

Interactive comment on “Ecosystem function and services provided by the deep sea” by A. R. Thurber et al.

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Reviewer 3

Anonymous Referee #3 Received and published: 10 March 2014 General comment
This paper aims to “review current knowledge on the functions and services provided by the deep sea, providing a foundation of knowledge for effective management, while identifying the traits that differentiate deep-sea habitats from other global biomes” The first reviewer already pointed some of the major issues concerning this review; I agree with most of his/her criticism and will not duplicate these issues in my comment although I must reinforce that in my opinion this is not a complete nor a balanced review of the functions and services provided by the deep-sea.

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Most importantly, while trying to complement the excellent work by Armstrong et al. (2012) the authors bring unneeded confusion to the field of ecosystem services.

> As highlighted by reviewer number one, there is a need for a more illustrative description of the goods and services provided by the deep sea and that is where we aimed to expand on the important work of Armstrong. In addition, the comparison among the time scale between function and service provides conceptual advancement to the field. Further, the most concerning comment here is the lack of completeness of the functions and services provided by the deep sea. Yet no suggestions are given what we might have missed. We have followed both previous reviewers comments which has increased the balanced nature of this manuscript (specifically the waste and fisheries sections – which have been largely recrafted).

As for “providing a foundation of knowledge for effective management” the chapter on threats (5.2 Interrelatedness and threats to ecosystem services and functions” with only 20 lines provided in this review is strikingly insufficient; and the same applies to the brief discussion on “Current challenges in function and service evaluation” which lags much behind the chapter “Valuation of deep-sea ecosystem goods and services” in Armstrong’s paper.

> Our aim was to mention but not focus on the threats – there are excellent papers that focus on current and future threats (i.e. Mora et al. 2013; Jones et al. 2013; Mengerink et al. 2014) and we felt that what was needed in the literature was a treatment of the services for this habitat. Further we wanted to bring up a few current challenges but this manuscript is not focused on evaluation – which is the focus on Armstrong et al.’s work and that would have increased the overlap between their paper and this one. Instead focused on services and their ties to functions in the framework (the same framework used by Armstrong) allowing a connection between the approaches. We in no way aimed to remove focus from Armstrong’s important advances within the field.

Finally, the issue of “identifying the traits that differentiate deep-sea habitats from other

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global biomes” is not specifically discussed at any point in the paper; the fact that most of the deep sea lies in Areas Beyond National Jurisdiction” which is an important difference from other biomes and of utmost relevance for management/stewardship issues is not addressed.

> We have added a section in the discussion and also the importance of abiotic factors in discussion the services of the deep sea. This has greatly been expanded upon in the discussion and introduction. Please see lines: (P2L23-P3L24 & P25L2-P27L30) with the point of its being beyond national jurisdiction brought up P27L20

Other comments

1. The terminology has to be clear! Different terms are used interchangeably and this has a confusing effect (in the text and especially in some of the figures). The Common International Classification of Ecosystem Services (CICES) notes the importance of making a clear distinction between final ecosystem services (which retain a connection to the underlying ecosystem functions, processes and structures that generate them) and goods and benefits (final outputs from ecosystems that have been turned into products or experiences that are no longer functionally connected to the systems from which they were derived) and recommends adequate definitions; CICES defines a model of “how the environment relates socio-economic systems, and in particular how the flows (=ecosystem services) take place between them”. Since the Millennium Assessment much has been debated on ecosystem services and I recommend a more thorough knowledge of more recent approaches such as The Economics of Ecosystems & Biodiversity (TEEB), System of Environmental-Economic Accounting: Central Framework (SEEA 2012) and CICES. After defining supporting services in the introduction, in chapter 2 these are now supporting functions. In the different sub-chapters under “2 Supporting functions and regulating services” what are the supporting functions and what are the regulating services is not clear.

> We have gone through and followed the framework more closely whilst providing

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reasons why we (and others) are of the opinion that current frameworks (based mostly on terrestrial systems and limited marine (coastal and shallow-water) systems) generate inconsistencies in used terminologies and conceptual mistakes when attempting to apply them to the deep sea.

