



University of Dundee

Numerical modelling of exchange flows through sea straits and across submerged sills

Grifoll, Manel; Cuthbertson, Alan; Berntsen, Jarle

Publication date: 2022

Document Version Peer reviewed version

Link to publication in Discovery Research Portal

Citation for published version (APA):

Grifoll, M., Cuthbertson, A., & Berntsen, J. (2022). Numerical modelling of exchange flows through sea straits and across submerged sills. Abstract from MASTS: Annual Science Meeting, Glasgow, United Kingdom.

General rights

Copyright and moral rights for the publications made accessible in Discovery Research Portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

Users may download and print one copy of any publication from Discovery Research Portal for the purpose of private study or research.
You may not further distribute the material or use it for any profit-making activity or commercial gain.
You may freely distribute the URL identifying the publication in the public portal.

Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Numerical modelling of exchange flows through sea straits and across submerged sills

Manel Grifoll^{1,2}, Alan Cuthbertson² and Jarle Berntsen³

¹ Department of Civil and Environmental Engineering, Universitat Politècnica de Catalunya (UPC-BarcelonaTech) <u>manel.grifoll@upc.edu</u> ² School of Science and Engineering, University of Durates Continuity of Science and Engineering

² School of Science and Engineering, University of Dundee, Scotland, UK. <u>a.j.s.cuthbertson@dundee.ac.uk</u>

³ Department of Mathematics, University of Bergen, Bergen, Norway.

Area being submitted to (delete as appropriate): 1. General Science Session

Preferred presentation medium (delete as appropriate): (i) oral

We may have one of the e-poster sessions as part of a wine reception on Tue 8th Nov. Would you be available for this? (Delete as appropriate): No.

Are you a student? (Delete as appropriate): No.

This study presents the application of ocean numerical modeling to gain understanding of the dynamics of exchange flows through sea straits and across submerged sills. The restricted density-driven exchange flows are generated in oceans, seas and coastal margins when adjacent water bodies with different densities are connected by narrow channels (i.e. straits) and/or natural topographic obstructions on the seafloor (e.g. submerged sills). Numerical model simulations, combined with scaled laboratory experiments, have proven to be a powerful tool to help understand the restricted oceanographic flow processes occurring within these complex regions.

We have conducted laboratory-scale numerical simulations using a non-hydrostatic 3-dimensional model (Bergen Ocean Model, referred to as BOM) in both non-rotating and rotating frames of reference (the latter considering Earth rotation effects through inclusion of Coriolis accelerations). These BOM simulations are shown to reproduce the main dynamic flow patterns and density structure of the large-scale exchange flows generated through an idealized trapezoidal sill-channel, with a lower layer saline intrusion (see sill-channel geometry in Figure 1). The numerical results also show that the saline intrusion flux across the sill is initially reduced and then eventually fully blocked under increasing netbarotropic flow conditions imposed in the counterflowing upper freshwater layer (Grifoll et al., 2022). The BOM simulations are also extended to consider rotating exchange flow dynamics, and demonstrate that the inclusion of Coriolis forces increases the overall blockage of the saline intrusion layer by the upper freshwater layer flow compared to equivalent non-rotating exchange flows. Based on these rotating exchange flow simulations, the numerical results reveal a distinct secondary crosschannel circulation pattern, characterized by Ekman dynamics in the lower dense water layer and the presence of two anticlockwise circulation cells in the upper freshwater layer. The strength and coherence of these secondary flow cells are also strongly controlled in the along-channel direction by the proximity of the overspill at the end of the trapezoidal sill-channel crest, with the significant increase in the densimetric Froude number (i.e. increase in inertial factors) at this location implying a relative decrease in the influence of rotation and dominance of non-hydrostatic flow effects.



Figure 1. (a) Schematic representation of the trapezoidal channel-sill including counterflowing lower saline Q_2 and upper freshwater Q_1 layers. (b) Numerical mesh used for the BOM simulations.

Acknowledgements

This work is supported by ECOBAYS project (MCIN/AEI/10.13039/501100011033) funded from the Agencia Española de Investigación (Spanish Research Agency).

References

Grifoll, M., Cuthbertson, A., Berntsen, J., (2022). Numerical experiments of uni- and bi-directional exchange flows in a rotating trapezoidal sill-channel Proceedings of the 39 th IAHR World Congress 19-24 June 2022.