Emiliania huxleyi calcite mass variability during periods of atmospheric CO_2 rising in the Mediterranean Sea

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Aim of this study

The coccolithophores play a significant role in both the marine food web and the carbon cycle. They are responsible for the photosynthetic fixation of inorganic carbon, regulating the particulate inorganic-organic carbon ratio and a large portion of the calcium carbonate ($CaCO_3$) production. It is challenging to understand how the current rising of atmospheric CO_2 concentration and the subsequent change in carbonate chemistry (i.e. ocean acidification) will impact the marine calcifying organisms.

Material and Methods

A total of 311 samples were used to estimate the calcite mass of *Emiliania huxleyi* from Mediterranean surface sediments and sedimentary cores that cover the industrial age, the Holocene, the last glacial-inter-glacial transition and the marine isotopic stage (MIS)

Sampling sites

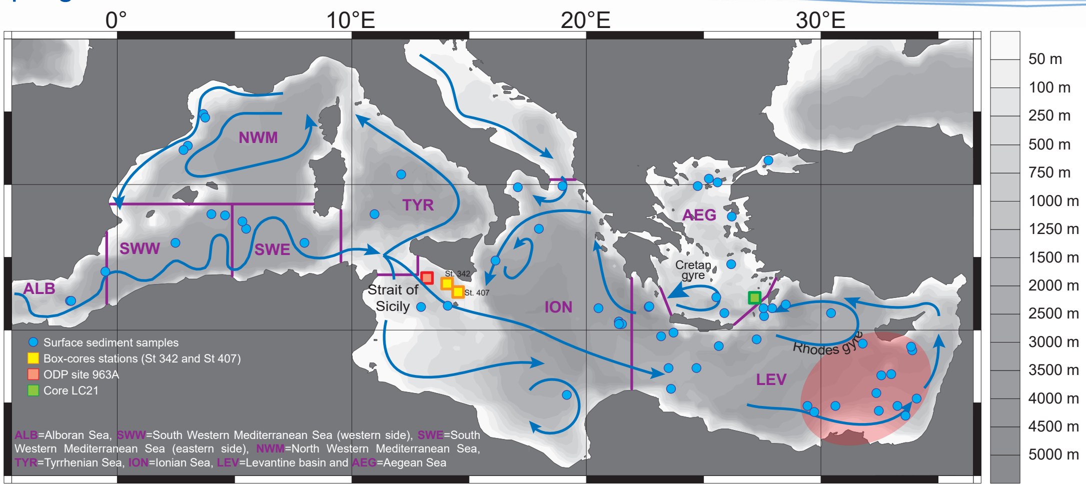


Figure 1: Distribution map of the sampling sites. The blue arrows represent the main patterns of surface water circulation. The Mediterranean sea is divided into 8 sub-basins delimited by the purple lines. The red lihgt area shows the samples of the extrem eastern Mediterranean Sea that were excluding from Figure 2c.

From the surface sediment : what possibly controles the calcite mass of *E. huxleyi* ?

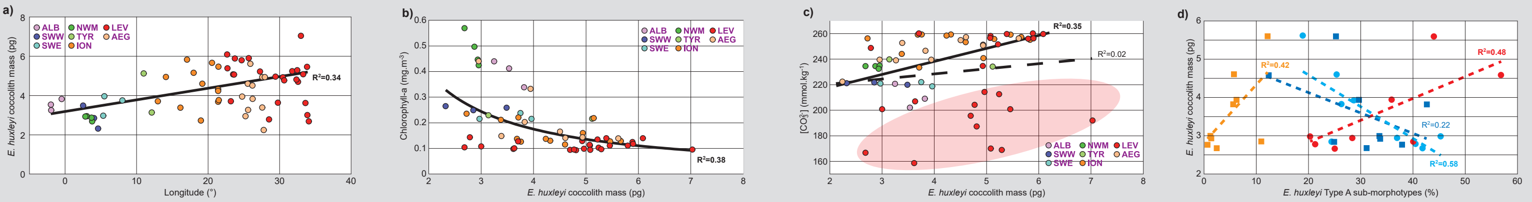
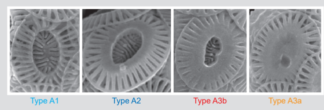


