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Interactive comment on "Is coccolithophore distribution in the Mediterranean Sea related to seawater carbonate chemistry?" *by* A. M. Oviedo et al.

Anonymous Referee #1

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The contribution by Oviedo, Ziveri, Álvarez and Tanhua entitled "Coccolithophore distribution in the Mediterranean Sea", brings a very interesting and novel dataset dealing with the ecology notably of coccolithophores in the context of a particularly oligotrophophic region. The detailed taxonomical and ecological analysis of coccolithophores in both diploid and haploid life-stages, and its relation with the other main phytoplankton groups is of great interest to broaden the knowledge of marine phytoplankton dynamics and to calibrate the coccoliths as environmental proxies in the Mediterranean Sea. Given the importance of coccolithophores in both organic and inorganic carbon pumps, therefore capable of both influencing and being influenced by climate change, investigating their relationship with seawater carbonate chemistry is

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particularly pertinent in our days. Being a naturally oligotrophic environment and an important storage of the global anthropogenic emissions of CO2, the Mediterranean Sea appears to be a specially suited location to investigate this group and to make inferences on the impact of ocean's acidification on coccolithophores.

All this fits the aim of the journal Ocean Science.

The manuscript is very well written, organized, focused and easy to follow. I believe that this manuscript is valuable contribution for the understanding of the coccolithophorid ecology and of the Mediterranean ecological dynamics. The study also benefits from a multi-proxy approach, which is fundamental to achieve a clearer understanding of the factors driving the productivity and distribution of coccolithophores. I recommend that it should be published in the journal Ocean Science, either due to the relevance of the topic under study, the remarkable geographical data set that is being provided, and the quality and clearness of its contents. Still, I have a few suggestions that may help to improve the final version of the manuscript.

1. General comments

- A general description of the regional settings could be added, describing the seasonality, wind regime, main water masses, currents and river discharge regime of the Mediterranean Sea. Despite of the large-scale of this study and the fact that the samples appear to have been collected along the deeper part of the Mediterranean Sea, you are dealing with a relatively small and land-locked ocean basin with a complex coastline and topographic relief where the phytoplankton dynamics may be highly influenced by the presence of gradients along the coastal-neritic-oceanic transition (see Bakun and Agostini, 2001). This part could be added as part of the introduction or as a separate section called "Regional settings". A figure nicely illustrating the main currents and water masses would also be welcome.

- Even though there is no doubt that the Mediterranean Sea is, on average, an oligotrophic environment (and especially the eastern part), it would be interesting to inves-

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tigate how much short-term variability there is. The authors should explicitly take into account that their observations represent a 23 days' snap-shot of something that is expectedly highly variable in 3-D space as well as in time, and that short-term variability may well mask any relationship with long-term average oceanographic gradients. For this, contextualizing of the cruise in terms of seasonal and oceanographic characteristics of the Mediterranean Sea would be welcome. A short description of the meteorological and oceanographic conditions prevailing during the cruise could be provided in order to give a clearer picture on the environmental conditions at the time of the sampling, and to clearly demonstrate that conditions did not vary significantly in space and time. This is particularly important when dealing with seawater samples collected from areas influenced by land where environmental conditions may vary very quickly, with major consequences to the productivity, composition and distribution of phytoplankton. In case it is not possible to acquire such data, the authors should at least discuss these limitations of the study in the manuscript.

- Since conditions may vary significantly in only 28 days, and given that the factor "light" was not considered in this study, I would be more cautious when inferring the relatively higher importance of seawater chemistry in coccolithophorid ecology in comparison to light and nutrients. In a recent regional study west off Portugal, light was observed being the triggering factor of a coccolithophore bloom within a few days, under eutrophic conditions near the coast (Guerreiro et al., 2013).

- This study would benefit from a figure representing the variation of sunlight (cloud coverage) and chl-a concentration during the cruise, which could be achieved with data from satellite imagery. For example, building a west - east transect representing the daily averaged value of the two proxies vs. longitude. Such plot would provide a more robust background for the period under study and at the same time, providing a more accurate term of comparison in terms of phytoplankton productivity between the two margins of the Mediterranean Sea during the cruise.

2. Specific comments

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Introduction

- The introduction is very well written and the study certainly brings a very considerable input concerning the taxonomy and distribution of coccolithophores in the Mediterranean Sea, especially concerning its haploid stage life and relationship with seawater carbonate chemistry. But I would avoid generalizing too much 23 days of seawater sampling along 28 stations to an entire up-to-date state of the art for the coccolithophores from this region (page 616, paragraph 25), especially considering that the discussion does not take into account the short-term variability (in space and time) related to the meteorological and oceanographic dynamics of the Mediterranean Sea. For example, differences between the present study and those presented by Ignatiades et al. (2009) concerning the distribution of the main phytoplankton groups along the Mediterranean Sea for the month of June (1999) suggest the occurrence of interannual variability for phytoplankton, which is not possible to address with the present data-set.

Material and Methods

- I would maybe divide section 2.1. "Hydrography and phytoplankton" in two separated sections called "Sampling" and "Phytoplankton analysis". Methods concerning the hydrography are actually described in section 2.2. Environmental parameters.

- It is not completely clear if you are also referring to the counts when you refer that hetero- and holoccolithophores were treated separately. In case they were counted separately, please provide the minimum and maximum number of counts for each.

- It is not clear which samples are represented in Figure 2, although I assume that they concern the W-E transect along the Mediterranean Sea.

- The coordinates, date, depth and analyzed proxies of each station should be provided in a table.

