CP-2021-134 Reviewer 3

The reviewer comments are in black text; our replies are in blue italicised text.

This is an interesting, original and well written study.

We thank the reviewer for their positive comments.

My main concern is the distribution of krill in coastal waters during the breeding season of snow petrels. The table 3 and the discussion section (lines 515-530) state that snow petrels feed less on krill near the continental shelf. However authors only consider the main krill species, Euphausia superba : "Post-larval krill are mostly oceanic (Atkinson et al., 2008)" and "adult krill move to deeper waters for egg development (Nicol, 2006) (lines 520 -525). Another krill species, Euphausia crystallorophias, known as ice krill, are closely associated to sea ice, feeding on diatoms under the ice and living in coastal waters, where it replaces the more oceanic E. superba. High densities of E. crystallorophias can be found in coastal polynya during the Antarctic summer (La, et al. 2015) and can be preyed by snow petrels (Ridoux & Offredo 1989). This should be considered to avoid shortcuts in the discussion (lines 525 "the observed shift in fatty acid and element profiles in Unit II suggests that fish became more important to snow petrel diet, suggesting that polynyas had opened up over the continental shelf between 26.8-25.7 ka. We hypothesise that these shifts in foraging habitat reflect changes in sea ice conditions, by either influencing prey distributions or access to surface waters for feeding". The discussion should thus include the distribution and ecology of E. crystallorophias for a more nuanced picture of the link between dietary changes (fish vs krill) and foraging habitat (pelagic vs neritic).

We agree with the reviewer that the presence of Euphausia crystallorophias in coastal waters could contribute to the signal of krill observed in our stomach-oil deposits, given their high densities in coastal polynyas (La et al., 2015). However, our argument for the shift towards a more shelf-dominated diet comes from the evidence that the proportion of fish in snow petrel diet becomes very high in shelf waters, even when E. crystallorophias is present (e.g. Ridoux & Offredo, 1989 state 95% fish and 2% euphausiid by mass in their study, with both E.superba and E. crystallophorophias present). Ridoux & Offredo (1989) describe the snow petrels as being "distinctive in their preference for fish" (p.142), and confirm that this dietary preference has been observed elsewhere (p.143). We also noted as a guide for Table 3, that where krill has been observed in higher proportions of snow petrel diet, this has occurred when feeding beyond the continental shelf (lines 517-519 and references therein).

We can clarify our text to highlight the potential availability of E. crystallorophorias in shelf waters, but also to flag that this species is not known to be a significant contributor to snow petrel diet. In response to the reviewers comment we also explored our data further to see if we could identify a signal of E. crystallophorias. There have been fewer studies of lipids in E. crystallorophorias for us to refer to, however some common characteristics have emerged and are noted below. In response to the reviewers comments we propose to adjust our text as follows (line numbers refer to those in the submitted manuscript, underlined text shows our additions):

- *Table 3: we will ensure that Antarctic krill (E. superba) is stated here. We can add details of E. crystallophorias biochemistry to the line referring to the Continental shelf environment.*
- *(line 520-525): "Post-larval Antarctic krill are mostly oceanic (Atkinson et al., 2008)" and "adult Antarctic krill move to deeper waters for egg development (Nicol, 2006) (lines 520 -525)".*
- *(lines 394-397): "The dominant fatty acids in WMM7 are consistent with the main snow petrel prey (Table 3): Antarctic krill (Euphausia superba, high abundances of C14:0, C16:0, sometimes C18:1 (Cripps et al., 1999; Raclot et al., 1998)), squid (dominated by C16:0, plus longer-chain fatty acids C20: 5 and C22: 6)(Raclot et 395 al., 1998)), and both notothenoid and myctophid fish (high concentrations of C18:1(n-9), C16:0, and several mono- and poly-unsaturated C20 and C22 fatty acids (Imber, 1976; Raclot et al., 1998; Mayzaud et al., 2011)). Although only recorded as a minor (~2%) contributor to snow petrel diet (Ridoux and Offredo, 1989), in coastal waters ice krill (Euphausia crystallorophorias) is found in very high densities (La et al., 2015), characterised by high abundances of the C18:1w9 and C16:0 fatty acids as well as C14:0 and C16:0 alcohols (Ju and Harvey, 2004;Bottino, 1975). The C16:0 fatty acid thus has a mixed origin from krill, fish and squid in contrast to C14:0 (Antarctic krill) and C18:x (fish, ice krill)...."*
- *lines 415 onwards: we will ensure our text refers to "Antarctic krill" or "ice krill" where it is appropriate to differentiate these two.*
- *Lines 436-441: "The similarity in the trends between d13C16:0 and d13C18:1 (Fig. 5c) confirms an increased importance of prey with C18 fatty acids in their tissues between 26.8-24.7 ka, consistent with incorporation of a phytoplankton signal in predator tissues, through their consumption of copepods, squid or fish, which can occur with minimal alteration (e.g. Lee et al., 1971). Today, elevated C18:1 (and C16:0) fatty acid contents have been recorded in E. crystallophorias (ice krill) (Ju and Harvey, 2004;Bottino, 1975), which inhabit coastal waters (La et al., 2015). However, ice krill remain a very minor component of snow petrel diet even in these settings, where fish dominate (Ridoux and Offredo, 1989). Elevated (~20%) C18:1 through Units I and II is consistent with an increased contribution of fish to the snow petrel diet between 26.8-25.7 ka, but identifying the particular fish species is more challenging."*

References :

La, et al. 2015. High density of ice krill (Euphausia crystallorophias) in the Amundsen sea coastal polynya, Antarctica" Deep sea research Part I: Oceanographic Research Papers, 95,75-84

Ridoux, V., & Offredo, C. (1989). The diets of five summer breeding seabirds in Adélie Land, Antarctica. Polar Biology 9(3), 137-145.

References cited in the authors replies:

Bottino, N. R.: Lipid composition of two species of antarctic krill: Euphausia superba and E. crystallorophias, Comparative Biochemistry and Physiology Part B: Comparative Biochemistry, 50, 479-484, https://doi.org/10.1016/0305-0491(75)90261-8, 1975.

Ju, S.-J., and Harvey, H. R.: Lipids as markers of nutritional condition and diet in the Antarctic krill Euphausia superba and Euphausia crystallorophias during austral winter, Deep Sea Research Part II: Topical Studies in Oceanography, 51, 2199-2214, https://doi.org/10.1016/j.dsr2.2004.08.004, 2004.

La, H. S., Lee, H., Fielding, S., Kang, D., Ha, H. K., Atkinson, A., Park, J., Siegel, V., Lee, S., and Shin, H. C.: High density of ice krill (Euphausia crystallorophias) in the Amundsen sea coastal polynya, Antarctica, Deep Sea Research Part I: Oceanographic Research Papers, 95, 75-84, https://doi.org/10.1016/j.dsr.2014.09.002, 2015.

Ridoux, V., and Offredo, C.: The diets of five summer breeding seabirds in Adélie Land, Antarctica, Polar Biology, 9, 137-145, 10.1007/bf00297168, 1989.