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# *Interactive comment on* "Ecosystem function and services provided by the deep sea" *by* A. R. Thurber et al.

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Overall the paper is good, and covers the wide range of ecosystem goods and services in the deep-sea. However, the presentation of some of the key aspects is unclear, and the intended audience also needs to be considered in terms of the use of technical terms and the detail of description. My main issue with the paper is that a number of key conclusions are not easily understood by readers who are unfamiliar with the detailed literature. I was reading this as an interested scientist who wanted to get a good understanding of the major aspects of ecosystem g&s without having to wade through a literature review. However, many aspects were simply stated as fact, and referenced, without description or an example or two which would make the concept much easier to understand.



> We had aimed to use this manuscript as a jumping off point for the literature and to keep it at brief as possible. However – this is an excellent suggestion (as are those below) and we have tried to provide examples throughout (e.g. P6L22, P7L5, P7L23, P7L26-27, P8L1-2, P8L9-12, P8L22, P13L17-19, P16L8-18, P16L24-27, P20L30, etc.)

For example: 18199, lines6-8 refer to more diverse systems having higher function. lines 12-13 refer to richness and variety underpinning ecosystem function. Yet there are no examples given to illustrate these sorts of things, and so the reader doesn't know on what it is based. It wouldn't take much to describe examples of simple versus complex interactions, and then explain how fewer linkages make the system easier to disrupt if a key component is removed-the idea of a buffering function. But the general issue is that many facts presented in the paper could easily be explained by an example or two, so the reader can more readily appreciate what is being concluded.

> We have added some of the information of what sort of functions are involved. For this section we use some of the more theoretical literature and now added examples from the deep sea and increased the literature we have referenced without diverging the paper too far. This particular topic is a rich and heavily debated one that we aimed to touch but not dwell on. Please see lines P7L25-P8L19 for this heavily edited section.

The use of examples will also, in general, reduce the rather heavy going nature of the paper at times. It needs lightening up to make it more readable and digestible.

>Comment already answered at beginning.

Habitats are described throughout parts of the paper. Often though, their area or the depths at which they occur are not described. e.g., methane gas hydrates. 18201, lines25 on. Most of this as far as I know is upper continental slope, on the continental margins at 500 m down. The resources are not oceanic. Hence they have a limited distribution. The size and geographical extent of these habitats is important to appreciate.

> We fully agree with this comment. That is why we had included figure 4a to emphasize this point. We have also now added more specifics within the text on the size and extent of the particular habitats, and included a new reference that is now in press (Harris et al., 2014) that provides even more specifics. We have incorporated these changes largely throughout section 1.1 but also in other places in the manuscript (e.g. P13L25)

Also on habitats, the temporal scale needs to be clarified in some cases. e.g. whale falls. (18205, lines 3-5 (and earlier page also)). There is a succession of faunal types with a whale fall. It would be useful to describe these so the reader can understand that this is dynamic. Also they may last only a few months, or a year or two at the most. Yet it is made to sound like a permanent function.

> This is an important point and has been input into the text. Please see P13L27-30.

The Fisheries section is way too general, and contains sweeping statements that seem to have an environmental damage agenda. Many, but NOT ALL deep-sea species are slow-growing. Non-target bycatch is large in SOME fisheries, very small in others. There is no indication of the scale of deep-sea fishing that can result in justifying the statement "...can greatly impact the services provided by the deep sea owing to the damage of 3-d structures, etc..". That fishing causes damage is fine, but the implication that it has a severe impact is arguable. Harvesting of precious corals, for example, is very localised and small-scale. Seamount fisheries are also quite localised, so their GLOBAL impact is uncertain Again, some points could be emphasised by explanation.

