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Interactive comment on "The Mediterranean is getting saltier" *by* M. Borghini et al.

M. Borghini et al.

h.bryden@noc.soton.ac.uk

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Overall response to both Reviewers 1 and 2

We thank the reviewers for their comments on our manuscript. The basic aim of the manuscript as stated in the Abstract was to show that there are 2 main processes that lead to higher salinities in the deep western Mediterranean Sea. The 2 processes are salt finger processes that transport heat, salt and density downwards below the core of Levantine Intermediate Water at about 400 m depth into the deep water and deep water formation events that sporadically inject new water properties into the deep ocean. We describe these processes using selected hydrographic stations and we try to compare their relative magnitudes in effecting the observed changes in deep salinity.

It was not our intention for this paper to make rigorous estimates of salinity change that would have required extensive analysis of thousands of historical profiles. Rather

we concentrate on using recent results quantifying salt finger fluxes and recent results on deep water formation events to compare the role of the processes in the observed increases in salinity of the deep water.

In the revised manuscript, we have made changes following Reviewers suggestions in Sections 1, 2 and 3; and we have done a major rewrite of the Discussion in Section 4 to focus the later stages of the paper on the two main processes and their implications for deep changes. Our reading of both Reviews is that the original Discussion section caused most of the problems for the Reviewers with respect to focus, clarity, and steady state assumptions. In the new Discussion, we have tried to avoid adding new material or drifting into extraneous topics and instead we now concentrate on the implications for the 2 processes in the observed salinity increase in the deep Mediterranean. We believe this focus improves the clarity of the entire manuscript. At the end, we have clearly stated that the Mediterranean is not in "steady state" and made some remarks on outstanding problems this lack of steady state condition causes for traditional understanding of Mediterranean circulation.

We upload the New Discussion as a Supplement

Specific responses to Reviewer 1:

1. We have now added uncertainties in reported temperatures and salinities in the text and in the Captions for Tables 1 and 2. We indicate what effect these uncertainties have on estimating differences

2. As stated in our response, we are trying to show indicative changes in temperature and salinity. We are not attempting an extensive analysis of historical stations.

3. The Discussion has been rewritten to eliminate confusion in the results.

4. We have not made a Table of estimated changes. We have listed the indicative changes in the text (with uncertainties) and we have tried to be consistent in reporting the changes in units per decade.

P736 L2: We now use 47 years

P737 L16: we now use "eg" rather than "most"

P737 L20: 0.04 salinity change is the model result by Skliris and Lascaratos (2004). The 0.13 salinity change is the projection by Rohling and Bryden (1992) for the salinity increase needed for the maximum exchange at Gibraltar to balance the higher net evaporation.

P738 L1: We do not know when "this LIW transited the Sicily Channel". Gacic et al (2013) estimated a 15 year transit time for the LIW to transit from Sicily Channel to Gulf of Lion but we think the exact time scale is more uncertain than that. The large deep water formation event occurred in winter 2005-06. There was another more minor event in 2012 reported by Durrieu de Madron et al. We think there were no other "major" deep water formation events between 1995 and 2012.

P738 L23: We have defined LIW and WMDW in the Captions for Figures 2 and 3. Their exact definition in salinity and temperature values as well as in depth range varies from year to year so in our view statistics would confuse rather than clarify.

P739 L2: We have now stated uncertainties in temperature and salinity and in their differences across expeditions, and we try to describe differences in units per decade

P739 L5: We have now noted the consistency with Nof and we have compared the heat gain with IPCC estimates of global warming.

P739 L9-Â■âĂŘ13: These profiles are complex and require careful examination. We emphasise the major change in the waters between the bottom of the halocline-thermocline and the top of the deep water. It is easy to see, difficult to quantify but that is done in the Bryden et al 2014 paper.

P739 L23-Â■âĂŘ24: the relation to Rohling and Bryden's argument is complicated and is dealt with in the new Discussion

P739 L25: The repeated surveys for stations 4 to 17 were used by Bryden et al (2014) to quantify the salt finger fluxes. Only station 9 is illustrated here.

P740 L7 We include uncertainties and use "significant" only rarely

P740 10-Â■âĂŘ13 Both. Schroeder is one of the authors here.

P740 L14-Â■âĂŘ16 Figure 3 is a new figure for this paper. The values are consistent with Schroeder et al's reported results for stations up to 2008.

P740 L16: We think the initial arrival of a thin layer of new deep water occurred in late 2005 less than a year after its formation, but that the complete arrival of the new deep water layer occurred after the 2006 survey so it took about 18 months to arrive completely. The arrivals were different at the different stations 4 to 17 as explained in Bryden et al (2014).

P740 L26 - P741 L4: Your Table does agree with the values we report. Because our analysis is indicative rather than comprehensive, we prefer not to present such a definitive summary of trends. In our discussion, we are trying to calculate the changes a) in the deep water layer below about 2200 dbar and b) in the layer between the bottom of the halocline-thermocline and the top of the deep water where salt finger transports are visible and quantifiable (Bryden et al (2014). Dyfamed station has an effective bottom depth of 2000 m. Thus it is difficult to make the depth ranges consistent across different locations and years. Station 9 represented the clearest example of the increasing of the temperature and salinity in the layer between the bottom of the halocline-thermocline and the top of the deep water, but the estimates of salt finger salt and heat fluxes are based on the average increases in this layer from 2008 to 2010 as described in Bryden et al (2014).

P741 L30: This is work done by Schroeder as part of this paper.

P742 L1-Â■âĂŘ4: They are "slightly smaller", we would not maintain that they are significantly smaller.

P742- 744 The Reviewer's comments convinced us that the Discussion section was overall confusing to the results already presented. We have re-written the Discussion to focus on the two processes (salt finger mixing and deep water formation), their signatures and their different implications for salinity, temperature and density changes in the deep water.

All Trivia have been adjusted for in the revised text. Thank you for your suggestions.

Figure 2. We have now included uncertainty estimates in the Caption. Our emphasis is on the depth-average change below 200 m depth. The difference between station profiles is relatively constant with depth so we do not consider the standard deviation for the depth average of each station to be a meaningful quantity.

Figure 3. We have defined LIW and WMDW now in the caption. We purposefully made the 2004 and 2013 profiles the same colour (black) so the reader could quickly identify the long-term change by looking at the difference between black profiles.

Figure 4. We have now defined the red and blue curves. We show both the 1600-1800m and 1800 -2000m layers to show they are similar and also because the 1800-2000m layer represents the deepest water at the Dyfamed site while the 1600-1800m layer best represents the layer between the bottom of the halocline-thermocline and the top of the deep water.

Please also note the supplement to this comment:
http://www.ocean-sci-discuss.net/11/C381/2014/osd-11-C381-2014-supplement.pdf

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Interactive comment on Ocean Sci. Discuss., 11, 735, 2014.