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Interactive comment on "Ideas and Perspectives: Climate-Relevant Marine Biologically-Driven Mechanisms in Earth System Models" *by* Inga Hense et al.

Anonymous Referee #4

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This is an interesting illustrative paper that will be helpful in guiding the discussion on the amount of complexity required in Earth System Models. The authors have identified some major mechanisms that have implications for climate feedbacks in the climate system. I can understand the underlying rationale of their selection and I agree with the proposed mechanisms, although I would stress the fact that the processes that are being listed under each mechanism may not be exhaustive. Another point of relevance is the role played by coastal processes. The authors seem to suggest that coastal parametrizations of nutrient supply may be sufficient to capture the most relevant aspects of the identified feedback-related mechanisms (this is for instance implemented in PISCES, both for macro and micro-nutrients). However, the next generation of ESMs

is moving towards higher resolutions, which would imply a better resolution of coastal processes and benthic-pelagic interactions. This would probably enhance the vertical supply in coastal regions, requiring a continuous readjustment of the parameterizations. I wonder if this is what the authors are suggesting as the way forward. Overall, the manuscript is well written and easy to read. It certainly deserves publication though it requires some minor clarifications, changes and amendments, as detailed below

P2L4: " ... without going into ..." This is a main explanation for the choice of the processes. I think it would deserve some more words, as for instance some feedbacks may not be known in general or not completely known to the authors.

P2L8-18: The initial sentence implies that the functional group approach may not be adequate for the description of the system. I cannot see the authors finding any substantial counter-argument against this approach in the rest of the manuscript. On the contrary, it seems like they are even suggesting a more lumped approach, as for instance with the use of bulk zooplankton and phytoplankton.

P3L1-4 The role of dissolved organic matter in the biogeochemical pump has been thoroughly demonstrated in the field (Hansell et al., 2009, 2012; Kim et al., 2011) and in ESMs (Patara et al., 2012; Letscher et al., 2015). Particulate organic is only one pathway of carbon cycling, and likely to be mostly reduced in the anticipated more stratified conditions of a high CO2 ocean.

P3L9-10 There are actually two forms of calcium carbonate with different dissolution rates used by different organisms. If the emphasis is on alkalinity, then both forms of CaCO3 (and the relative biological pathways) should be considered or at least indicated why neglected.

Table 2. There are some inaccuracies in this table. The authors are invited to check the work by Laufkotter et al. (2015, their Table 1 and 2) to get a complete overview of the various processes implemented in the current generation of ESMs. In particular, TOPAZ has parametrized zooplankton and PELAGOS is the only model with separate

bacterioplankton and dynamic DOM cycling (not included in zooplankton). PELAGOS was used in CMIP5 in the CMCC-CESM model.

P4L25-31 It is a bit dismissive to state that the regions of low oxygen concentration are confined to the shelf seas. It has been demonstrated that the open-ocean oxygen minimum zones (e.g. Stramma et al., 2008) are expanding and the biogeochemical cycles of these gases may be enhanced in a warmer ocean (Wright et al., 2012).

P6L1-3 The inclusion of cyanobacteria would imply the inclusion of another pathway in the nitrogen cycle because these organisms are N-fixers. This should be clearly indicated and the possible interactions with M2 should be provided.

P6L5-7 I would tend to disagree that the buoyancy status is one major discriminant in underwater light attenuation by phytoplankton. The current representation of light absorption in ESM is rather crude and since most of the models listed in Table 1 have now a variable Chl:C ratio, it may be necessary to consider the specific attenuation of chl in various functional groups as this may affect the size of the oligotrophic regions of the subtropical gyres

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