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Interactive comment on "Are seamounts refuge areas for fauna from polymetallic nodule fields?" *by* Daphne Cuvelier et al.

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We would like to thank the reviewer for their point of view and suggestions that contributed to the revision of the manuscript. We have added a supplement .pdf, with the same contents as listed below, but featuring our replies in blue and paragraphs altered or added in italic.

There are a few comments below that could be addressed to improve the paper. Major comments

R2: 1) The appendix fig1 is a very important figure to place all the observations into context. I would move it from an appendix to a regular figure for the paper or as new panels in existing Fig. 1.

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A: We have incorporated it as an extra panel in Figure 1.

R2: 2) The data presentation used to compare nodule transects to seamount transects should be refined. Right now figure 3 portrays averages of densities for fine taxa which, based on the finding of very low overlap between transects, means little - averaging a large number for one transect with low or zero numbers in other transects. Rather the data should be presented at broader taxonomic categories (as in Appendix table 1) with average (and standard deviation) densities and # of morphospecies. This would also follow the language in the results section better. Data on each fine morphospecies (level of taxonomy in Fig3) could be presented an an appendix and by transect.

A: We decided to add morphospecies to Table A1 (also taking into account the comments made by the other reviewer), which thus give information per transect, help to elucidate Fig. 3 and add the desired level of taxonomy. Figure 3 was withheld because it was considered a key figure to show how different the presence/absence/abundance of the fauna varies between the two ecosystems, but the 3 parts were separated more clearly and different breaks at the X-axis, thus enhancing readability and interpretability. This information was added in the figure caption as well.

R2: 3) Once data is pooled at higher taxa levels, statistical comparisons could be drawn to compare the average # morphospecies and average density between nodule and seamount transects.

A: There were no significant differences for the densities (T-tests for samples with unequal variance) per taxon (taxa pooled and tested: Actiniaria, Alcyonacea, Ceriantharia, Corallimorpharia, Antipatharia, Pennatulacea, Scleractinia, Zoantharia, Bryozoa, Asteroidea, Crinoidea, Echinoidea, Holothuroidea, Ophiuroidea, Porifera, Tunicata, Enteropneusta, Gastropoda. The pooled data were visualised as a histogram with st. dev., added as an extra figure to this reply to the reviewer (Fig. R1), and could be added to the appendix. The number of morphospecies per higher pooled taxon group proved more difficult, since often we know there are >1 or >2 morphospecies, but not the exact numbers. Using the minimum known number would be and under-estimation, which is why we chose not to test these pooled observations.

R2: 4) The authors conclude that the ratio of hard/soft habitat may explain some of the faunal trends they observe. Can't this ratio be determined from the transects? If possible add this metric to help explain faunal communities along or between the transects.

A: We have added information on the amount of hard substrata under the form of 3 categories: (1) Predominant soft substrata (<40% hard substrata), (2) mix or transition (40-60% hard substrata) and (3) predominant hard substrata (>60% hard substrata), annotated over 10m distance units. Very few significant relationships were revealed (only for Mann Borgese ROV15), though backscatter data is currently being analysed to model the geomorphology along the transects in more detail and help reveal more details of fauna/substratum relationships, but it is out of the scope of this article. The following paragraph was added in section 3.1 (also taking into account the other reviewer's suggestions): "About 57% of all sessile fauna was associated with predominantly hard substrata, followed by 31% on the mixed substrata. For the mobile taxa the pattern was less pronounced with 41 and 42% associated with predominantly hard and mixed soft/hard substrata respectively. The amount of predominantly hard and soft substrata were negatively correlated though, not significantly. This was due to the elevated amount of mixed hard/soft substrata featuring equal amounts 40-60%. Over all seamount transects pooled together, no taxa were significantly correlated with the amount of hard substrata, nor with soft substrata. When looking at the individual transects, no significant correlations were found between taxa and substrata for ROV02 or ROV04 or ROV09, most likely due to the equal distribution of the amount of hard/soft/mix substrata. In this perspective, ROV15 stood out, as it was dominated by predominantly hard substrata (56/%): For this transect, Pennatulacea were significantly negatively correlated with the amount of hard substrata and Zoantharia/Octocorralia were significantly and positively correlated with hard substrata, as were Ophiuroidea, Asteroidea, Crinoidea and Mollusca."

