# THE COUNT-DOWN FOR CALCIFIERS TO DISSOLVE IN WATER MASSES OF THE STRAIT OF GIBRALTAR


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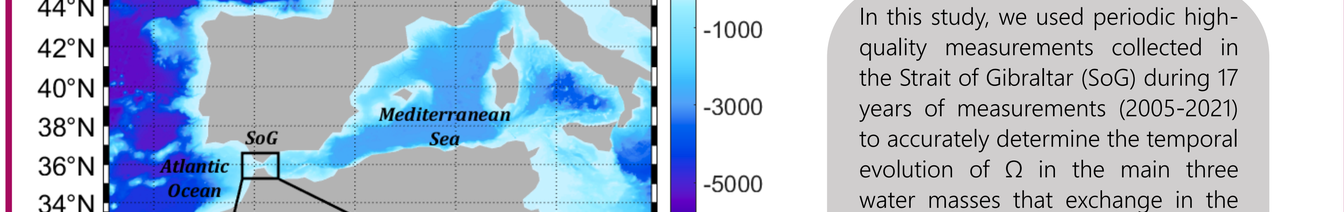
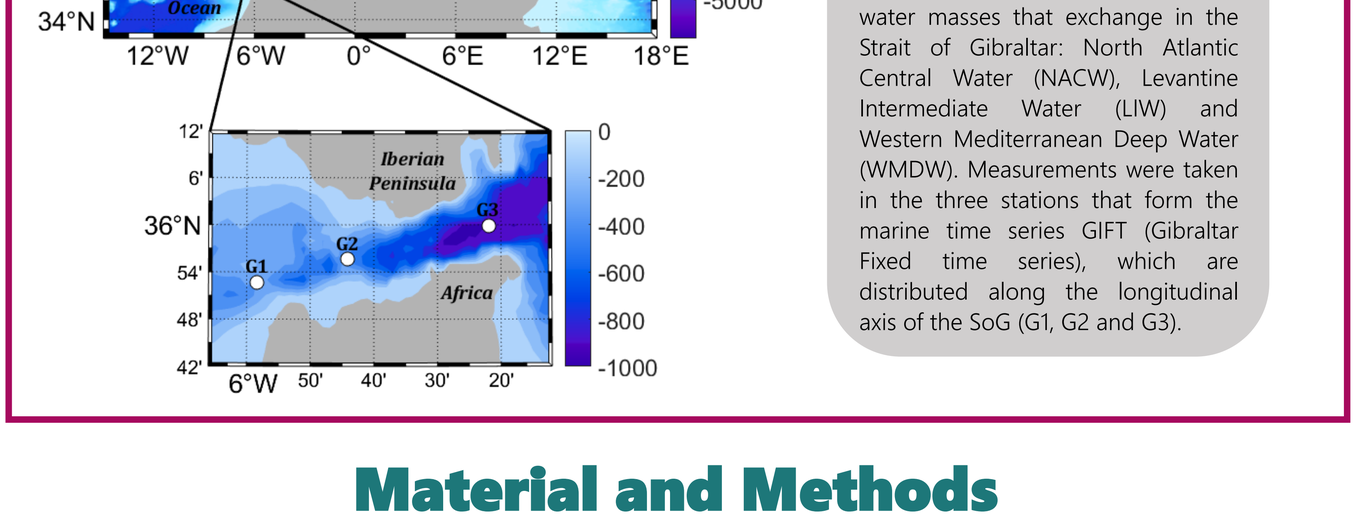
## Introduction

