

APPENDIX B. MEDITERRANEAN LAYER FROUDE NUMBER ESTIMATION

The internal Froude number for the lower Mediterranean layer in the simple two-layer model is

$$F_2^2 = \frac{u_2^2}{g'h} \quad [\text{B. 1a}]$$

where u_2 is the lower layer velocity, $g' = (\Delta\rho/\rho)g$ is the reduced gravity ($\Delta\rho$ the density difference between layers, ρ the lower layer density) and h the interface height for a non-rotating channel of constant width. For nonrectangular cross-section, h should be replaced by h_c , defined as the cross-area of the flow divided by the interface width (Henderson, 1966; Bryden and Kinder, 1991)

$$F_2^2 = \frac{u_2^2}{g'h_c} \quad [\text{B. 1b}]$$

Equation [B.1b] can be written in terms of the flow $Q_2 = Au_2$ (A the cross-area) and the *observed* interface height h .

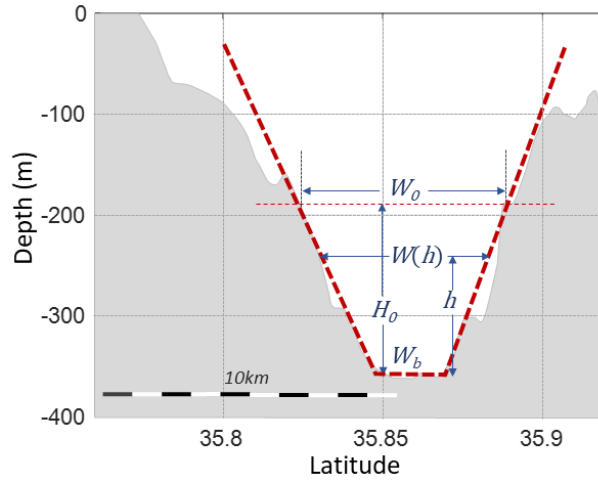


Figure B1. Cross-section of the south channel of Espartel Section and its trapezoidal shape approximation. The geometry has been chosen to match the cross-area below 150m, depth below which the interface is found more than 99% of the time. Horizontal, dashed red line is the mean depth of the interface (-187m), the bottom base of the trapezoid is at -360m, which gives $H_0 = 173\text{m}$.

Figure B.1 shows that the cross-section of Espartel south channel has trapezoidal shape below 150 m depth, in which case the appropriate equation for F_2 is [B.1b]. The trapezoid has width W_b ($\sim 2100\text{m}$) at the bottom and W_0 ($\sim 7000\text{m}$) at H_0 ($\sim 173\text{m}$), the mean height of the interface estimated from the observations. The channel width W and the cross area A at height h are

$$W(h) = W_b + ch, \quad [\text{B. 2}]$$

$$A(h) = W_b h + \frac{ch^2}{2} \quad [\text{B. 3}]$$

where $c = \frac{W_0 - W_b}{H_0}$

Replacing $h_c = A(h)/W(h)$ and $u_2 = Q_2/A(h)$ in [B.1b] and making use of [B.2] and [B.3], the Froude number in terms of the outflow Q_2 and interface height h is

$$F_2 = \frac{Q_2(W_b + ch)^{1/2}}{(W_b h + 0.5ch^2)^{3/2} g'^{1/2}} \quad [\text{B. 4}]$$

REFERENCES APPENDIX B

Bryden, H.L., and T.H. Kinder (1991). Steady two-layer exchange through the Strait of Gibraltar. *Deep-Sea Res.*, 38, S1, S445-S463. [https://doi.org/10.1016/S0198-0149\(12\)80020-3](https://doi.org/10.1016/S0198-0149(12)80020-3)

Henderson, F.M. (1966). *Open channel flow*. MacMillan, New York, 552 pp.