The Impacts of pH on Biodiversity in Marine Environments

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Background

Climate change continues to impact each and every environment on Earth due to rising levels of greenhouse gasses. CO2 is the most pervasive of these gasses, and when mixed with seawater it creates carbonic acid increasing the pH of water. Ocean acidification has led to large-scale die-offs of more sensitive marine species like coral; therefore, this project serves to evaluate the interaction between pH and the biodiversity of coastal marine environments.

Fig 1. A shell placed in seawater with increased acidity slowly dissolves over 45 days. (NSF)

Fig 2. Coral Bleaching in response to rapidly shifting water quality (WWF)

Methods

Species identifications have been performed by European Marine Observation and Data Network throughout the Mediterranean sea since the 1980s. These identifications were mapped (Fig. 3) and used to calculate Biodiversity, a measure of species richness divided by species evenness. (richness/evenness = Biodiversity index) pH was determined using Using water quality data from European Environment Agency. This data was then processed in R to measure the interaction between biodiversity and pH.

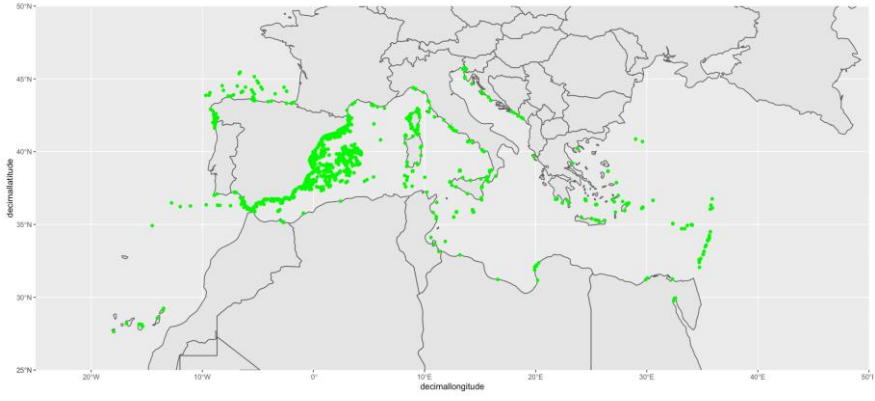
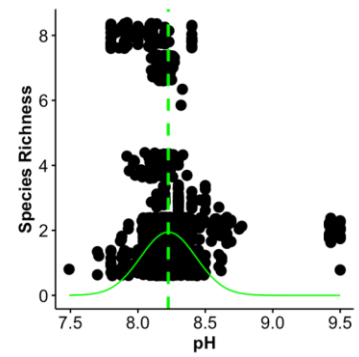
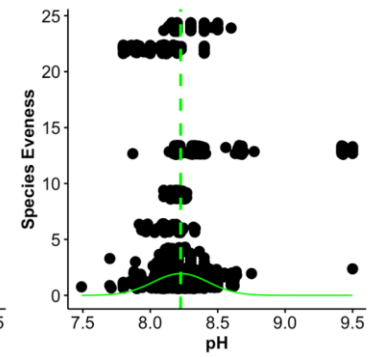


Fig 3. Map of the Mediterranean Sea with points depicting the location of each species identification (EMODnet)

Results

The pH of marine environments significantly impacted biodiversity in the Mediterranean sea. (LMM, x2 = 1602.7, df = 0, p-value < 0.001 The pH of the water also led to variation in species richness (Fig. 4) and species evenness (Fig. 5). When pH data is grouped into “High”, “Low”, and “Safe”, “Safe” pH levels correspond with a high mean Biodiversity index. “High” and “Low” pH levels correspond to a lower mean Biodiversity index.





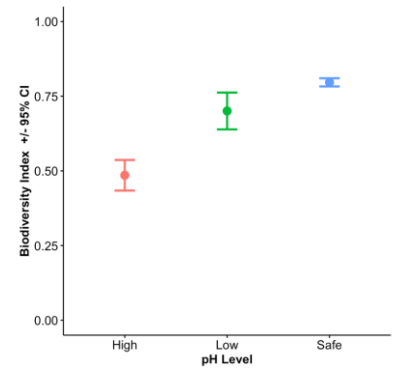


Fig. 4 Species Richness compared to pH with mean pH and normal curve
Fig. 5 Species Evenness compared to pH with mean pH and normal curve

Fig. 6 The biodiversity index grouped pH level with ±95% CI. (High > 8.4, 8.4 > Safe > 8.0, low < 8.0)

Conclusion

The pH of a marine environment was found to be and potential indicator for Biodiversity. Changes in marine pH have been demonstrated to impact the Biogeochemistry of the entire environment. Increasing acidity causes free carbonate(CO_3^{-2}) ions to react with free-floating Hydrogen (H+) forming bicarbonate ions (HCO_{3-}). bicarbonate ions are inaccessible to the benthic organisms that carbonate ions and calcium (Ca^{+2}) ions to build their calcium carbonate ($CaCO_3$) shells. (ie. Clams, snails, corals) Reduced levels of biologically accessible carbonate ions will inhibit the growth of the calcium carbonate shells, this would impact the biological fitness of entire populations and if unchecked could lead to large dies-offs of the benthic community.

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References

EEA. 2022 Apr 7. Waterbase - Water Quality ICM. European Environment Agency. https://www.eea.europa.eu/data-and-maps/data/waterbase-water-quality-icm-1

EMODnet. 2022 Data Portal | emodnet biology. Portalhttps://www.emodnet-biology.eu/portal/index.php?dasid=2144

NSF. 2012 Sep. Ocean acidification: Finding new answers through National Science Foundation Research Grants. National Science Foundation. https://www.nsf.gov/news/news_summ.jsp?org=NSF&cntn_id=125523&preview=false