Figure 2: a) Distribution of *E. huxleyi* coccolith mass according to the longitude. b) Relation between *E. huxleyi* coccolith mass and [Chl-a] from satellite imagery (Feldman and McClain, 2011). c) Relation between *E. huxleyi* coccolith mass and the concentration of carbonate ion [CO_3^{2-}] extracted from the "Global Alkalinity and Total Dissolved Carbon Estimates" dataset (Goyet et al., 2000). The dashed line shows the linear regression including all the samples. The black line shows the linear regression excluding the samples of the extrem eastern Mediterranean Sea highlighted by the light red box (see Figure 1). In all graphes, the coloured symbols refer to the different sub-basins depicted in figure 1. d) Relation between the relative abundances of *E. huxleyi type* A sub morphotypes in the sediment of the Mediterranean Sea and the average calcite mass of *E. huxleyi* (light blue: undercalcified type (A1), dark blue: normally calcified type (A2), red: overcalcified type with open crentral tube (A3b), orange: overcalcified type with closed central tube (A3a). A picture of each sub-morphotype is given below (images cortesy of Barbara d'Amario). All the R^2 values set in bold are significant (p=0.05).



Increase of *E. huxleyi* calcite mass from the west to the east, with higher values in the Ionian Sea and the Levantine basin (Figure 2a).

Higher *E. huxleyi* calcite mass where the surface productivity is lower, such as in the Ionian Sea and the Levantine Basin (Figure 2b).

No clear relation between *E. huxleyi* calcite mass and [CO_3^{2-}], unless the samples of the extrem eastern Mediterranean Sea are excluded (Figure 1 and 2c).

The relative abundance of the different sub-morphotypes seems to clearly influence the average mass of *E. huxleyi* (Figure 2d).

Box-cores St. 342 and St. 407

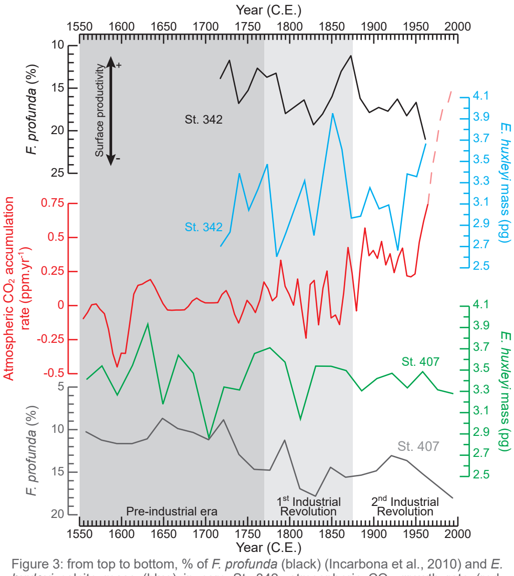


Figure 3: from top to bottom, % of *F. profunda* (black) (Incarbona et al., 2010) and *E. huxleyi* calcite mass (blue) in core St. 342, atmospheric CO_2 growth rate (red, extrapolated from Etheridge et al., 1998), *E. huxleyi* calcite mass (green) and *F. profunda* % (grey) in core St. 407.

ODP site 963A

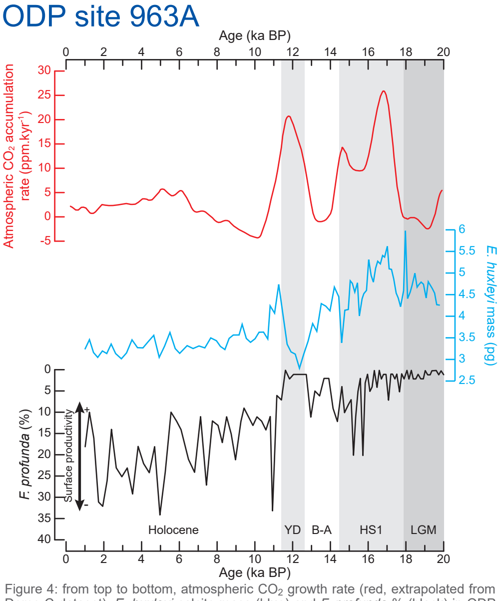


Figure 4: from top to bottom, atmospheric CO_2 growth rate (red, extrapolated from Dome C dataset), *E. huxleyi* calcite mass (blue) and *F. profunda* % (black) in ODP site 963A.