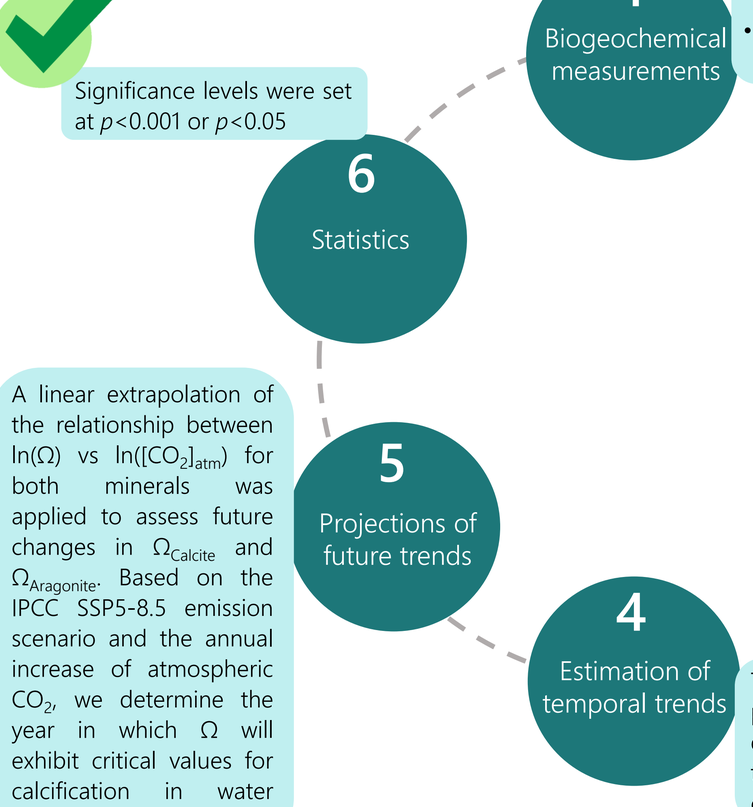
The ocean plays a significant role as a sink for anthropogenic carbon dioxide ($CO_2$) (Sarmiento & Gruber, 2002). When the $CO_2$ molecule enters the ocean, it hydrates and forms carbonic acid, which is a weak acid that tends to dissociate water producing hydrogen ions. As a result, the concentration of hydrogen ions ([$H^+$]) in the seawater steadily increases, leading to ocean acidification and a decrease in the concentration of $CO_3^{2-}$, which is essential for marine calcifying organisms to form their skeletons and shells. The decline of carbonate ions severely affects the biogenic calcification process (Doney et al., 2020).




Calcification can be assessed through the estimation of the saturation state of calcium carbonate minerals (Ω). Values of Ω for calcite ($\Omega_{Calcite}$) and aragonite ($\Omega_{Aragonite}$) higher than 1 indicate favourable conditions for calcification to proceed whereas values of Ω lower than 1 denote corrosive conditions for calcifiers (Doney et al., 2009). Nevertheless, biogenic calcification is also affected by other factors (Melzner et al., 2020). In fact, Ω=1.5 has been considered to define negative consequences for marine ecosystems even at a planetary scale (Broadgate et al., 2013; Ekstrom et al., 2015; Gruber et al., 2012; Zhai, 2018) and it has been adopted as a critical value that allows a proper calcification by marine organisms.




