

Interactive comment on “Central Arctic Ocean paleoceanography from ~ 50 ka to present, on the basis of ostracode faunal assemblages from SWERUS 2014 expedition” by Laura Gemery et al.

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Interactive comment on “Central Arctic Ocean paleoceanography from ~50 ka to present, on the basis of ostracode faunal assemblages from SWERUS 2014 expedition” by Laura Gemery et al. A. de Vernal (Referee) devernal.anne@uqam.ca Received and published: 4 June 2017

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The manuscript by Gemery et al. addresses an important topic, that of the ocean and climate change in the Arctic during the Quaternary. The new data from the SWERUS

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core 32 add useful information on the stratigraphy of ostracods over the last 40,000 years in the Arctic Ocean. The study core is one of the rare relatively well-dated sequence from the central Arctic Ocean, at least for the last 35 kyr and relatively high sedimentation rates (~1 cm/kyr on average) permit to report the stratigraphical distribution of microfossils with millennial time resolution. The new results from core 32 are very interesting. They are used together with the data from many other cores (most being already published) to present an Arctic Ocean wide synthesis for the last ~40 kyr. This offers a very valuable contribution as announced in the title and summarized in the abstract. In the manuscript, however, other data encompassing longer time scales, ranging up to the 160 kyr or even 340 kyrs, are discussed with reference to occurrence peaks of *Rabimilis mirabilis* in the ostracode assemblages. Hence, the scope of the paper is not clear. There is a hiatus between the abstract summarizing the new data from the SWERUS core 32 data and the discussion dealing with the longer time scales. In my opinion, the new data unquestionably deserve publication after a few points is clarified. The comparison with other records encompassing the last 40 kyr is very interesting and could be much useful especially if the basin-scale results are discussed in a more comprehensive manner. The synthesis part on the longer time scales, however, seems to be another story, which would require a better presentation/demonstration of the chronostratigraphy (including uncertainties) before to offer a robust scientific contribution.

My recommendation is therefore to revise the manuscript by focusing on the new data and their implication in term of large-scale paleoceanography at the scale of the last 40 kyrs. The manuscript will then offer an original, robust and useful contribution providing that some clarification/modification are made with regard to (a) the chronology and (b) the absolute abundance of ostracodes. Authors' reply: We thank the reviewer for these suggestions, and to refocus the scope of the paper to the last ~40ka. The revised copy does this and focuses more on large-scale paleoceanography of the central Arctic Ocean. We reorganized the Results section so that all environmental interpretations are in the Discussion section. Also, in the chronology section we acknowledge that

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revised age models may be needed in the future.

(a) The age-depth relationship in cores 32MC and 32G was derived from linear interpolation between ^{14}C dates as shown in figure 2. However, other solutions with highly variable sedimentation rates are very likely in the Arctic Ocean context. In particular, no accumulation or extremely low sedimentation rates during the last glacial maximum are recorded at many sites of the central Arctic Ocean (e.g., Norgaard-Pedersen et al. 2003; Polyak 2004; Not & Hillaire-Marcel 2010; Hanslik et al. 2010). Hence, the age of ca. 20 ka in core 32MC can simply result from mixing. The use of a Bayesian approach (e.g., with the Bacon software for depth/age modelling; Blaauw & Christen, 2011) would be appropriate and could help constraining the uncertainties. Another concern comes from the old ^{14}C ages (> 40 ka) that must be considered with caution because of potential biases due to even extremely small contamination (e.g., Hughen 2007), notably through diagenetic processes and carbonate recrystallisation (Sivan et al., 2002; Douka et al., 2010). Thus, the chronology of the lower part of the sequence, older than about 35 kyr, is equivocal because the absolute age as well as the linear interpolation can be questioned. A critical presentation of the age-depth relationships in the other cores from the Lomonosov and Mendeleev ridges (Figures 4 and 5) would be useful to give an information on the time window represented by the samples analyses, to strengthen the regional zonation proposed and to clearly demonstrate the synchronicity or time lags in the records. Authors' reply: We agree the dates >40 ka need to be approached with caution, and we amended the chronology section to note this concern. We agree that a presentation of the age-depth relationships of the other cores from the Lomonosov and Mendeleev ridges (Figures 4 and 5) would be ideal, and we acknowledge in the amended figure caption that the chronology of these cores may NOT have been derived from a standardized method or with the assumptions used to generate 32MC/GC chronology. Our goal of showing these comparison plots of indicator species' abundance was to emphasize the broadly similar faunal changes that occur from core to core in the central Arctic Ocean. Also we specified that the reservoir age was not likely constant through time. Chronology beyond 50ka and use of

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E. huxleyi is presented is based on correlation of sediment properties and dates from other nearby cores. Chronology beyond 50 ka is not relevant to this paper, albeit we still present it as supplementary information for the reader.

(b) The results are presented in term of number of ostracod counted and percentages of main taxa. The concentration or density of ostracode valves per unit of weight (g) or unit of volume (cc) would be very useful to describe the real abundance of ostracod in sediment and to get a picture of the actual fluxes of the key species. Moreover, *Rabimilis mirabilis* is discussed as an important species, but its downcore distribution is not shown in figures 3-5. It should be added (% and concentration) in the diagrams of these figures. Authors' reply: We added the density of ostracodes per gram of sediment to the Appendix, which also lists raw ostracode counts in each sample. The number of ostracode specimens in all 32MC samples exceeded 300, and specimen counts in 32GC ranged from 52 to more than 1000. *R. mirabilis*' abundance is not plotted in Fig 3 because it is instead presented in Fig.7 along with other cores in which it is found. *R. mirabilis*' abundance is not plotted in Figs 4 and 5 because it was not present in any of the cores on the Lomonosov Ridge and only in one core on the Mendeleev Ridge (HLY6 in the top 12cm of the core).

