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Investigations on the marine current regime in the maritime port of Constanta and its adjacent areas

E Vlasceanu[1], R Bosneagu[2], I C Scurtu[2], D Marin[1], R Mateescu[1,3]

[1] National Institute for Marine Research and Development "Grigore Antipa", 300 Mamaia Blvd., RO-900581, Constanta, Romania
[2] Naval Academy "Mircea cel Batran", 1 Fulgerului Street, RO-900218, Constanta, Romania
[3] Department of Mechanical Engineering, Faculty of Engineering, "Dunarea de Jos" University of Galati, 47 Domneasca Street, 800008 Galati, Romania

E-mail: evlasceanu74@yahoo.com

Abstract. The aim of this work is to analyse the marine currents distribution within Constanta port and its vicinity areas, in order to evaluate the impacts on port operations and coastal system as well. The currents propagation into the port basin and adjacent areas were the subject of ADCP measurements in relation with the incident waves and sea level variations. Certain experiments and special conditions were considered such as storm surges, storm induced currents, seiches propagation into the port basin, specific marine currents around the port jetties, and the influence of vertical water movements.
Keywords: marine currents, ADCP measurements, port basin

1. Introduction

Modern measurement methods of hydrodynamic parameters and water masses circulation in the areas of maritime interest are significant in evaluation of hydrodynamic processes variability.

Theoretical elements of marine currents regime, as well as the currents types were considered in advanced way in the water masses circulation models [10], [11], [19]. The two types of velocities approaches in the fluid mechanics: the trajectory-based velocity of a moving water particle, or the drift velocity (The Lagrange method) and the water velocity reported for a static position (the Euler method) are included in the two application-based modelling system [1], [7], [9], [17]. Based on these two mathematical methods, several measurement methods have been developed, for marine currents [6], [21], [24], [25]. Of these, the most frequently used are the drifter observation and the long-range and short-range remote sensing (HF radar and satellites observation) or acoustic current measurements based on the Doppler effect [2].

The general regime of the Romanian seashore currents has been described properly since 70s [3], [4], [13], [14]. It was correlated with marine and coastal measurement methods, based on the two mathematical principles mentioned above [5]. In order to make direct high-resolution spatial measurements [11], [12], both horizontally and in-depth, for the marine circulation in the north-western area of the sea, the equipment was used, to determine the currents' vertical profile, based on the Doppler effect [20]. The equipment had the capacity to operate in a static position, and/or lateral of a moving vessel/boat.

2. Material and Methods

A field measurement session was carried on October 26th, 2019. Its purpose was to validate the results obtained [8] using the MOHID coastal numerical model [15], [16], [23] applied for Constanta area, part of Romanian shelf model down scaled from the Black Sea model [18].

The equipment was made of the „Grigore Antipa” National Marine Research and Development Institute motorboat, which had a GPS and an ADCP (Acoustic Doppler Current Profiler), type WHS600 - Workhorse Sentinel 600 KHz, equipped with the Bottom track module for dynamic measurements of currents profiles, on the water column (figure 2). The area of interest included the entire waterway of Constanta port, from the port entrance to the „Berth Zero” located in the most sheltered sub-port basin. The measurement route started from Tomis Marina, a tourist harbor near the Port of Constanta. The measurements consisted in several ADCP profiles, made between the opening of the main port basins, following the trajectories shown in figure 1.

