WIND-DRIVEN CURRENTS IN THE CHANNEL AREA: AN EXAMPLE OF THE CHANNELS ZADARSKI KANAL AND PASMANSKI KANAL (EAST ADRIATIC COAST)

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Abstract

The paper deals with the response of the channel area to the different wind forcings. For that purpose current measurements were performed in the channels Zadarski kanal and Pašmanski kanal. Basic statistic, spectral and system analysis and low-pass filter have been applied on the data, and the results have been verified by numerical model. The interesting results are eddies appearing at the wider entrance of the channel Zadarski kanal, both detected from the data and achieved by the model.

Key-words: Adriatic Sea, circulation models, straits and channels

Introduction

The region of the channels Pašmanski kanal and Zadarski kanal, which embraces the eastern coast of the Adriatic Sea (Fig. 1), is a typical enclosed channel area of limited dimensions. The southeastern part of the channel (Pašmanski kanal) is narrower (about 2 km) and shallower, with the depths from 10 to 25 metres, as distinguished from its northwestern part (Zadarski kanal). The depths of the channel Zadarski kanal reach 50 metres at the mouth, and width is more significant (about 7 km at the mouth). An important factor are the small islands and shoals (8-10 m) inside Pašmanski kanal, as they considerably reduce the horizontal section of the channel and in this way influence circulation.

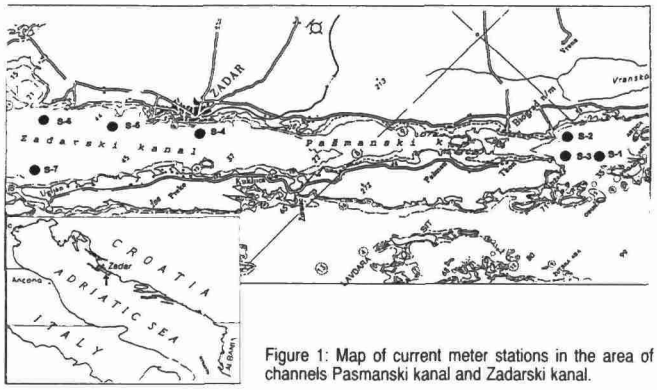

Figure 1: Map of current meter stations in the area of channels Pasmanski kanal and Zadarski kanal.

Data and methods

Current measurements were done at the stations S-1 to S-7 (Fig. 1) from 28 June to 21 July and from 24 August to 17 September 1994. Current direction and speed were being measured using AANDERAA RCM4S and RCM7 current meters in the surface layer (3-5 metres) and bottom layer (4-5 metres above the sea bottom), with a sampling interval of 5 and 10 minutes. Positions of current meters were selected so as to describe properly the marginal processes and the circulation inside the basin.

Characteristics of the circulation system were being investigated analyzing the time series of hourly and daily current vectors, progressive vector diagrams and current roses. In order to investigate the influence of wind on circulation in such an enclosed channel area, the wind data obtained from the meteorological station Šibenik were used. This was the nearest meteorological station at which wind measurements were carried out. Current and wind vectors were divided into components, vertical to the coast and parallel with it, and passed through a low-pass filter. Spectral and system analyses, according to Jenkins and Watts (1) were applied as well.

Experimental results of current measurements were used for verification of the results obtained from application of a three-dimensional numerical hydrodynamic model (2). The model is based on the equations for momentum of mesoscale marine hydrodynamics with Boussinesq and hydrostatic approximations. For horizontal diffusion the Joseph-Sendner approximation (3) is used, while vertical diffusion is defined from the turbulent energy equation with second-order closure (4). Sea surface boundary is forced by wind, while the bottom boundary condition is calculated from the logarithmic bottom profile (5). At the solid boundary no-slip conditions are used, and no divergence at open boundaries. The numerical scheme for the model is space-centered with semi-staggered grid, and time integration is performed using forward-backwards scheme.

Results

Weather conditions during the experiment were influenced by high-pressure circulation, occasionally disturbed by slow and rather weak low-pressure systems. Several times from 20 August to 17 September, stable and warm weather was disrupted by cyclonic disturbances, particularly after 2 September. The entire measurement period was characterized by frequent calms, so that even the typical summer Etesian (northwest wind) was not recorded.

In the first part of the experiment, circulation in the researched sea area was a typical channel, two-layer circulation of SE-NW direction, because of the stable weather conditions. In the surface layer, circulation of SE direction was prevailing, while in the bottom layer occurred a counter-current of lower intensity. The data analysis shows the prevailing low-frequency circulations with several day periods, on which are superposed tidal oscillations. Current polarization is less manifested at the stations S-6 and S-7 due to the channel width and influence of the circulation from the neighbouring sea areas.

In the second part of the experiment, the current field is more extended in the channel direction, with higher speeds at all stations, due to an intensified cyclonic activity above the researched area. Low-frequency oscillations are better manifested, with periods of cyclonic disturbances (Fig. 2), while stability of the current flow is disrupted by a frequent change of inflowing and outflowing current direction.

The comparison between wind and currents (Fig. 3) shows a great correlation between surface currents and wind during strong wind. In such weather conditions circulation can be described as a two-layer model with wind driven currents in the surface layer and counter-currents in the bottom layer.

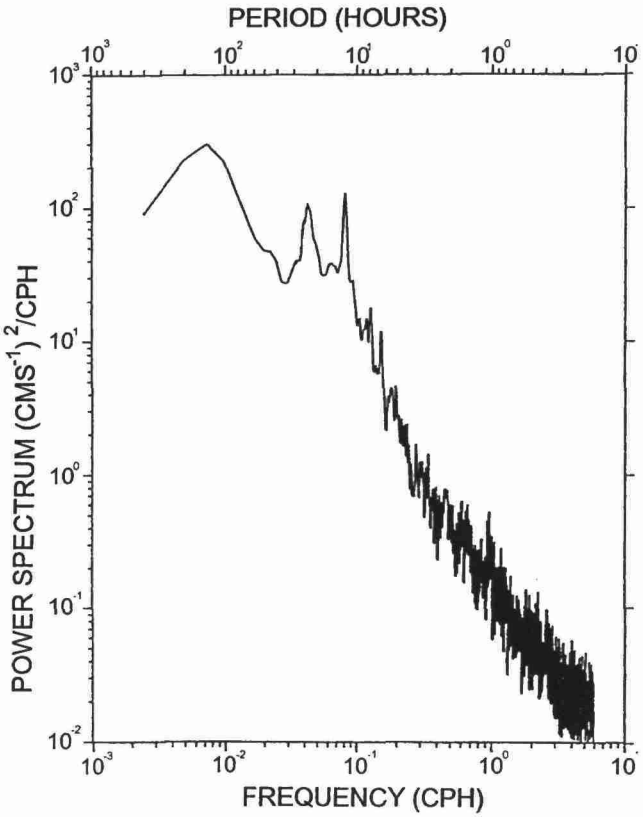

Figure 2: Total power spectrum of surface currents measured at the station S-1 from 24 August to 19 September 1994.