## Study area



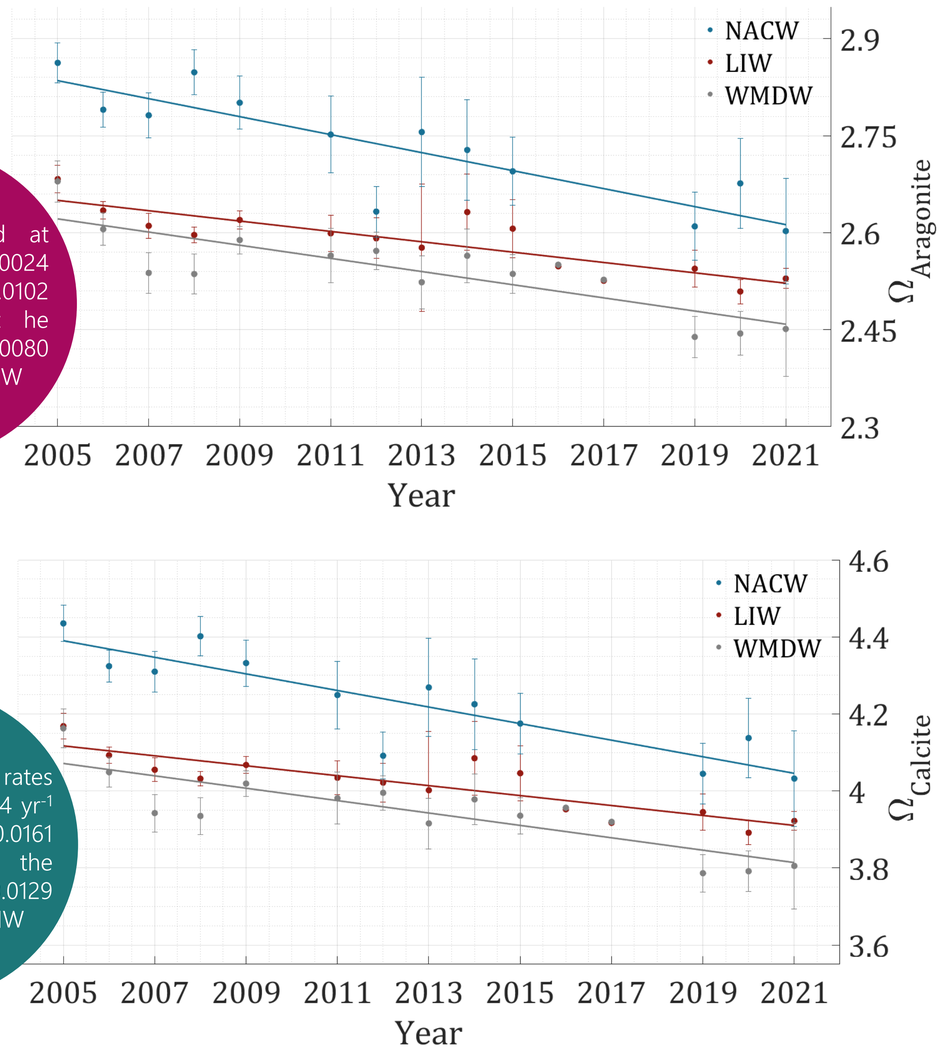

In this study, we used periodic high-quality measurements collected in the Strait of Gibraltar (SoG) during 17 years of measurements (2005-2021) to accurately determine the temporal evolution of Ω in the main three water masses that exchange in the Strait of Gibraltar: North Atlantic Central Water (NACW), Levantine Intermediate Water (LIW) and Western Mediterranean Deep Water (WMDW). Measurements were taken in the three stations that form the marine time series GIFT (Gibraltar Fixed time series), which are distributed along the longitudinal axis of the SoG (G1, G2 and G3).

## Material and Methods



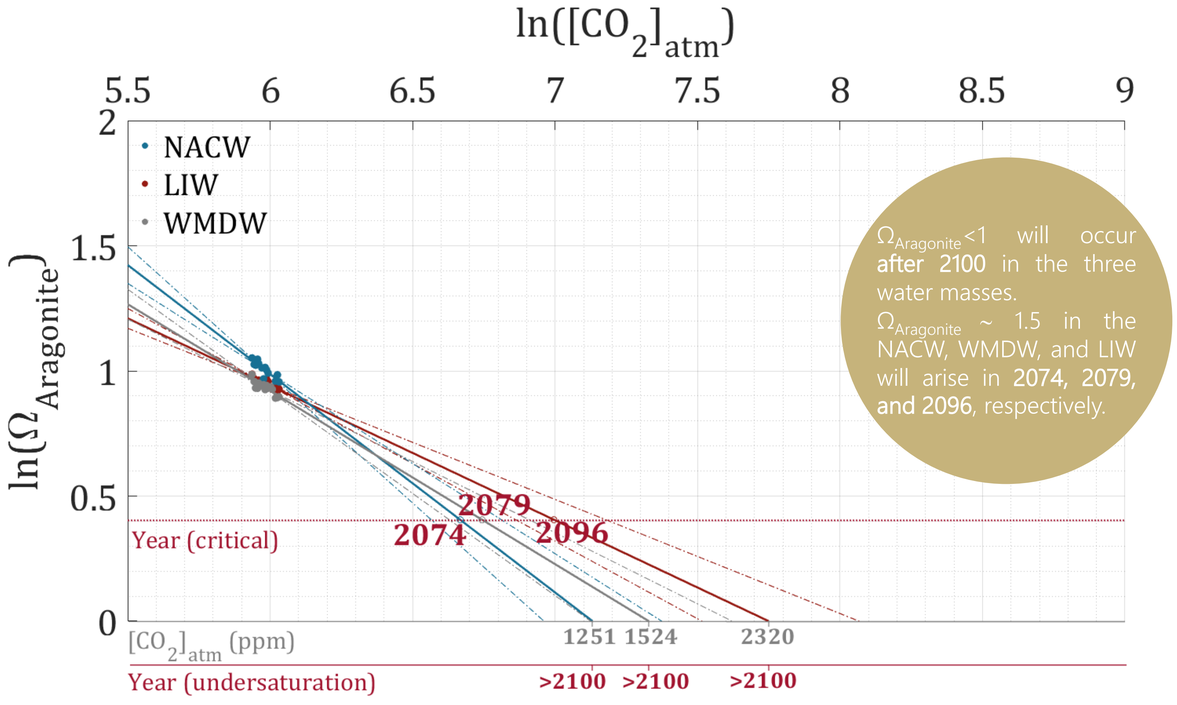

## Results

$\Omega_{Aragonite}$ decreased at rates of -0.0139 ±0.0024 $yr^{-1}$ in the NACW, -0.0102 ±0.0019 $yr^{-1}$ in t he WMDW, and -0.0080 ±0.0013 $yr^{-1}$ in the LIW

