MODELLING THE BOSPHORUS FLOW DYNAMICS

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Abstract
A 3D dimensional, bottom-following sigma-coordinate Princeton Ocean Model of the Bosphorus Strait is used to reproduce the observed flow and stratification characteristics. The simulations are extended to several oil spill scenarios to explore their impacts along the strait. The model successfully reproduces the typical two-layer, quasi-steady exchange flow system, which is shown to experience another hydraulic control at the northern sill near the Black Sea entrance of the strait.
Keywords : Bosphorus, Models, Danube Delta.

The Bosphorus Strait is a long (∼ 30 km), narrow (<3.0 km), and shallow (<80 m) waterway between the Black and Marmara Seas. It consists of two oppositely flowing currents: the upper layer coming from the Black Sea with a salinity ranging from 18 to 20 psu, and the lower layer coming from the Aegean Sea with a salinity ranging between 36 and 38 psu. It lies along the high oil tankers traffic route from the Black Sea, which makes the strait a high risk area for oil spill accidents.

The three dimensional, time dependent, primitive equations, bottom-following sigma-coordinate Princeton Ocean Model is used to reproduce its observed flow and stratification characteristics. The simulations are extended to several oil spill scenarios to explore their impacts along the strait. The model resolves the strait with a grid distance of 100 m in both along and cross-channel directions. It extends 7 km into the Black in order to simulate the underflow structure along the underwater channel at its northern end. There are 21 sigma levels in the vertical with finer resolutions near the surface and the bottom. The maximum vertical grid spacing is about 5 m within the deepest section (∼ 80 m) of the channel. Forced radiation open boundary conditions are imposed on both sides for the normal velocity component, whereas the tangential velocity component is set to zero. The forced radiation open boundary conditions are adjusted to provide the flow conditions consistent with the observed sea level elevation difference of 30 cm along the strait.

The model successfully reproduces the typical two-layer, quasi-steady exchange flow system that is to be hydraulically adjusted by a series of morphological features (Fig. 1). Three successive hydraulic controls occur within the southern 10 km zone: first near the southern exit due to convex bending of the channel, then at the southern sill and at the constriction section of the strait. The exchange flow system is shown to experience another hydraulic control at the northern sill near the Black Sea entrance of the strait.

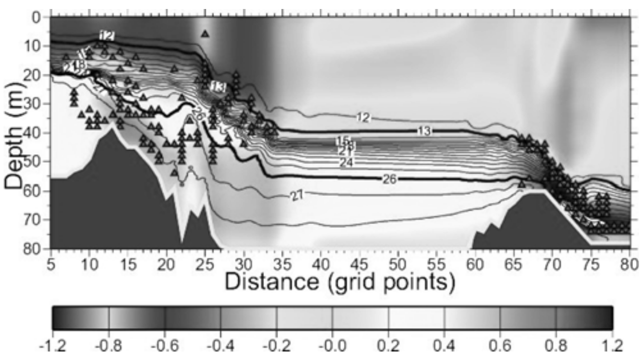

Fig. 1. Simulated Sigma-t (kg m^{-3}) and horizontal current (m s^{-1}) distributions versus depth along the main axis of the channel. Sigma-t contours (black lines) are plotted at an interval of 1 kg m^{-3}. The color bar gives the current speed with negative (positive) values for the upper (lower) layer. Triangles denote supercritical flow conditions identified by the Richardson number less than 0.25.