Specific comments

R2: line 82 - Explain why the north or northwestern flanks of the seamounts were chosen for the transects.

A: These flanks were chosen based on the positioning of the vessel and the predominant surface current in order to avoid the umbilical of the ROV to drift/being transported towards the vessel. Predominant currents in the CCZ are South-East oriented, allowing for an ROV positioning "downstream" of the vessel's location while visiting the north-northwestern seamount flanks. We added this as follows: "The four seamount transects were characterised by different depth ranges and lengths and, due to the vessel's positioning and the predominant South-East surface currents, were all carried out on the north to north-western flanks of the seamounts (Table 1 and Fig. 1)."

R2: line - 97-99 - Provide the range of altitude, speed that were kept constant.

A: Target altitude was <2m above seafloor and travel speed $\sim$0.2m/s, though interrupted by sampling actions, instrument check-ups, exploration, object avoidance (in the case of the uphill seamount transects) etc. This was added in the body of text.

R2: line 208-209 - this statement appears true when examining the higher taxa pooled data in appendix table 1. however in the cited fig 3, its hard to actually make this comparison because averages at finer taxonomic categories are highly variable due to lack of fine taxa overlap between transects.

A: This is amended by adding the morphospecies information in Table A1.

R2: line 267 - Start the sentence with, "Amongst the seamount transects,..."

A: Ok

R2: line 269 - The point of this sentence is not clear as it opposes the trend you find. Clarify.

A: This sentence was to point out that it could rather be depth influencing their similarity than their adjacent location. This part was changed (also taking into account the comments from the other reviewer) as follows: “For seamounts, distance separating them might be a less determining factor than depth, since (mega)faunal communities can be very different even between adjacent seamounts (Schlacher et al., 2014; Boschen et al., 2015). Overall, parameters that vary with depth, such as temperature, oxygen concentration, substratum type, food availability, and pressure are considered major drivers of species composition on seamounts (Clark et al., 2010; McClain et al., 2010).”

R2: lines 296-306 - Nice to see a paragraph which lays out what future transecting should look like. The paragraph mentioned that wider depth ranges should be included and the data and literature certainly support that. Might it also be wise to have transects that move along countours so there are many replicate obsrevations at a given depth, instead of conducting uphill transects? Adding a sentence or two addressing across slope vs with slope transecting would be worthwhile.

A: This is a valid observation and we added the following sentence to this paragraph: “Alternatively, across slope transects, following depth contours, should be considered as these could provide observation replicates for a given depth”

R2: line 308 - The sentence should be slightly reworded based on the authros findings to "Seamounts were shown to share FEW fauna with surrounding habitats...."

A: Based on the literature, fauna from seamounts tend to occur in neighbouring habitats quite easily, but that is not the case here. We rephrased the sentence to clarify this. “In other areas, seamounts were shown to share fauna with surrounding habitats (Clark et al., 2010) and could thus potentially serve as source populations for neighbouring environments (McClain et al., 2009).”

R2: Line 316 - this topic sentence needs to be improved. Rather than simply reiterating the results section can this paragraph be rewritten and a topic sentence created that summarizes the functional differences between taxa on seamounts vs nodules?. See literature by Rowden etal that look at functional variation of taxa on seamounts and neighboring areas. E.g. Rowden et al 2010 Marine Ecology