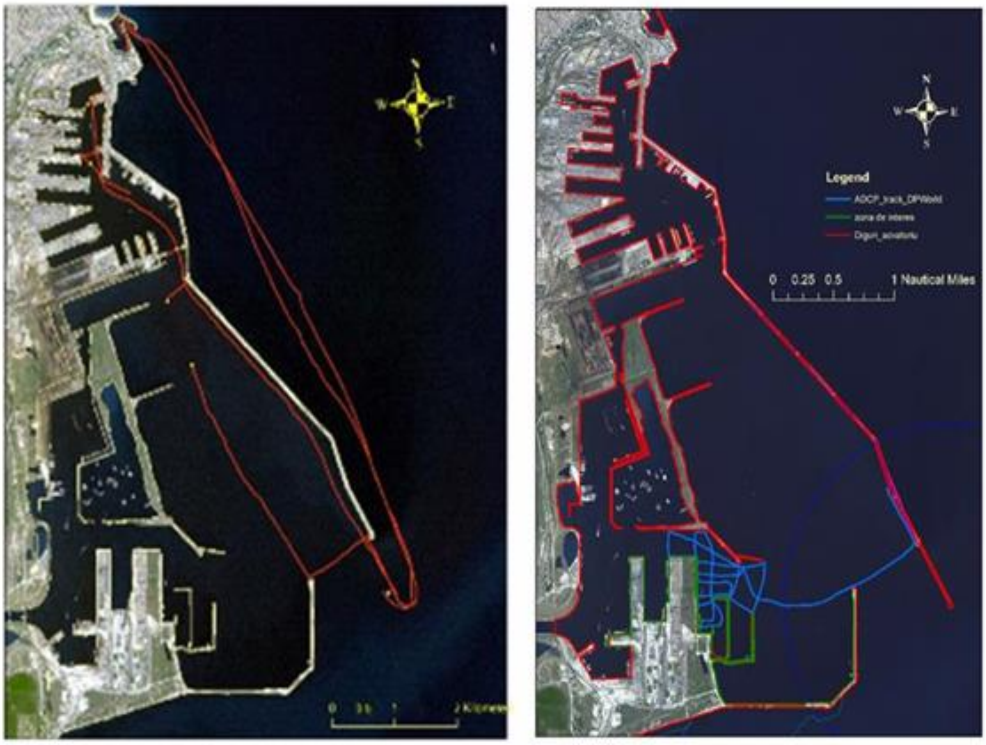

Figure 1. The measurement route of water currents in Constanta Port.

An experimental session was setup before and after the storm of July 21, 2021 in the area of Eforie, in the vicinity of the southern dam of Constanta Port, aimed to record the changes of currents movement in the short term, during a storm or an untimely hydrological event with wind gusts of 40km/h from the NW direction, generating 1.5 m hight waves in approximatively 30 minutes.

For data collection on the current circulation within the port basin, the ADCP WHS 1200KHz was connected to a water resistant, all terrain tablet, with dedicated pre-installed Teledyne – RD Instruments dedicated software. For the measurements positioning it was used a Trimble GEOXH6000 GPS, with a PPK/Post Processing Kinematic correction, with centimetre precision [22].

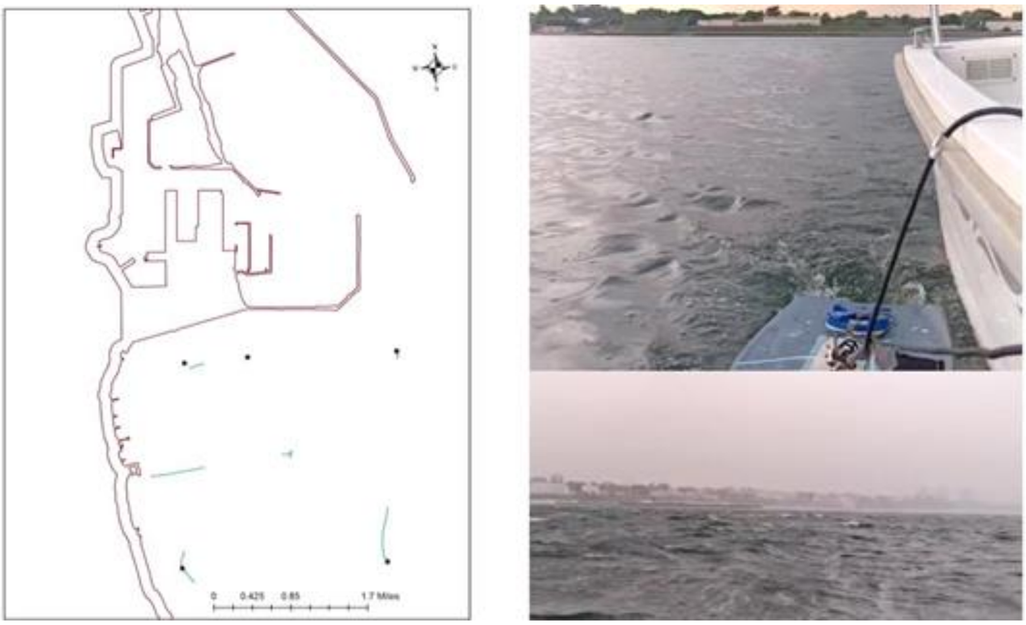

Figure 2. ADCP measurements in the area of Eforie

3. Results and Discussions

An important cross-section was measured in the area of the port's access mouth. The selected alignment during the data recording operations was the new opening created, after port jetty extension in 2015 (figure 1).