> We aimed to keep a non-environmental agenda throughout this manuscript, and clearly were unsuccessful for the fishing section. This has been toned down, tightened up, and examples given of those fisheries considered sustainable. At the same time, the majority of fisheries papers about deep-sea fish stocks tend to be doom and gloom. We attempted to add in what little rays of hope there are, but they are not abundant. Currently, we feel that this sections represents the state of the literature at the moment



with an attempt to be as balanced as possible. We have rewritten this section as a result of this comment, please see Section 3.1.

e.g., strong upwelling...why not actually state the example of the millions of tonnes pelagic anchoveta fisheries off Peru driven by the Humboldt upwelling. Lay it out for the reader please!

> Done. P16L26-29

Mining. The examples used are SMS, manganese nodules, and crusts. It would be useful to also bring in phosphorite nodules, as off New Zealand these are at 300-400m, and the most advanced in terms of a mining license having been granted. Note also that many Pacific Island countries in the western South Pacific also have resources that are actively being investigated-not just the Nautilus PNG situation, but also nodules off the Cooks, SMS in Tongan waters. Refer SPC 2013.

> While mentioned previously, we now increase the discussion of phosphate nodules, however we were unable to find the SPC 2013 reference. P19L4 and P19L15.

With cultural services. There isn't much about the aesthetic value of the deep-sea fauna. The beauty of the charismatic deep-sea corals and sponges, hydrothermal fauna, the "weird and wonderful, unique and bizarre" that are often mentioned when talking about deep-sea discoveries. The value of this untouched diversity is thought to be high in terms of humans wanting to know it is there and unmodified.

> We have expanded this point. P21L28-L3

Section 5.3 refers to lack of knowledge limiting any economic valuation of deep-sea value. It would be good to see this expanded so that some advice or recommendations about what key things need to be developed are presented. i.e., what is needed to have a good go at this?

> We have added in the one study that has attempted this and more fully expressed how we need to use a framework that allows the services provided by the deep sea to

be there. (P2L23-P3L24 & P25L2-P27L30)

A few specifics: 18195, line 15. Fishing is no longer expanding rapidly. The development of the early 2000s is over and I am not aware of many fisheries that are really broadening their geographical scope.

> This is contrary to my understanding of the literature. Watson and Morato have found continuing deepening of the depth of fish stocks up until 2004. We have recrafted this section to more completely address these comments however, We are unaware of literature suggesting this (and would gladly include it if I knew of it). Please see Section 3.1

line 24: A great diversity of fisheries and "yet to be harvested" fish stocks...Really? What is there that is on the books for exploitation?

> Statement removed

18197: line 28. The cold-water coral reefs are not just >2000m. They are from 300m down, and in the southern hemisphere from about 800m.

> Depth changed to 300m

18197: line 7. There is a mix of technical and general terminology. echiurans and sipunculans are OK for an invertebrate-literate reader, but maybe add in WORMS for the not so familiar. On line 13, you refer the echinoderms from Bowden et al. This should be clarified to featherstars and brittle stars, to match the earlier reference to urchins and holothurians.

> Both suggestions accepted although we added in both the common names and scientific names for all of the echinoderms P7L7-8.

18200, line 28.Only 1% of the carbon is deposited on the seafloor. Earlier it is stated that 55% of that below 1000m is respired. So is most of the loss in the upper 1000m? Below 1000m, what happens to the other 45%. Is it just that the 55% is already a small



fraction of the surface production, so the confusion is just the mixture of reference percentages? Please clarify.

> This has been further clarified. P10L4

18201. line 13. anammox needs definition.

> We just changed this to anaerobic ammonium oxidation, while we had defined anammox earlier we interpret this comment that this name was not as approachable as one would hope and have modified it as a result P10L22

18206: line 8. Some numbers would help the reader appreciate the extent of the work of the microbial community-as it is their role is difficult to evaluate.

>We have added in both the abundance of methanotrophs as well as the DOC concentrations (P14L11 and 14)

18210. Line 14. What is the scale of munitions. This relates to a more generic comment, that the SCALE of various activities and services is often not adequately drawn out.

> We have added this in (what is known) P20L4 but not expanded too heavily as there is an excellent review that we point the readers too. We also add scale estimates whenever possible for habitats throughout the manuscript.

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Interactive comment on Biogeosciences Discuss., 10, 18193, 2013.