

## ***Interactive comment on “Potential environmental impact of tidal energy extraction in the Pentland Firth at large spatial scales: results of a biogeochemical model” by J. van der Molen et al.***

### **Anonymous Referee #2**

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The paper by J. van der Mole, P. Rurarij and N. Greenwood with the title “Potential environmental impact of tidal energy extraction in the Pentland Firth at large spatial scales: results of a biogeochemical model” is well written and provides up to date model expertise. The model study applies two scenarios in terms of marine renewable energy generation in the Pentland Firth by tidal turbines, a 800 MW and a 8 GW scenario. Of special interest are the far field implication of this local application of tidal energy extraction on the ecosystem of the North Sea and beyond. Therefore the manuscript should be published after minor revision.

Before going in any detail of the study it is necessary to define some of the terminology

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that is used. The expression “academic 8 GW study” might be misleading and, for my understanding, in consequence the results of the study are sold far below its practical value. The way I see it, the study should be evaluated as a kind of sensitivity study to test which response the North Sea ecosystem will show under a massive expansion of using tidal turbines. As described (noted) in the introduction a number of different forms of marine renewable energy production are under way to be implemented practically. Therefore it is highly relevant to test the system response for possible accumulation of one energy form first, before going into studies with combined forms of energy production.

In view of the fact that the paper deals with marine renewable energy production the sentence “As with any source of energy, energy in the atmosphere and marine environment is a finite resource, ...” is misleading. As a matter of course the simple physical fact is correct, but if we follow the reasoning that renewable energy is beneficial in comparison with limited resources like oil or gas, then this formulation is not well worded.

The paper shows a very detailed validation for the parameters SPM, chlorophyll, silicate and nitrate for five individual Smart Buoy stations. As one can expect the selected parameters show differences compared to the measured time series. However, there is no general pattern apparent, like the model is always slightly overestimating chlorophyll or nitrate, but each site has its own local characteristics which makes it difficult to judge the overall behavior of the model on a wider scale. In addition, the results of the scenarios are only presented in horizontal maps. Concluding from these facts it would be good to see the validation also in a horizontal representation. This should at least be done for nitrate, and preferably also for chlorophyll or net primary production. For nitrate the additional suggestion is to show distribution of winter nitrate concentration rather than yearly averages, since it is the winter nitrate concentration that determines the spring bloom and therefore also the level of summer standing stock of chlorophyll.

In comparison to the detailed description of the model and the applied methods, the

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explanation of the results is rather sparse in its cause-effect presentation. For example, it would be interesting to explain why in the results of the current-induced bed-shear stress there is an area in both scenarios south of Ireland which still shows a reaction to the introduction of the tidal turbines. I understand that even a small implementation in the Pentland Firth which alters the current velocity and/or structure could lead to changes in the area of the English Channel as a reaction to an overall balance within the North Sea. But why this area in the south of Ireland should be effected is not clear to me. Even more, since there is no change appearing in the English Channel itself in the 800 MW scenario. In the conclusion the sentence: " Beyond 800 MW, the current results suggest a linear far-field response of the tidal system, with associated changes to the marine ecosystem, and linear interpolation of the current results might be used as a crude first indication of potential effects" needs deeper explanation and maybe also correction. For my understanding it is extremely difficult to extract a linear relationship out of the two scenario results. I mentioned already the difference in the current-induced bed-shear stress where in the 8 GW scenario also the English Channel is affected. In contrast, for nitrate the effect in the 800 MW scenario disappears in the English Channel. So overall I do not see a simple linear increase when going from the results of the 800 MW towards the 8 GW scenario. There might be a crucial threshold value for the implementation which brings abrupt changes in the response of the presented parameters. Therefore I also commented already on the fact that the 8 GW scenario is no simple academic spinoff but provides important information on the response of the marine ecosystem.

One overall problem is the different simulation interval for the two models application. Since they are presented as an integral study for the two scenarios it is worthwhile to discuss in which way the two different simulation intervals can be seen as comparable in their overall representation of the North Sea. Therefore it is important to tell the reader if there are any constrains to be expected in the interpretation of the results when addressing the same scenarios for two different time intervals. Finally a technical detail. For my understanding each figure should be self-explaining from its figure

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caption. Therefore the description of most of the figures needs more care.

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