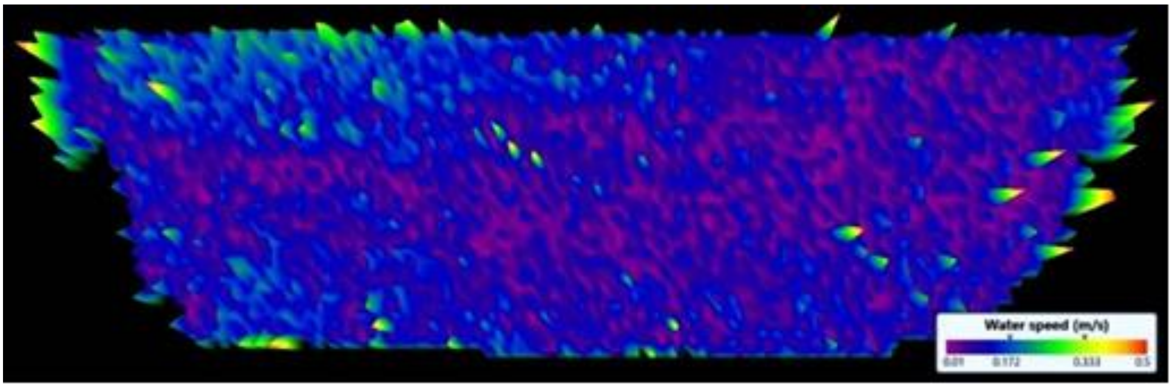

Figure 3. The currents distribution for the section of the northern dam's farther end – The access mouth in Constanta Port

The analysis of the data collected during the experiment shows that velocity levels of the current have been recorded, in the range of 0. 002 m/s and 1. 058m/s taking into account the working regime in a normal currents' velocity regime for the Constanta Port's area of interest. Exceptions outside the normal velocity regime were also recorded in corner terminals and/or at the channel extremity and the passage waterways, where the currents' average value exceeds 0.5m/s, nearing the value of 1m/s. For the critical areas, measurements were made, using the ACDP in permanent station. The measurements provide details on the velocity distribution on water column, as shown in figure 4.

Figure 4. ACDP profile photographed on the tablet screen (left) and the marking of currents at the port entrance (right), as well as an anticyclonic current nearby the northern dam of the port's precinct

For the support of the analysis was accessed the hydrodynamic model (MOHID, realized under the iSWIM project: http://iswim.rmri.ro/maps/maps1.shtml), which provides current distribution maps at different scales, including local scale (Constanta Port area) . The results obtained after the model was run based on wind data from wind directions with impact on the area of interest [26], show a good quantitative agreement with the measurements results of hydrodynamic parameters, including the magnitude of the current for the surface layer (figure 5).

