Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2020-74-AC2, 2020

Biogeosciences Discussions

Interactive comment on "Changes in population depth distribution and oxygen stratification explain the current low condition of the Eastern Baltic Sea cod (*Gadus morhua*)" *by* Michele Casini et al.

Michele Casini et al.

michele.casini@slu.se

Received and published: 12 May 2020

We thank the reviewer for the helpful comments.

The reviewer asked about other factors that drive the poor condition of cod. In fact, we presented briefly the potential other factors contributing to the cod condition patterns in the Introduction to provide some background, specifying that in literature deoxygenation has been advocated as one of the major drivers of the condition decline (e.g. Casini et al. 2016). However, in the present manuscript, we specifically wanted to ex-

plore the link between deoxygenation and condition and investigate the circumstances that brought cod into greater contact with (and higher exposure to) low-oxygen waters. We appreciate the reviewer's point, and thus we can add some text in the Discussion section about the alternative factors that could contribute to the patterns in cod condition, especially before the mid 1990s when the cod population seemed outside the sub-lethal oxygen layers but condition was quite low. We can also add some sentences about the reasons of the shallowing of the low-oxygen layers, from literature. On the other hand, the reasons for the deepening of the cod population have not been investigated, only speculated about in other papers (Orio et al. 2019). These are beyond the scope of our paper, but we have suggested that this is an important question to answer in futures studies.

In the revised manuscript we will be more quantitative, spelling out the most important changes across time. We will provide information on the statistics that have been used, i.e. linear regressions for the time-series of condition and overlap to low-oxygen layers, and Anova for the otolith analysis. The otolith analysis is a modification of the analysis done in Limburg & Casini (2019), so we thought not to explain the method too much in detail but just refer to that paper for further information for example about the sampling etc., but we could do that if the Reviewer #2 and/or the Editor prefer so.

In the revision we will also address the specific questions and comments raised by the Reviewer #2. The main responses are listed below:

- (Q on line 107) We did not use Subdivisions 29 or northward because of the spatial distribution of the cod population. Since the early 1990s the population has concentrated in the southern Baltic Sea.

- (Q on lines 108-109) The two length groups for condition were selected to represent small and large fish. The small fish can also be seen as juveniles even though the size at maturity has declined with time for this population. The large fish on the other hand can all be considered adults. Currently, there are very few cod above 50 cm and

therefore we could not use larger size-classes.

- (Q on line 117) The population distributions, divided in < 30cm and $\geq$ 30 cm, come from Orio et al. (2019). In the condition estimations, we did not want to use too large ranges of fish sizes in one group because Fulton condition factor (used in the paper we refer to and compare to ours) can be affected by fish size. Moreover, cod start to become piscivorous around 30 cm and therefore fish below 30 cm (but larger than in the plankton- and nektobenthos-feeder phase, around 15 cm) can be considered occupying similar ecological niche. Therefore, the 20-29 and 40-49 size groups were chosen for condition estimation just to represent the small and large sizes with different ecological niches and therefore likely different behavior and food requirements.

- (Q on line 273) Regarding the question "Was there a way to directly link otolith chemistry with body condition? (e.g. from the same individual?)". Yes, it is possible analyzing the Mn/Mg elements ratio in the otoliths of individual fish, see Limburg & Casini (2018, 2019).

References

Casini, M., Käll, F., Hansson, M., Plikshs, M., Baranova, T., Karlsson, O., Lundström, K., Neuenfeldt, S., Gårdmark, G. and Hjelm J. 2016. Hypoxic areas, density dependence and food limitation drive the body condition of a heavily exploited marine fish predator. R. Soc. Open Sci., 3, 160416. Doi: 10.1098/rsos.160416.

Limburg, K.E and Casini, M. 2019. Otolith chemistry indicates recent worsened Baltic cod condition is linked to hypoxia exposure. Biol. Lett., 15, 20190352.

Limburg, K.E. and Casini, M. 2018. Effect of marine hypoxia on Baltic Sea cod Gadus morhua: evidence from otolith chemical proxies. Frontiers in Marine Science, 5: 482.

Orio, A., Bergström, U., Florin, A.-B., Lehmann, A., Šics, I. and Casini, M. 2019. Spatial contraction of demersal fish populations in a large marine ecosystem. Journal of Biogeography, 46: 633-645.

Interactive comment on Biogeosciences Discuss., https://doi.org/10.5194/bg-2020-74, 2020.