sedimentation of the navigation channel and coastline dynamics are analyzed on the basis of the results of physical and numerical modeling, It is concluded that the construction of the channel and jetty will not initiate the intensification of the coastal erosion of the coastal forms southward from the channel, because the sediment flow from the river will be redirected after the completion of the construction by such way that it will promote the slow coast accretion processes in these areas. The construction will not provide transboundary effects at the coastline taking into account that the Ukrainian –Romanian coastal border is located at 20 km southward from the marine part of the DNC.