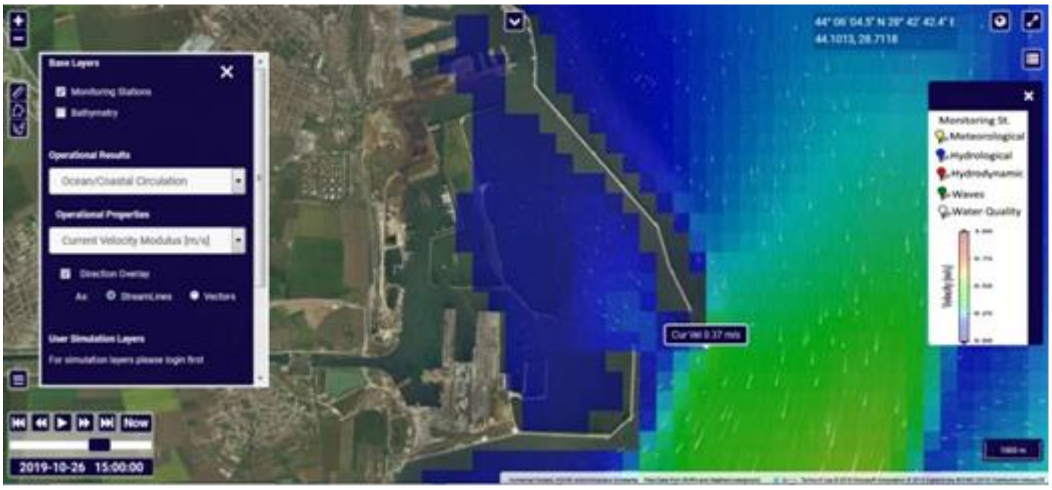

Figure 5. Current distribution on October 26th, 2019 - SW current at the entrance of Constanta port, with a forecast speed of 0.37m/s, at 15:00

For the second experiment, the measured velocities in the surface layer in the semi-closed port basin corresponds to the model distributions of a south-east wind-induced circulation (figures 6 and 7).

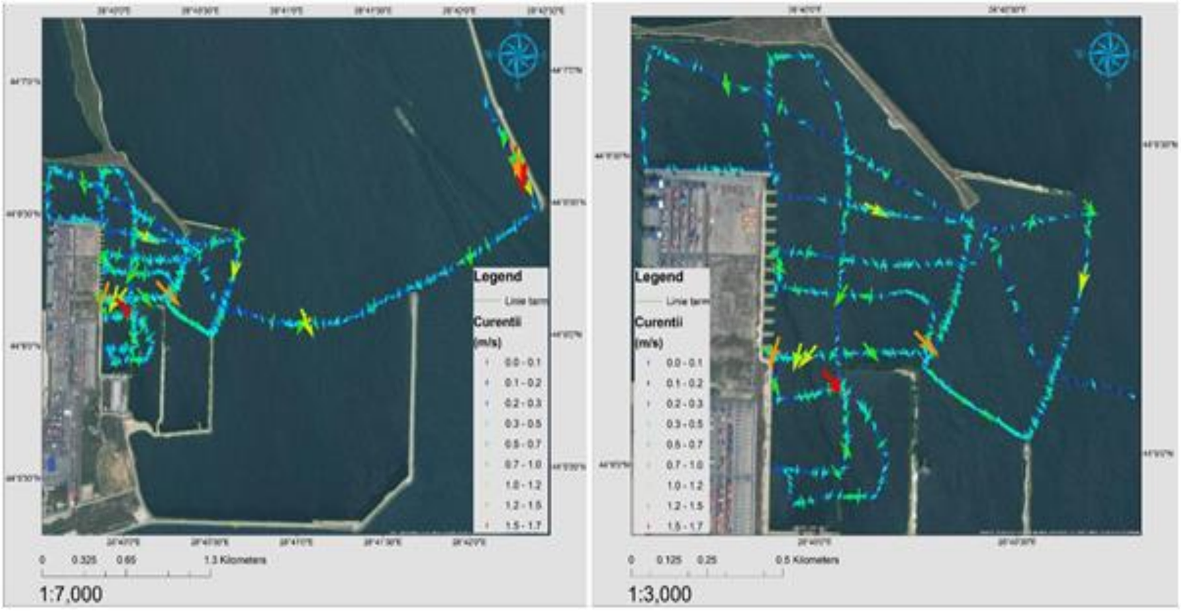

Figure 6. Surface currents representations - measurement session in September 30th, 2020

