Response to Referee#2: Interactive comment on "Identifying areas prone to coastal hypoxia – the role of topography" by Elina A. Virtanen et al.

Anonymous Referee #2

We thank Referee #2 for insightful comments on our manuscript that improved it substantially. We have now taken into account all the comments received and edited text accordingly. Referee #2 comments marked as grey and our responses as black.

Thank you for inviting me to review "Identifying areas prone to coastal hypoxia -the role of topography" by Virtanen et al, submitted to BIogeosciences. In general, this is a very well written, well-structured and interesting study where the authors use new approaches to quantify the impact of topography on bottom-water [O2]. I strongly recommend it to be published in Biogeosciences and I hope the approaches presented will be widely used for also other geographical areas. My major objection is the following statements in the beginning of the manuscripts: "We hypothesized that the enclosed nature of seafloors facilitates hypoxia formation." "We discovered that topographically sheltered seafloors and sinkholes with stagnant water are prone to the development of hypoxia" It is text book knowledge that topography (i.e. sills, deep basins, restricted morphology, skerries etc.) has a large impact on residence time and water circulation, hence also on dissolved [O2] in the bottom water. I honestly don't think this was new knowledge for the authors and hence the main driver of the study. However, and here is where the study becomes more interesting, to determine the degree to which a restricted setting affects the [O2] (i.e. the quantification) and then model that effect. That is interesting and new. I would like to see the author rephrasing their aim and their hypothesis.

We have now edited the aims and hypothesis of our manuscript, and changed texts in Abstract and in Introduction.

In Abstract:

"It is well known that the enclosed nature of seafloors and reduced water mixing facilitates hypoxia formation, but the degree to which topography contributes to hypoxia formation, and small-scale variability of coastal hypoxia, has not been previously quantified."

And:

"We developed simple proxies of seafloor heterogeneity and modelled oxygen deficiency in complex coastal areas in the northern Baltic Sea. According to our models, topographical parameters alone explained ~80 % of hypoxia occurrences. The models also revealed that less than 25 % of the studied seascapes were prone to hypoxia during late summer (August-September)."

In Introduction:

"…It is widely recognized that the semi-enclosed nature of the seafloors, and associated limited water exchange is a significant factor in the formation of hypoxia in coastal waters (Rabalais et al., 2010;Conley et al., 2011;Diaz and Rosenberg, 1995a;Virtasalo et al., 2005). However, to determine the degree to which seascape structure restricting water movement, contributes to hypoxia formation has not been quantified. …"

And:

"We tested how large fraction of hypoxia occurrences could be explained only by structural complexity of seascapes, without knowledge on hydrographical or biogeochemical parameters."

Minor details: It would help the reader to use abbreviations as sparingly as possible and to remind us what the geographical abbreviations stand for in the beginning of the result/discussion section, and preferable use the names of the regions more in the text.

Abbreviations replaced with place names accordingly in the text to help the reader, both in the results section and in the discussion.

I find it slightly difficult to accept the term normoxic and that is defined as > 4.6 mg/l. What is the "normal"/norm for a deep-water in a coastal setting, should we expect fully oxygenated conditions, should that our reference value? It is important to think about in these type of studies.
We agree that "normal oxygen conditions" are difficult to define in an environment like the Baltic Sea.

We have deleted the term "normoxic" and edited text accordingly:

"…to discriminate a hypoxic site from a **normoxic** one" changed to:
"…to discriminate a hypoxic site from **an oxic one**"

"…AS, EGoF and SA were **normoxic**…" changed to:
"…AS, EGoF and SA were **not hypoxic**…"

"…channels are mostly **normoxic**…" changed to:
"…channels are not **usually hypoxic**…"

"…many local depressions are more often hypoxic than **normoxic**…" changed to:
"…many local depressions are **often hypoxic**…"

The threshold for hypoxia admittedly varies in literature, but here we define it as O2 >4.6 mg/l. This limit is mentioned Section 2.2. Hypoxia data:

"Here we define hypoxia based on two ecologically meaningful limits: moderately hypoxic <4.6 mg L -1 O2 – as this has been estimated to be a minimum safe limit for species survival, behavior and functioning in benthic communities (Norkko et al., 2015)"

Dead zones is a popular science word which isn't really accurate, dead zones are devoid of higher life but not of all organisms. It should be used within " ", if used at all in this type of publications.
Dead zones deleted from the text, and now we talk about anoxic areas and anoxic zoned devoid of higher life throughout the text.

The conclusions are very short, general and undersell the study. I would suggest the authors to be more detailed and really highlight the specific conclusions from the study. One of them is: topographically prone areas to deoxygenation represent less than 25 % of the investigated seascapes.
Conclusions (and Abstract) are now thoroughly edited to highlight the key findings of the study:

"We found that a surprisingly large fraction (~80 %) of hypoxia occurrences could be explained by topographical parameters alone. Modelling results also suggested that less than 25 % of the studied seascapes were prone to hypoxia during late summer. Large variation existed in the spatial and temporal patterns of hypoxia, however, with certain areas being prone to occasional severe hypoxia (O2 < 2 mg/L), while others were more susceptible to recurrent moderate hypoxia (O2 < 4.6 mg/L). Sheltered, topographically heterogeneous areas with limited water exchange were susceptible for developing hypoxia, in contrast to less sheltered areas with high wave forcing. In some areas oxygen conditions were either better or worse than predicted by the model. We assume that these deviations from the "topographical background" were caused by processes not accounted for by the model, such as hydrographical processes, e.g. strong currents causing improved mixing, or by high external or internal nutrient loading, inducing high local oxygen consumption. We conclude that formation of coastal hypoxia is probably primarily dictated by local processes, and can be quite accurately projected using simple topographical parameters, but that interaction with the associated watershed and the adjacent deeper basins of the Baltic Sea can also influence local oxygen dynamics in many areas.."

The link to SMHI doesn't work (paragraph 2.2).
Hyperlink changed to a link that works: https://www.smhi.se/data/oceanografi/havsmiljodata

The references are not consistently formatted.

References checked and reformatted.

I can’t evaluate the modelling approaches, as that is far from my field, and I hope a second reviewer can do that.

I’m looking forward to see the study published.