Results

- Page 620, section 3.1: It would be interesting to take this great opportunity to explore

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in more detail the relationship between the main phytoplankton groups and the environmental parameters during the sampling period, instead of only taking into account the larger-scale W-E physicochemical parameters and reporting to the full description of the settings presented by Tanhua et al. (2013b) and Álvarez et al. (2013).

- Page 620, P.15: I think that this agreement between your in-situ measurements and the satellite data would be better demonstrated if you would use a map showing an averaged Chl-a concentration for each station, instead of generalizing 4 days of satellite data for the 23 days of the cruise. This way you would be providing information on the spatial and temporal variability of Chl-a production during the sampling period. It would also allow you to more accurately compare different sectors/basins within of the Mediterranean Sea, thereby providing a more robust basis from which you could compare your in-situ measurements.

- Page 620, P. 15-20: "coccolithophores were the most abundant group during the sampling, in all main Mediterranean basins (68-99%)". This remarkable result somewhat contradicts previous observations from Ignatiades et al. (2009) reporting the dominance of diatoms in the west and of dinoflagellates+coccolithophores in the east, during the month of June 1999. You should discuss this difference in the manuscript.

- Page 621, P. 15: "Some of these species were negatively correlated to phosphate concentrations and only D. tubifera showed a high positive correlation with temperature". Please specify which species were negatively correlated with phosphate.

- D. tubifera is not correctly written.

- Page 621-622: The spatial and vertical distribution of the species within Group 1 and Group 3 are mentioned in the text, but not Group 2.

- Page 621, P.25: Labels for the main basins should be given in Figure 1.

- The section "Results" is focused and well written but I have the general feeling that it may be perhaps too much "succinct" and therefore could be extended and more de-

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tailed. For instance, you don't characterize the meteorological conditions during the cruise and you almost don't refer the relation between the species and the environmental parameters (their geographic and vertical variation).

Discussion

Main phytoplankton community

- Page 623, P. 5: the names of the basins and seas should be indicated in Figure 1.

- "This study documents the dominance of coccolithophores in the phytoplankton community (Fig. 3), including the ultra-oligotrophic eastern region where nutrients concentrations fell below detection limits"... for the period under study.

- Page 623, P. 10-15: "Even though only reached at the Gibraltar Strait, the highest cell density of coccolithophores was 1–2 orders of magnitude higher than for the other phytoplankton groups." This sentence is not completely clear to me...

- Page 624, P. 1: "However, a threshold in nutrient concentrations, below which coccolithophores would perform better than other groups in a competitive scenario; would affect their populations". You mean that under oligotrophic conditions, coccolithophores are in advantage to compete for the available nutrients in comparison to the others phytoplankton groups?

- Page 624, P.10: "We suggest that the relative success of coccolithophores over diatoms, dinoflagellates and silicoflagellates during April 2011 in all Mediterranean Sea basins, can be due to a combination of environmental parameters rather than nutrients and turbulence alone." But in the following chapters you mostly discuss the influence of seawater chemistry in the distribution/diversity of coccolithophores, but not as being the cause of the remarkable dominance of coccolithophores over diatoms and dinoflagellates.

Heterococcolithophoes and holococcolithophores

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- This section is perhaps too long and dealing with too many different and complex aspects. It could be re-organized in separated sections, such as: 4.2. Heterococcolithophores: species assemblages and relationship with the environmental settings 4.3. Heterococcolithophores versus holococcolithophores.

- Page 624, P.25: “it is therefore plausible that the availability of the necessary resources of carrying out calcification should facilitate coccolithophore’s growth in the ocean”. Which resources are those? Please be more specific.

- Page 626, P.25: “Overall, we suggest CO3-2 and pH as functionally related important variables in explaining heterococcolithophore distribution in the Mediterranean Sea.” It remains unclear the reason behind the remarkable dominance of coccolithophores over diatoms and dinoflagellates, especially in the western nutrient-richer part of the Mediterranean Sea. Is it because the Mediterranean Sea is generally enriched with CO3-2 in comparison with other marine environments?

Conclusions

- This part could be slightly extended, while succinctly referring in what manner was the seawater chemistry important in the distribution of heterococcolithophores, and what were the distinct environmental parameters influencing the distribution of the two life stages. It could also be mentioned the remarkable dominance of coccolithophores over diatoms and dinoflagellates.

Figures

Figure 1 – The Chl-a image represents an averaged Chl-a concentration at the sea surface for the days 27, 18, 14 and 8 of April? As mentioned above, you should clearly demonstrate that conditions did not vary significantly during the cruise before generalizing 4 days of Chl-a data for a period of 23 days covering the entire length of the Mediterranean Sea. The map is lacking labels indicating the names of the main basins and seas.

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Figure 7 – It is interesting to note that the deeper species do not present a clear W-E gradient as in the case of the other two heterococcolithophore groups. You think it is because they are relatively more dependent of nutrients' availability than of seawater carbonate chemistry?

References

Bakun, A., Agostini, V.N., 2001. Seasonal patterns of wind-induced upwelling/downwelling in the Mediterranean Sea. Sciencia Marina 65, 243-257.

Guerreiro, C., Oliveira, A., De Stigter, H., Cachão, M., Sá, C., Borges, C., Cros, L., Quaresma, L., Santos, A.I., Fortuño, J.M., Rodrigues, A. (2013). Late winter coccolithophore bloom off central Portugal in response to river discharge and upwelling. Continental Shelf Research 59, 65 - 83.

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