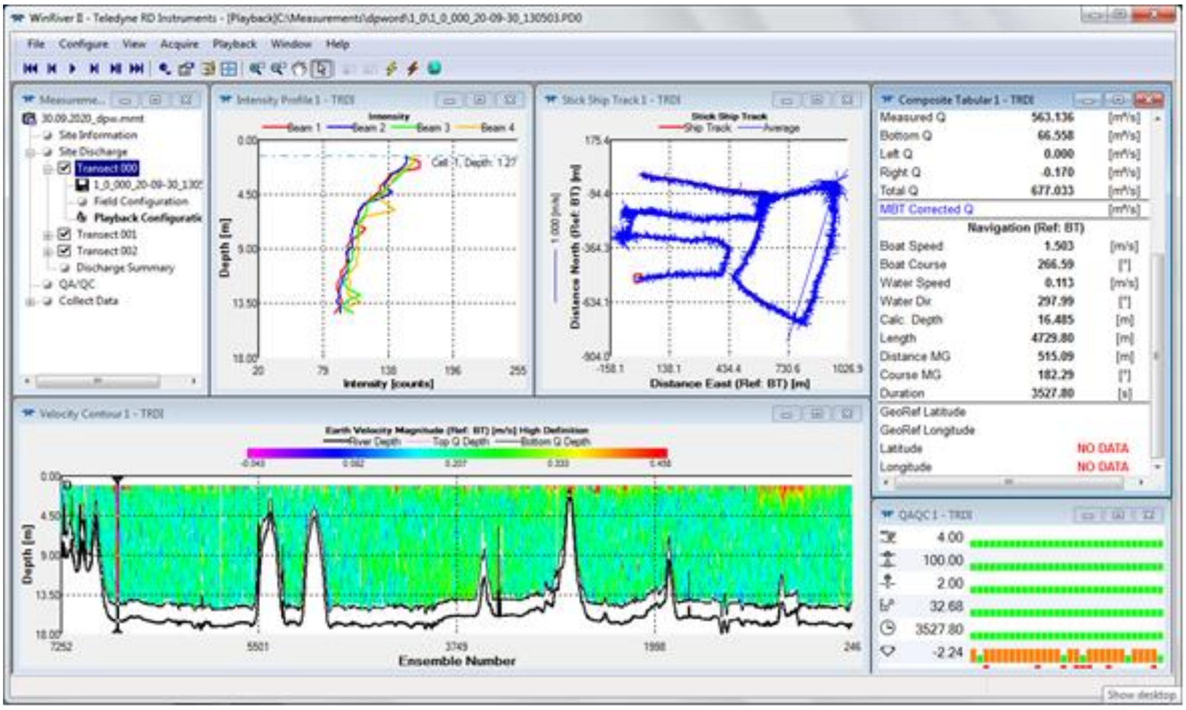

Figure 7. Currents' profiles in a port basin

Surface currents related to the area of interest, (session from 30.09.2020) are patterned within ArcGIS and in similar way, the measured data shows the induced current in the basin, together with its intensifications in specific areas of convergence, due to underwater obstacles, but also due to the division of the port precincts in two connected sub-basins. For third registration, in the vicinity of the southern dam of Constanta seaport, after the storm, in alignment with the Children's Camp in Eforie area, it was performed a fix station at 25m deep, thus locating certain intensifications of the ascending currents, and also an important variation of the currents speed for the surface layer, with a maximum values for the recorded currents of 35 cm/s (figure 8).

Figure 8. The current distribution in a fix station (Eforie area at 25m depth) – 27.07. 2021

The predominant orientation of the eastern currents on the water column is induced due to inland wind from NV in a zone of north-south orientation of the shoreline.

4. Conclusions

Data recorded on the premises of the port waters have enabled to assess the movements of water masses, also highlighting the existence of several critical areas in the surface layer as a result of the intensification of the marine hydrological regime, in the cold season, lies under the incidence of storm waves, occurring from the NE sector. Special situations have been observed, providing an image of exceptional regime phenomena. The recorded data was confirmed and in the same time enabled us to validate the MOHID hydrodynamic model, applied for the coastal calculation domains, specific for the Constanta Port areas, for the specified low regime timeframe, as well as for the timespan when the measurement of currents was made. This period corresponds to the transition from the warm season to the cold season. A slight intensification could be noticed as regards the circulation of water masses, all that being the result of the wind rotation cycle, active during the validation experiment, but also the result of the complex configuration of the port water basins. The integrated use of the remote sensing products (Earth Observation/EO), in parallel with the numerical models results and the in situ measurements used for the description of coastal navigation conditions highlight the potential development of a complex algorithm, created for the inter-calibration of data provided by various sources, for various temporal and spatial scales as well as for the modelling and observation of marine phenomena.

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