Core LC21

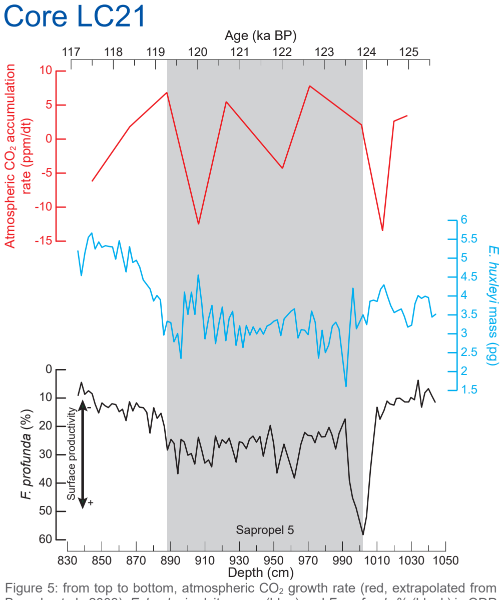


Figure 5: from top to bottom, atmospheric CO_2 growth rate (red, extrapolated from Barnola et al., 2003), *E. huxleyi* calcite mass (blue) and *F. profunda* % (black) in ODP site 963A.

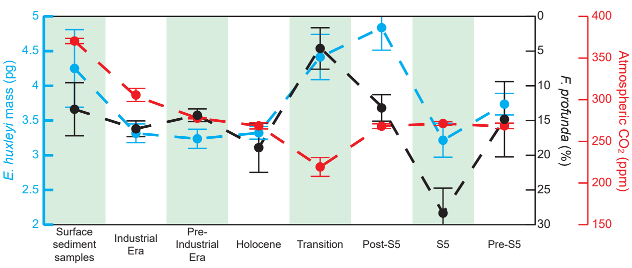


Figure 6: Summary of the data presented in this study. For each parameter, each symbol represents the average for the concidered period: *E. huxleyi* calcite mass (blue), % of *F. profunda* (black) and atmospheric CO_2 (red). The error bars represent the 1σ.

Main conclusions

During the periods of rising atmospheric CO_2 (last glacial - interglacial transitions) the main factor controlling the average *E. huxleyi* calcite mass is likely changes in *E. huxleyi* productivity and growth rates.

During the most recent periods (Figure 3), in the shallow water sediments of the two box-cores retrieved off Sicily, the average calcite mass of *E. huxleyi* appears to be controlled by a combination of multiple drivers, including seawater carbonate chemistry characterizing the industrial era, the surface productivity and the possible impact of coastal runoff.

The surface sediments from the entire Mediterranean Sea (i.e. covering the last 50 - 800 years depending on the sedimentation rates) demonstrate that *E. huxleyi* mass distribution depends on the different type A sub-morphotypes (Figure 2d). The large range in surface water carbonate chemistry seems to be an important factor controlling their distribution (Figure 2c). In the region affected by the Nile River, productivity (via nutrient inputs) could be key to explaining their mass (Figure 2b).

The overall results of this work (Figure 6) show that the rate of atmospheric CO_2 accumulation is key for understanding the impact on *E. huxleyi* calcite mass. In pre-industrial time *E. huxleyi* calcite mass is mainly controlled by primary production, followed by seawater carbonate chemistry in recent periods in areas characterized by a large variability in [CO_3^{2-}].

Acknowledgement

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References

Barnola et al., 2003. Historical CO_2 record from the Vostok ice core. In Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A.

Icarbona et al., 2010, The Impact of the Little Ice Age on Coccolithophores in the Central Mediterranea Sea, Climate of the Past, 6, 6, 795-805.

Etheridge et al., 1998. Historical CO_2 records from the Law Dome DE08, DE08-2, and DSS ice cores. In Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A.

Feldman and McClain, 2011, Ocean Color Web, CZCS, OCTS and SeaWiFS Reprocessing 5, edited by N. Kuring, Bailey, S. W., NASA Goddard Space Flight Center.

Goyet et al., 2000, Estimated alkalinity and total dissolved inorganic carbon, http://odv.awi.de/en/data/ocean/global_alkanity_tco2/