Towards parametrized modeling of the current vertical structure during extreme events: application to Alderney Race.

Martin GOIX[1,2], Anne-Claire BENNIS[1], Pierre-Henri MUSIEDLAK[2], Lucille FURGEROT[1]

1 : M2C, UNICAEN-CNRS-UNIROUEN, 24 rue des Tilleuls, 14000 Caen, France
2 : HydroQuest, 16 Chemin de Malacher, 38240 Meylan, France

Email : martin.goix@unicaen.fr

Abstract

This study aims to improve the parameterized modeling of velocity vertical profiles in coastal environments under strong tidal currents. The primary study site is the Alderney Race in Normandy, France. This location experiences a macro-tidal and semi-diurnal environment with powerful sheared currents reaching up to 5 m/s. As part of the FloWatt project, led by HydroQuest, this site will host a pilot farm of seven tidal turbines. Ultimately, this study may simplify the representation of hydrodynamic processes in tidal energy converter deployment sites, predict vertical current shear during extreme events, aid in turbine design by anticipating fatigue risks, and minimize maintenance operations.

The analytical laws currently used to assess the current are either logarithmic or power law and are based on zero-equation turbulence closure models or partial similarity. These models predict velocity profiles in the bottom boundary layer well for colinear waves and currents. However, studies show that the vertical profile is modified by wave-current interaction (WCI) throughout the entire water height, which causes deviation from the log law in the upper layer, especially during extreme events [1]. On the other hand, the power law was used in the Alderney Race, and it was found that the parameters are subject to high variability, depending on both tidal phase and ambient turbulence, and do not always follow the values recommended in the literature [2]. So, a new formulation is required.

An improved parametrized law of the current specific to Alderney Race will be derived by sorting profiles based on parameters such as surface shear (acceleration or deceleration), orbital velocity, and the depth of the zone affected by wave breaking, among others. Then, the relation between this classification and meteorological-oceanographic parameters will be investigated. The data are from both in-situ measurements and numerical modeling. During

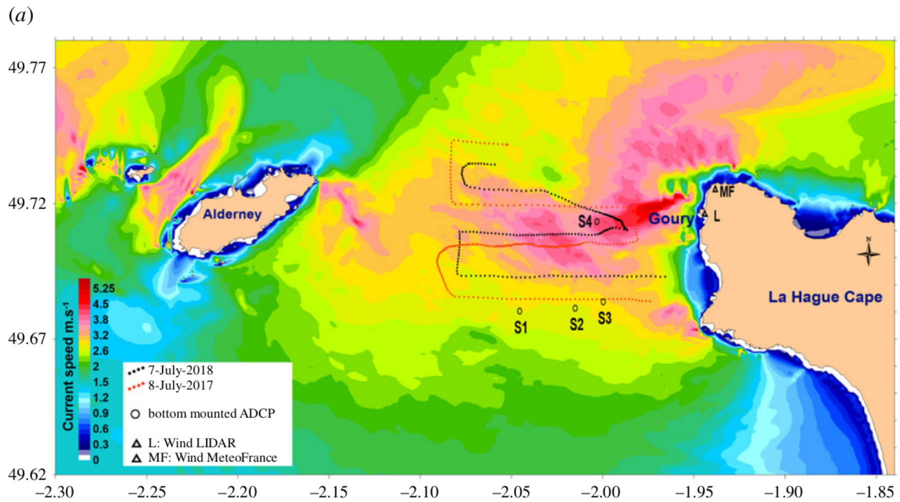

Figure 1: Locations of ADCPs from Hyd2M, mounted ADCP S1 to S4 shown by circles and towed ADCP transects shown by blue and red dots. The color shading indicates the maximum depth-averaged horizontal velocity computed by MARS-2D. Figure from : [4]

2018, towed and mounted ADCP were deployed in the Alderney Race as part of the Hyd2M project (see Figure 1), as well as HF radars on the coast [3]. These data are used to evaluate the model results. For the numerical part, the spectral wave model WAVEWATCH-III and the Coastal and Regional Ocean COmmunity model (CROCO) are coupled to include WCI. The January 2018 winter storm is chosen as the study period due to data availability and to ensure a diverse representation of hydrodynamic conditions. The model has already been configured and run for other periods, and the collection of necessary input data has been completed. The following steps involve running the coupled model and analyzing the results.

References

[1] A.-C. Bennis et al. “A winter storm in Alderney Race: Impacts of 3D wave–current interactions on the hydrodynamic and tidal stream energy”. In: *Applied Ocean Research* 120 (Mar. 2022), p. 103009.

[2] Alexei Sentchev et al. “Underway velocity measurements in the Alderney Race: towards a three-dimensional representation of tidal motions”. In: *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 378.2178 (Aug. 21, 2020), p. 20190491.

[3] Pascal Bailly Du Bois et al. “The Alderney Race: general hydrodynamic and particular features”. In: *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 378.2178 (Aug. 21, 2020), p. 20190492.

[4] L. Furgerot et al. “One year of measurements in Alderney Race: preliminary results from database analysis”. In: *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 378.2178 (Aug. 21, 2020), p. 20190625.