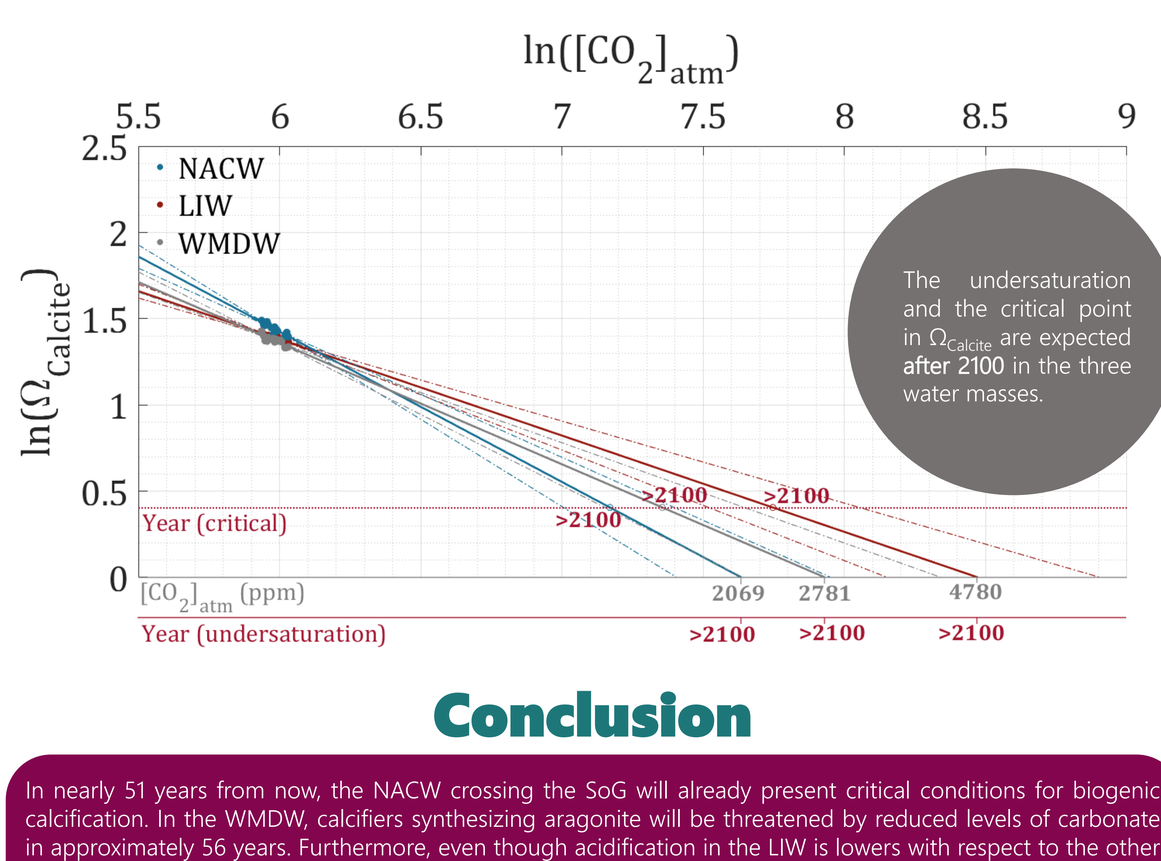



$\Omega_{Calcite}$ decreased at rates of -0.0215 ±0.0034 $yr^{-1}$ in the NACW, -0.0161 ±0.0029 $yr^{-1}$ in the WMDW, and -0.0129 ±0.0021 $yr^{-1}$ in the LIW




$\Omega_{Aragonite}$<1 will occur after 2100 in the three water masses.
$\Omega_{Aragonite}$ ~ 1.5 in the NACW, WMDW, and LIW will arise in 2074, 2079, and 2096, respectively.




The undersaturation and the critical point in $\Omega_{Calcite}$ are expected after 2100 in the three water masses.

## Conclusion

In nearly 51 years from now, the NACW crossing the SoG will already present critical conditions for biogenic calcification. In the WMDW, calcifiers synthesizing aragonite will be threatened by reduced levels of carbonate in approximately 56 years. Furthermore, even though acidification in the LIW is lowers with respect to the other two water masses, an unfavourable scenario for calcification is expected to occur in 73 years. Due to the lower solubility of calcite in seawater compared to aragonite, unfavourable conditions with respect to this mineral will arise later. Therefore, if $CO_2$ emissions continue to progress according to the IPCC SSP5-8.5 scenario, over the next century the water masses exchanging in the SoG will not support the chemical environment required for survival of marine calcifiers.

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