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Interactive comment on "Effect of hypoxia and anoxia on invertebrate behaviour: ecological perspectives from species to community level" *by* B. Riedel et al.

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We are very grateful to both reviewers for their positive evaluation of our manuscript and their encouraging words about the "carefully carried out experimental in situ study" and "substantial amount of novel data". Particularly, the acknowledgment of our "titanic work" was noted with major satisfaction. We have addressed every point the reviewers made and are happy to take up the offer to re-submit a revised version of the manuscript. The most important issue is that, although both reviewers specifically state that the paper is well written, they feel that the major block of results slows its reading. We have therefore taken reviewer 2's advice and now present the species

data in tabular form (see details below). Moreover, to shorten the length of the overall manuscript we move Figs. A1– A33 into the Supplementary Material (see details below). The items outlined below are listed in the order given by reviewer 1 and 2 and refer to the lines in the original manuscript.

REVIEWER 1

[1] "P. 14335. L. 19. Maybe here a definition of anoxia would be appropriate".

Short definition of anoxia now provided.

[2] "P. 14336 L. 29-P.14337 L.2. Although behaviour could be an early-warning indicator of hypoxia, it is difficult to observe in natural environments".

Yes, behavioural observations in the natural marine environment are challenging, both from the technical and personnel point of view. We have now added a short paragraph in the Introduction. Regarding the technical requirements, various subtidal monitoring and surveillance options are available today. For initial or local hypoxia assessment, for example, remote observation or SCUBA diving could be useful tools, both abetted my novel, ever smaller and inexpensive video-recording equipment. These methods allow first-hand behavioural observations and the equipment is widely available in marine institutes and aquaria. Towed underwater video or ROVs enable visually covering wide areas of the seafloor: these approaches require greater effort, are expensive and not widely available. One intermediate solution between SCUBA and ROVs might be the installation of underwater video networks, comparable with and "upgrading" typical underwater (sensor) monitoring systems at the seafloor. Examples include a growing number of webcams installed from coral reefs to the deep sea. The availability of professional/trained personnel, able to distinguish stress behaviour from "normal" behaviour, is also a challenge. Here, our approach of identifying key categories of stress reactions could serve as a "first-aid" tool for marine biologists, technicians, divers, or fishermen.

[3] "P. 14340. L.11. Add “and” after the comma".

Done.

[4] "P. 14370 L. 20 and P. 14371. L. 18. I think it should read “scape” instead of “flight”, to make it easier to understand (here and elsewhere in the manuscript)".

“Flight” replaced by “escape” here and elsewhere

[5] "P. 14372. L.2. Delete “the”".

Done.

[6] "3.3.2. Predator-prey interactions. It could be interesting to mention the experiment number where these interactions took place. If the video is the webpage, could help readers to visualize it".

Indeed, two predatory events occurred in experiment 13, shown in the video http://phaidra.univie.ac.at/o:87923. The first event involves one (of overall three) Calliactis parasitica individuals, attached to an already overturned hermit crab's shell (lower left centre). The brittle star lies moribund on the adjoining ascidian Phallusia mammilata about 8 cm away. The anemone first pulls the brittle star from the ascidian onto the sediment and then consumed it at sec. 31 of the video. The mucus-covered remains (disc and attached arm stubs) are regurgitated at sec. 41. The second predation event is concurrent with the first interaction. Here, an extended Cereus pedunculatus (centre top) touches the arm of the moribund brittle star on the sediment at sec. 32, then pulls the ophiuroid in and consumes it. About half a day later (sec. 44), the remnants are regurgitated in mucus and fall onto the sediment. We have now included a short sentence in the manuscript (page 14371) as well as in the video text, with gives information about the attack and regurgitation time point of predation event 2.

[7] "Tables Table A2. This table is quite difficult to understand. I suggest summarize it and make it clearer".

We agree that Table A2 (a summary of all macrobenthic species and their behaviours evaluated) in the present version is difficult to read. We think, however, that this is based on the page proportions of the journal BGD, i.e. the original version is a single table shown across an A4-sized page, while for the BGD print that table had been subdivided into two sections. If the paper is accepted, we would ask the layout team to show Table A2 in its "original" form. If this is not possible we could consider shifting this table into the Supplementary Material.

REVIEWER 2

[1] "Shortening of the results section: I believe that this section should be dramatically shortened. The authors might think about integrating the main points into a table and to move the bullet points for each species into the supplementary".

We understand the reviewer's view regarding the length of the Results section and appreciate his/her suggestion. However, the primary effort and intention of this study was to fully document the reactions and interactions of the community's representative set of species from the onset of hypoxia until late anoxia/mortality, and to set these responses as accurately as possible in relation to different oxygen categories. Presenting the main points in one table might give the reader a quick overview over the behavioural trends, but this could never adequately reflect the full amount of data, observations and impressions we have gathered, from individual species behaviours to species interactions. Moreover, this would entail deciding what information may be "worth" making it into the table or being shifted to the Supplementary Material. Thus, we fear that splitting the results – selected points into a table/manuscript, bullet points for each species into the supplementary – does not adequately fulfill the study's fundamental concept and results. Nonetheless, to improve considerably the readability of the results, we have put the bullet point information on each group into separate, more structured “tabular” form. Although the telegram-style of these texts cannot be shortened significantly, this tabular presentation markedly shortens the overall text/Results part. To further reduce the length of the manuscript we also now moved Figures A1-33

to the Supplementary Material. We are confident that our modifications help improve the digestibility of the manuscript and hope that these changes meet with the editor's and the reviewers' approval.

[2] "The authors discuss oxygen thresholds using ml/l. This is difficult, as oxygen supply to animals is a function of partial pressure and solubility of oxygen in water, see e.g. Verberk et al. 2011 Ecology, Hofmann et al. 2013 BG for an explanation. The temperature dependence of critical oxygen partial pressures is also well documented. The authors should discuss these points, particularly with respect to variability in temperature in the habitat and anticipated future changes in temperature. The concept of critical oxygen partial pressure should be explained".

Yes, the reviewer is right in critically questioning the use of ml/l. Unfortunately, the units and terminology used to define hypoxia, as well as the conventional definition of when a critical oxygen concentration is reached, vary between and within earth and life sciences and their sub-disciplines. Our decision to work with ml/l was particularly for reasons of comparability of behavioural responses in relation to hypoxia/anoxia in the literature: most research done on benthic fauna behaviour under low oxygen conditions – most notably the classical review by Diaz & Rosenberg, 1995 – is based on this concentration unit. We are aware of the "biological response vs. some arbitrary oxygen concentration" debate and now briefly discuss this issue, including the concept of critical partial pressure, in the revised version of the manuscript. For comparison we have also included a line providing approximate equivalencies with other oxygen units (at 20°C and a salinity of 38). Furthermore, we include a short paragraph on the raised issue of anticipated temperature and pH changes (see below) and their potential impacts on the marine ecosystem.

[3] "The authors nicely demonstrate that pH significantly decreases during the incubations. Here, it would make sense to briefly discuss that low pH goes along with high CO2 partial pressures and low calcium carbonate saturation state, a problem that will become much more severe in the future (see Melzner et al. 2013 and references

therein for a discussion)".

We have now included a short paragraph on this topic in the revised version of the manuscript.

Interactive comment on Biogeosciences Discuss., 10, 14333, 2013.