> While the MA is not as current as CICES, it does a more comprehensive job of taking an ecosystem view. The exclusion of abiotic factors in the MA and the partial exclusion of abiotic factors in CICES are shortcomings for their application to the deep sea. Excluding abiotic factors (but leaving in water? as in CICES), as suggested as the more up to date framework would be a disservice to the underlying aim of providing a overview of the services provided by the habitat. Further, using goods and benefits (those that are no longer connected to their function) misses the interconnectivity of the ecosystems. Using oil feeds back on the function that provides it (primary marine productivity) but would this count as a good and benefit or not? (clearly yes – but this is an example of why we have not used this approach). This is also highlighted in the work of Armstrong et al. (2010, 2012) and the work by Van den Hove and Moreau (2007).

> In addition, CICES presents an additional issue with the omission of supporting services as these are crucial in the assessment of deep-sea services. The fact that CICES excludes the intermediate (supporting) services (instead it focuses on final services) so as to bring coherence between ecosystem and economic accounts, is not representative of the important intermediate deep-sea services that support the functioning of the global ecosystem and indeed many of the final deep-sea services that benefit humans more directly (although Haines-Young and Potschin 2013 argue that CICES allows for intermediate services to be referenced; this is inadequate for the deep sea, cf. Armstrong et al. 2012 for the deep sea and Lique et al., 2013 for marine and coastal ecosystem services). Both exclusion of abiotics and supporting services lead to a disconnection between services connected with the system they came from and is a failing of the community to recognize the interconnected nature of the deep sea

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and indeed the global ecosystem. To address these issues, we have amended the introduction and have added a section at the end to discuss this with the reader and use that as further reason to adopt the approach of Armstrong et al. (2010, 2012) since this is most appropriate to the deep-sea habitat (but with inclusion of abiotics and a treatment of supporting and regulating services adapted to the complexity of the deep sea (P2L23-P3L24 & P25L2-P27L30))

> While we have also put some of this discussion in the text, as this clearly will be a question for others who read this manuscript, we did not want to spend too much time on this in the text proper and so have put a more brief summary of our reasoning (location cited above). P18207-8 Under "Fisheries" the authors mix provisioning services like animals harvested for nutrition and animals harvested for raw materials (e.g. coral for jewelry)

> We have moved the raw material harvesting into mining. (P19L20)

The lack of clarity in the terminology used in the submitted paper is particularly confusing in tables and figures: Table 1: Species diversity is presented as a supporting function (in the text the same as supporting service) and simultaneously a provisioning service, species diversity should be approached more specifically (e.g. animal biomass for nutrition and genetic materials for pharmaceuticals are provisioning services, bioremediation by microorganisms is a regulating service); climate regulation is simultaneously a supporting function and a regulating service; fishing is shown as a provisioning ecosystem service but in fact the service should be described as "biomass of wild animals (fish, shellfish, etc) harvested by commercial and/or subsistence fisheries"; the classification of large area, high pressure, cold remote environment, waves and currents as provisioning services is confusing because these are abiotic components of the structure or processes of the ecosystem and not final ecosystem services; oxygen production is an ecosystem process, should not be under "examples of goods".

> This is a series of interesting points. However, with regards to the confusion of sup-

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porting vs regulating services there are examples that can be considered one or the other. For instance nutrient cycling can be a supporting service (supporting primary production), but the processes that are involved with nutrient cycling are also relevant as a regulating service. It is not always a clearcut case. This has, for instance, also been pointed out by Costanza (2008) who states "Likewise, ecosystem goods and services, whether intermediate (or "supporting" in the Millennium Assessment typology) services or final services are all contributors to the end of human well-being. Also, ecosystem processes and services are not mutually exclusive categories, as Wallace seems to imply. Some processes are also services, others are not. Some services are intermediate, some are final, and some are partly both." This is a very good illustration of what we are trying to convey in our treatise applied to the deep sea. However, we do appreciate that we should be clear as to which functions, services or mixture of these we are talking about so we have added clarification throughout the text, where necessary. > As a result, we have also chosen to remove the "converge towards a framework" since there is a lot of divergence among frameworks. While there may be more new frameworks such as those cited they do not deal well with the deep-sea habitat. We have adapted our discussion sections accordingly. > In regards to Table 1, we have removed it. It added very little to the paper and much of this confusion was also simply due to formatting allowed within BG Discussion (no vertical lines) making our points less clear.

