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Biogeosciences
Discussions

Interactive comment on "Macrofaunal assemblages from mud volcanoes in the Gulf of Cadiz: abundance, biodiversity and diversity partitioning across spatial scales" *by* M. R. Cunha et al.

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The authors wish to thank the valuable comments made by the reviewer Lisa Levin which contributed to an improved version of our manuscript.

REV: This manuscript represents a highly significant contribution to the literature on continental margin habitats, mud volcanoes and cold seeps. The Gulf of Cadiz displays a wealth of diversity associated with mud volcanoes with different levels of seepage, at different depths, and exposed to different water masses. Bg-2012-571 does

an outstanding job of characterizing the macrofaunal diversity patterns and exploring their linkage with the abiotic and biotic settings. Several suggestions below are made to strengthen the ms and improve its readability. Introduction – this should do a better job of covering key topics treated in the paper. (1) The final paragraph of the introduction suggests a highly descriptive study but in fact the authors target a number of fundamental hypotheses throughout the paper concerning the biology of cold seeps. These should be outlined in this introduction of the paper aims. Among these are: a) the scales of variability in diversity (within and between mud volcanoes/ across fields). b) the influence of water masses interacting with the seepage c) depth effects d) relationships between chemosynthetic species prevalence and heterotrophic macrofauna. Rather than being brought up for the first time throughout the results, these key topics should be raised in the introductory literature review.

AUT: We added the following to the first paragraph of the introduction Accumulated knowledge faded the distinction between hydrothermal vents and cold seeps which are evermore considered to exhibit a continuum of abiotic and biotic characteristics (Levin et al. 2012). In this context it becomes increasingly important to differentiate the intricate effects of water depth and relevant changes in the oceanographic and geologic settings in the composition and structure of biological assemblages from reducing environments." . . .and reformulated the objectives: "Here we analyse quantitative samples taken during the cruises TTR14 and TTR15 onboard the RV Prof. Logachev (Kenyon et al. 2006; Akhmetzhanov et al. 2007), and MSM01-03 onboard the RV Maria S Merian, and describe patterns in biodiversity, abundance and community structure of the benthic macrofaunal assemblages in seven mud volcanoes along a bathymetric gradient in the Gulf of Cadiz. This unique set of mud volcanoes spanning shelf and abyssal depths within a single region of the continental margin, provides an ideal framework to investigate: a) the spatial scales of variability in α- and β-diversity; b) the influence of the changing environment conditions with increasing water depth in the macrofaunal assemblages; c) the role of chemosymbiotic and heterotrophic species in the composition and structure of the seep assemblages."

REV: Results paragraph 1. The compilation of all sites (including reference stations?) in the listing of specimen numbers, species numbers, singletons is not especially useful. Could these statistics be split up into shallow MV, deep MV and reference stations? Can the total numbers be evaluated in light of the total surface area sampled?

AUT: This is a general account of the structure of data on gama-biodiversity to frame the subsequent description – separation of results by the groups of Shallow and Deep MVs is then made in sections 3.1, 3.2 and 3.3. Also, table 1 refers all individual and pooled statistics to the area sampled.

REV: Results Section 3.3 This will read better if the plots and statistics are not the primary subject (or object) of the sentences. Although this is a matter of style, I recommend the authors write more about the science rather than the plots, axes, and statistical tests.

AUT: Section 3.3 is in fact more technical but in our opinion needed to afford statistical validity to the scientific hypotheses. We agree that by integrating the discussion in the results would increase the readability of statistics but we would like to keep this style instead of converting the whole ms.

REV: Section 4.3 Could the discussion be broadened to place the mud volcano diversity in a more general context? How does it compare to diversity on seamounts that do not have seepage? To other isolated or more contiguous settings in the deep sea?

AUT: Because we would like to keep Section 4.3 short and focused on the GoC (in a way like a take-home message) we added the following paragraph but inserted in section 4.1: "Cold seep assemblages in general tend to be highly dominated by sulphide tolerant species and therefore show low ES(100). The values obtained from the Deep MVs assemblages are similar to the ones reported from hydrodynamically disturbed and/or organically enriched deep-sea areas in the NE Atlantic such as the Nazaré canyon (ES(100): 16.9-33.4; Cunha et al. 2011) or the summit of the Condor Seamount (ES(100): 20.4; Bongiorni et al. submitted). The ES(100) estimates

from pooled samples in the groups Reference, Shallow MVs and Deep MVs are similar (50.5), higher (56.6) and lower (24.9), respectively, than the mean value (50) obtained from different deep-sea regions (review by Snelgrove and Smith, 2002)".

REV: One of the best parts about this paper is that, rather than treating the seeps in isolation, it explores the role of hydrography and water masses. I think the final synthesis on p. 18352-3 is excellent!

AUT: Thank you!

REV: Minor edits suggested are: p. 18336 line 10 & 28. What is the isotope signature of methane?

AUT: δ13C values were inserted

REV: p. 18341 line 25. Higher abundances than what?

AUT: "than the reference sites" was added to the sentence.

REV: p. 18342 line 12 abundance of ophiuroids and sipunculans should be given... not useful to say they are relevant.

AUT: Percentage values were added.

REV: p. 18344 Line 15 What does Complimentarity mean here? Not clear?