A: We added in topic sentences for several paragraphs and cleaned up the remainder of the body of text as to not repeat the results. The section currently reads as follows: “Overall, nodule fields showed higher faunal densities than seamounts. Such shifts in density patterns between nodule fields and seamounts were clearer in a number of taxa, where the variety of morphospecies and feeding strategy within each group was likely to be at play. One taxonomic group in which this was rather clear were the Echinodermata, which group Asteroidea (predators and Brisingid filter feeders), Crinoidea (filter feeders), Echinoidea (Deposit feeders), Holothuroidea (Deposit feeders) and Ophiuroidea (Omnivores). Ophiuroidea were most abundant on the nodule fields (ratio 7 to 1 when compared to seamounts). Asteroidea and Echinoidea (with exception of one very abundant morphospecies at the nodule fields) were both more abundant and diverse on the seamounts. Same ophiuroid morphospecies were present at seamounts and nodule fields but in very different abundances and they showed preference for different substrata, which also appeared to correspond to different lifestyles, feeding behaviour and corresponding dietary specialisations (Persons and Gage, 1984). Previously it was already demonstrated that Ophiuroidea did not show high levels of richness or endemism on seamounts (O’Hara, 2007). At nodule fields Ophiuroidea were often observed in association with xenophyophores (Amon et al., 2016, this study) and a similar observation was done at east Pacific seamounts off Mexico (Levin et al., 1986), though no such associations were observed on the seamounts studied here. Holothuroidea densities were thought to possibly decrease when less soft sediment was available since they feed mainly on the upper layers of the soft-bottom sediment (Bluhm and Gebruk, 1999). No significant link was established between holothuroid densities and the amount of hard substrata, but their community composition varied distinctly between nodule fields and seamounts with more families being observed at the latter. Additionally, at the seamounts, many holothurians were observed on top of

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rocks, possibly reflecting different feeding strategies and explaining the observations of different morphospecies. Geographical variations, different bottom topography, differences in nodule coverages and sizes and/or an uneven distribution of holothurians on the sea floor were thought to play a role in holothuroid community composition (Bluhm and Gebruk, 1999). On the other hand, variability in deep-sea holothuroid abundance was proposed to depend primarily on depth and distance from continents (see Billet, 1991 for a review). Stalked organisms, such as Crinoidea (Echinodermata) and Hexactinellida (except for Amphidiscophora, Porifera) rely on hard substrata for their attachment and are considered being among the most vulnerable organisms when mining is concerned. Crinoidea were more abundant on seamounts, possibly because hard substrata were less limiting than in the nodule fields. Porifera densities (stalked and non-stalked) varied among all analysed transects, revealing no particular trends in abundance. However, the species composition of deep-sea glass sponge communities from seamounts and polymetallic nodule fields was distinctly different. Polymetallic nodule field communities were dominated by widely-distributed genera such as Caulophacus and Hyalonema, whereas seamount communities seemed to have a rather unique composition represented by genera like Saccocalyx. Corals were considered to be more abundant on seamounts than adjacent areas, due to their ability to feed on a variety of planktonic or detritus sources suspended in the water column, (Rowden et al., 2010). In this study, the Alcyonacea densities were lower at the seamounts than on the studied nodule transects. The Antipatharia were most abundant at the Mann Borgese seamount (APEI3) compared to all other transects, seamounts and nodule fields. The depth difference of more than 3000m between this particular seamount and the nodule fields could explain the abundance in Antipatharia which were shown to be more abundant at lower depths (Genin et al., 1986). The Antipatharia and Alcyonacea morphospecies of the seamounts did not occur on the nodule fields and vice versa, with exception of Callozostron cf. bayeri which was present at the nodule fields but in very low densities (1/10 of those observed at seamounts). Additional presence of Pennatulacea, which were virtually absent from the nodule field transects, resulted in completely distinct coral communities for each ecosystem. Actiniaria were denominated the second most common group at CCZ nodule fields, after the xenophyophores (Kamenskaya et al., 2015) and, in our study, were also more abundant on nodule fields than on seamounts. Depending on the species and feeding strategy, the ratio hard/soft substrata and their preference for either one could play a role. Since morphospecies were distinct between seamounts and nodule fields, their role in the respective communities are likely to differ as well. Combinations of deposit feeding and predatory behaviour in Actiniaria have been observed, as well as burrowing activity, preference for attachment to hard substrata and exposure to currents (Durden et al., 2015a; Lampitt and Paterson, 1987; Riemann-Zürneck, 1998)." On a side note, functional traits of seamount and nodule field fauna are being investigated in a broader framework, extending beyond the feeding group and including life history, mobility etc.

