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Rip currents on the Romanian Black Sea coast – distribution, characteristics and dynamics

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Rip currents occur on many wave-exposed coasts worldwide, expressed as both morphological and hydrodynamic elements of the nearshore circulation system (surf zone). They comprise of onshore mass transport over the bars, longshore currents in the feeder channels and relatively narrow and concentrated offshore flows in the rip channel. They are variable in space and time due to changes in incident wave conditions and nearshore morphology. These dynamic conditions often threaten the safety of the beach, beachgoers or the infrastructure.

Despite the low to moderate wave energy environment of the Romanian Black Sea coast, the relatively high potential of rip currents formation, the rapid hydrodynamical and morphological change (e.g. minutes to months) of the beach state, the very little knowledge of rip currents distribution and behaviour and the very low public's awareness related to rip currents associated dangers make a deadly combination each year on many beaches.

We present the first results about rip currents distribution, characteristics, and dynamics along the Romanian coast, which is, to our knowledge, also a first run for the entire Black Sea basin. The analysis of rip currents spatial distribution revealed that more than 50% of the Romanian touristic beaches (18 out of 35 sectors – totalizing 28.6 km in length) are affected, under certain conditions, by various types of rip currents. Most of them were identified on beaches with 3D sandbar morphology, the dominant type being represented by channel rip currents.

The most affected sector is the Eforie Nord beach (Techirghiol Barrier), where 10 individual rip currents are constantly developing along 1-km area, associated with the largest number of deaths and rescues during the summer season each year. A field experiment during low-energy wave conditions (offshore average H_s between 0.35 and 0.55 m; average periods between 3.6 and 4.5 seconds; propagating from ENE) in October 2021 highlighted the circulation patterns and dynamics of three of these rip currents. Drifters and ecological dye deployments along this area, complemented by UAV surveys and video camera footage, revealed both 'circulatory flow' and 'exit flow' circulation regimes, with alongshore feeding channels developing between adjacent rips. The average surface velocities registered during drifters' deployments ranged between 0.34 and 0.43 m/s, with maximum instantaneous values exceeding 1 m/s. These circulatory patterns and surface flows were then successfully reproduced for similar hydrodynamic conditions by employing a

preliminary modelling framework (Delft3D) for this area.

We hope that our results will raise the public's awareness of rip currents and their related hazards on the Romanian Black Sea coast to reduce beach management and lifeguarding costs, risks to public health and safety and losses of human lives.