AUT: The term "Complementarity" (not "Complimentarity") was introduced by Vane-Wright et al (1991) in biodiversity conservation studies and in the context of beta-diversity it is used to describe differences between sites in terms of the species they support (see Magurran 2004).

REV: p. 18346 Line 1-8 Rarefaction data are the best comparisons... it is hard to compare species numbers unless they are normalized to sampling area or number of individuals.

AUT: The number of species is referred because there are so few studies with data

at the species level and in our opinion this must change in the future. We agree that rarefaction data are best for comparisons and ES values are also discussed.

REV: Line 9-14. Examine the mesh size in various publications and provide this information when drawing density comparisons. Levin papers use 0.3 mm. Also consider whether a microscope was used. Sahling et al. 2002 for example writes: For macrofauna (>0.5 mm, excluding Crustacea, Nematoda) studies, the uppermost 1 cm of the sediment from the TV-MUC cores was left in one piece while the rest was processed through 0.5 mm sieves. The macrofauna were immediately extracted by hand, preserved in 10% buffered formaldehyde, sorted to the lowest taxonomic level possible, and counted. Extraction by hand (without scope) could easily account for lower densities.

AUT: Mesh sizes used in the various studies cited were added; the following sentence also advices caution regarding density comparisons: the comparisons between different studies and regions are often confounded by methodological aspects (e.g. sampling gear, mesh size and sorting technique).

REV: p. 18347 line 12-15. Can you make this statement about the relationship between siboglinids and macrofaunal diversity and evenness quantitative by plotting frenulate abundance vs Es 100?

AUT: Following this interesting suggestion, a new figure was included in section 3.4 together with the text "At the small scale (individual sample; α-diversity) siboglinid abundance explains about 60% of the variability in ES(100) values. Figure 6 shows that there is a significant negative relationship between ES(100) and siboglinid abundance (log10(n+1), R2: 0.6069; regression coefficient r: 0.779, p<0.001). In section 4.1, P18347 the following text was added: " and by the significant negative relationship between siboglinid abundance and small-scale α-diversity." Subsequent figures were renumbered accordingly.

REV: p. 18347 line 18. Do not hyphenate deep sea unless it is used as a double

adjective

AUT: Corrected!

REV: p. 18347-8/18349 line 14. Do the mud volcanoes bring fluid influence from the mantle? At a subducting seamount off Costa Rica (Jaco Scar) - there were fields of frenulates (Siboglinum sp. in the vicinity of warm, methane-rich, mantle-influenced fluids. Levin, L.A., V.J. Orphan, G.W. Rouse, W. Ussler, A. E. Rathburn, G. S. Cook, S. Goffredi, E. Perez, A. Waren, B. Grupe, G. Chadwick, B. Strickrott. A hydrothermal seep on the Costa Rica margin: Middle ground in a continuum of reducing ecosystems. Proc. Royal Soc. B. doi: 10.1098/rspb.2012.0205 (2012)

AUT: As mentioned in the introduction and description of the study area: "The deep hydrothermal alteration of basement rocks of the ocean-continent transition crust may be involved in the production of these fluids (Nuzzo et al., 2009)"; the different MVs are subjected to a differential influence of the crust either continental or oceanic according to their depths and distance to the continent. A reference to the occurrence of siboglinids under mantle-influenced conditions was inserted in page 18349: The morphology and physiology of frenulate tubeworms, capable of overcoming low fluid flow conditions (Sommer et al., 2009) enables them to form dense populations under a very wide range of geochemical conditions including warm, methane-rich, mantle-influenced seepage (Levin et al., 2012) and endure high temporal and spatial variability.

REV: p. 18348 line 27. There are a number of papers that talk about depth effects on cold seeps (those on vesicomyids, Levin and Mendoza 2007), and that examine deep seeps. What you may mean is that most papers don't examine a depth gradient within a single margin. Also perhaps describe the difficulting in accessing the deepest seeps - need to use ROVs or Subs.

AUT: Changes were made to the text in order to accommodate for these comments: "there are few studies attempting to infer depth-related effects on cold seep assemblages within the same region of a continental margin. Detailed accounts of seep

macrofauna focus mainly on shelf or upper slope sediments and there is few detailed information on the macrofauna of seeps deeper than 3000 m (Levin and Mendoza, 2007) also owing to the logistic difficulties (adequate equipment and working time restrictions) in accessing greater depths."

REV: p. 18350 line 4 - Citation needed after assemblages (the first).

AUT: Citations were added

REV: p. 18351 Should you be citing Olu and Menot seep papers for more examples of the role of foundation species.

AUT: References to Olu (Mediterranenan seeps) and Menot (Gulf of guinea) were added.

REV: Fig. 4 legend – Can you write out the volcano names? Or give the abbreviations? It might be useful to write out the color coding. . .are these depth zones?

AUT: Legend of the figure was changed

Interactive comment on Biogeosciences Discuss., 9, 18331, 2012.

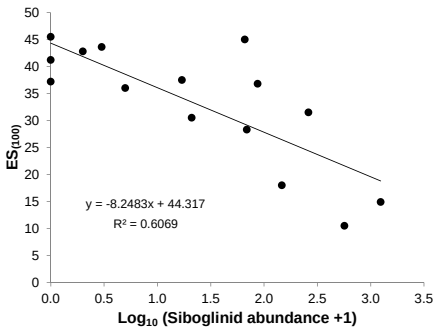

Fig. 1. new figure