Figure 3 (looks more like a Table): the first column is a mix of biotic and abiotic goods, different types of services and other unspecified categories/activities/threats (military? communication cables?).

> We discuss this in the text. One of the services that the deep sea provides is as an area where the military operates and cables are laid for communication. Further we do not separate abiotic from biotic due to our already mentioned reasoning that this is a construct that is more appropriate for terrestrial systems.

All these should be clearly categorized and organized. Figure 5 Why is paleoclimate

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classified as a provisioning service? (In Table 1 paleoclimate archives are defined as an “example of goods” for cultural services

> We have removed paleoclimate from the figure following this comment. In addition – this point is an important one in that Figure 5 did not match up with the text in common use of terms. It now does and has been completely remade.

2. Who are the intended recipients of this paper? The level of scientific detail decreases from chapter 2 to chapter 3 and then to chapter 4; the language is not uniform throughout the paper, sometimes more scientific sometimes more adequate to outreach.

> To do the deep sea ecosystem services and the complexity of the functions and processes justice we need to provide scientific content. It was our choice not to simplify it to the level where we would have to exclude scientific rationale. We hope that this will appeal to the non-specialist who wants more insight in the functions, processes and resulting services as well as the specialist who is interested in an address of deep-sea issues in an ecosystem services context. As highlighted by reviewer one, examples are powerful tools to illustrate the goods and services provided by a habitat. To our knowledge this approach hasn't been followed yet by previous authors and we fill in gaps that required filling, guided by opinions from our colleagues in deep-sea networks. We have tried to walk a balance here, however, and put in common names and the like (largely driven by reviewer 1's comment) to keep it approachable.

3. More specific comments

P18194 Abstract “Each of these processes occur on a very small scale”; “many functions occur on the scale of microns to meters and time scales up to years” The emphasis of these statements on the small scale of processes/functions collide with the scales shown in figure 4.

> The boxes on figure 4 were not as clearly delineated as they should be, which showed

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that most of the functions expand down into the mm to m scale and rapid temporal scales. We have now added bounding boxes to make this clearer.

P18199 “It is now well acknowledged that the deep sea has a relatively high diversity (Hessler and Sanders, 1967; Grassle and Maciolek, 1992; Rex and Etter, 2010), although this can vary dramatically depending on the habitat being investigated (Levin et al., 2001)” the most recent paper on marine biodiversity (Appeltans et al. 2012) provides rather low estimates on the total number of marine species contrarily to the opinion of most deep-sea researchers –do you have a comment on that?

> This is a much debated “can of worms” and we have chosen not to expand upon it in the text as our current sentences agree with the state of knowledge for deep-sea habitats. However – it is an interesting topic and question nonetheless! Appeltans et al 2012 used the results of WoRMS and the Census results which are skewed towards shallow fauna (since we know vastly more about those habitats) and thus result in a lower estimate than only looking at the deep water fauna. Deep-sea diversity is not discussed in Appeltans et al.'s manuscript however it would be a useful exercise to rerun their analysis on only those fauna collected from >200m water depth to see if the estimates are the same. Hopefully someone does this in the future.

P18206 “Methane seep and hydrothermal vent communities provide an outlier of intense secondary production in the deep sea”- firstly because they provide an outlier of intense primary production

> We rephrased this sentence to address this comment P14L9

P18207 “However, owing to the pervasive nature of the function of the deep sea, and the threats to it, an important additional link is needed between each of these scientists and the stakeholders of the deep sea, which is the global population” – this sounds like “bla bla” talk; what can be done in order to increase public awareness on the relevance of the deep sea and make them feel really like stakeholders?

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> It is an important function to emphasize that the global population is the stakeholders of the deep sea. If we follow the suggestions of TEEB, the first step is doing - what the point of this manuscript is –to summarize the functions and services provided by an ecosystem. We have not changed this sentence as while it may read as “Bla Bla” it is a summary of the important take home message of this manuscript.

Figure 4 A: How did the authors estimate the spatial extent of each of the main deep-sea habitats? References and/or methodology should be indicated.

>This was an oversight on our part – and we have added in the appropriate reference.

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