R2: Table 1 - Add "SM:" before Mann Borgese

A: This was added to the table.

R2: figure 3 - given that there is so little overlap in the morphospecies between each sampled transect. Figure 3 is a bit hard to interpret. Error bars would help. Its great that the taxonomic diversity is presented but this might be better in the appendix.

A: We changed the Y-axis of the different parts of the figure 3 graph to make them more easily interpretable. See reply above. We have uploaded an extra figure linked to this reply to the reviewers that can be included in the appendix, pooling the densities into larger taxa.

R2: Instead, appendix table 1 which presents higher taxa and # morphospecies might be the better data to show in the main paper. Here densities at higher levels can be better compared. Averageing the abundances across the transects seems ill advised given the differences observed between each one.

A: We have added the morphospecies' densities to the appendix table, which also clarifies the taxonomy and figure 3.

R2: Figure 6 - It is not clear what data is being presented here. Are these only taxa present on both seamounts and nodules? Please clarify in the figure caption

A: Yes, indeed. We clarified the caption to: “Morphospecies present in both seamounts and nodule field transect and their average density (ind/100m) in each ecosystem.”

Please also note the supplement to this comment:
https://www.biogeosciences-discuss.net/bg-2019-304/bg-2019-304-AC2-supplement.pdf

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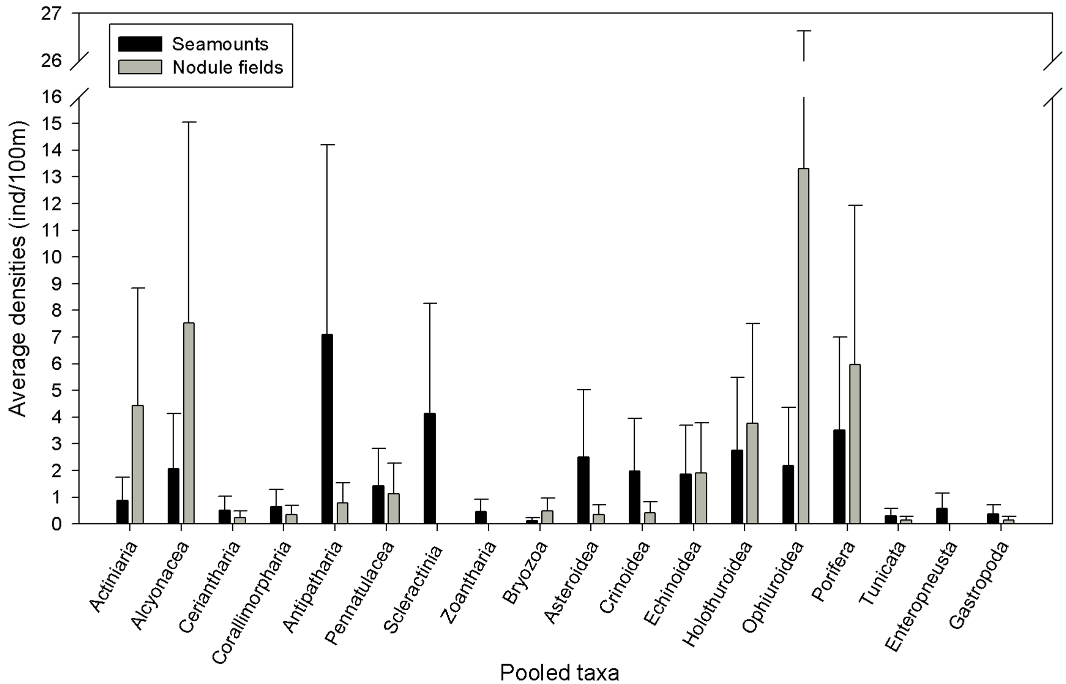

Fig. 1.

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