Beyond clarification in the presentation of results, some discussion about the actual significance of the ostracodes in the sediment would be helpful, as briefly suggested below. 1. In the interpretative schemes of the result section, the ostracode assemblages are associated with water masses, some of Atlantic origin. Are the ostracodes indicative of actual conditions in bottom waters or to transport with water masses ? Authors' reply: Unlike planktic foraminifers that live in the uppermost water column and are free-floating within water masses, most ostracode species are benthic in habitat and their ecology reflects bottom water environmental conditions. We added a sentence in the introduction to clarify this.

2. *Acetabulostoma arcticum* is associated with multi-year sea-ice cover, which makes it a very important bio-indicator, actually the only one that can be used to assess "pos-

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itively” on the occurrence of perennial sea ice as far as I know. The fact that it characterizes the postglacial on the Lomonosov Ridge is important, but its low occurrence during the glacial interval is equivocal. Can it relate to low general productivity due to too thick perennial ice? Its low occurrence on the Mendeleev Ridge for most the study interval is also intriguing. Authors’ reply: *A. arcticum* characterizes perennial sea ice conditions where light can penetrate through the sea ice and surface-ocean productivity is possible. *A. arcticum* is not benthic dwelling; it lives parasitically in an amphipod that lives under sea ice. We clarified this in Table 4: The stratigraphic distribution of *A. arcticum* is used as an indicator of periods when the Arctic Ocean experienced thicker sea-ice conditions but not fully glacial conditions when productivity would have halted. This pelagic ostracode is a parasite on *Gammarus* amphipods that live under sea ice in modern, perennially sea-ice-covered regions in the Arctic (Schornikov, 1970).

3. *Rabimilis mirabilis* is mentioned as a shallow water taxon. Could it be transported from the shelf (with sea ice for ex.) ? The fact that both adult and juvenal specimens are recovered (lines 361-364) is not a very convincing argument. Authors’ reply: The preservation quality of the valves and abundance of valves leads to the hypothesis that spikes in *R. mirabilis* signify abrupt environmental changes. The *R. mirabilis* valves we found in narrow sediment slices were extremely well preserved. It is highly unlikely that a *R. mirabilis* population would be transported in such numbers and with excellent preservation as the valves that we found in not just one core but multiple cores on the Lomonosov and Mendeleev Ridges. Transported shells are typically partially dissolved, corroded and/or chalky.

4. The zonation from the Lomonosov Ridge seems relatively robust, but *Krithe* spp. and *Pseudocythere caudata* show somewhat different records in the study cores. How can the difference be interpreted ? Does the deeper location of core AOS94-28 matter ? Similar, the assemblages from the Mendeleev Ridge show differences notably with regard to *Krithe* spp. *Pseudocythere caudata*. Are the differences indicative of a regionalism? Authors’ reply: Usually we find *Polycope* is inversely correlated with

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that of *Krithe*. Yes, *P. caudata*’s signal could be indicative of regionalism. We include *P. caudata* because of its fairly robust signal during MIS 3-2 in 32MC/GC. *P. caudata* appears to be ecologically linked to the surface conditions and generally with *A. arcticum* and perennial sea ice conditions (per Cronin et al 2014, Fig 6b). The significance of *P. caudata* could benefit from a DCA or CCA that involves multiple Lomonosov and Mendeleev Ridge cores.

5. High abundance/dominance of *Polycope* spp. characterizes the pre-Holocene sediment of almost all cores (Figures 3-5). This is interesting as it might indicate uniform water masses from Atlantic origin in intermediate layers of the Arctic Ocean during glacial time. Authors’ reply: Yes, *Polycope* spp. demonstrates a strong signal in most of the cores; it’s abundance is inversely correlated with that of *Krithe*; *Polycope* becomes dominant ~ 30-35 ka during late MIS 3 (Cronin et al., 2014, Fig 8). We followed Poirier et al., 2012 faunal zonation, as these zones are well established throughout the Arctic Ocean and in the SWERUS 32 cores. Broad deglacial-Holocene faunal changes are discussed as interpreted in Poirier et al. (2012) and further in our paper.

Other minor comments : - The supplementary tables are not easy to read and there are parts missing. Probably there was a problem when saving them as pdf. Authors’ reply: Yes this will be corrected in final production. The spreadsheets were created in excel and exceed the length of a page when converted to a pdf for the review process. - The nomenclature of cores in figures 4 and 5 is not exactly the same than in the map of figure 1, which is a little confusing. Authors’ reply: We clarified this in the caption. - In figure 5, the spacing of data points from core HLY6 is so large that comparison with other cores is not very useful ; Linking the data points between _12 ka and _27 ka for core AOS94 8, and between _ 13 ka and 40 ka for core AOS94 12 is inappropriate. Authors’ reply: The sampling interval of HLY6 was not as highly resolved compared to the other cores, but is presented because the data are still important in helping to understand the environmental conditions at a millennial scale. We agree about linking data points during a hiatus period or time when a species abundance was zero, so we

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have removed the long lines linking the data points from 12 to 27ka and 13 to 40ka.

Please also note the supplement to this comment:

<https://www.clim-past-discuss.net/cp-2017-22/cp-2017-22-AC3-supplement.pdf>

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