We thank two referees for the insightful and accurate comments. Below are our responses to the specific comments made by these referees:

Review 1:

The effect of temperature on organism metabolisms and the rates of microbially catalyzed geochemical reactions is represented by a Q10 = 2 factor. It is not clear whether this factor represents a typical increase in reaction rates observed over some short periods of time, or whether it would be expected to hold over the centurial time frame when the long term adaptation of microbial communities is taken into account. Could the authors discuss this?

In the manuscript a Q_{10} = 2 response of microbial metabolism is adopted, where we assume that this is the proper response over the 100 year time scale. This Q_{10} = 2 formulation is the standard temperature response adopted in the OCMIP type ocean biogeochemistry models (Marinov, Doney, & Lima, 2010; Najjar et al., 2007). Therefor this approach was used in this modeling study as well. However adaption of communities as well as changes in community structure might occur, which may cause change in Q10 = 2 factor. But such influences are difficult to predict. This consideration will be added to the discussion.

The reaction list for the sediment model does not include anammox, which now emerges as a potentially significant pathway of nitrogen removal. How would including anammox affect the nitrogen balance and the conclusions of the paper?

To our knowledge, only one study has been looking at anammox at the Oyster Grounds. Neubacher et al. (2011) show that anammox rates are low compared to denitrification with contribution of around 18 % to nitrogen loss. Considering the limited importance compared to denitrification it was opted not to include anammox since this would complicate model formulation (necessity to include nitrite as a porewater species). To clarify this, we will add following sentence to the text:

Neubacher et al. (2011) showed that anammox rates only accounted for 18 % to nitrogen loss at the Oyster Grounds, and hence, anammox was not include as a separate reaction process in the model.

The 1D hydrodynamic model cannot account for the lateral transfer of oxygen depleted water masses. The text does mention that currents in the study area are weak, however it is a non-quantitative statement and it is not clear that over the long term such currents would not affect the oxygen levels at Oyster Grounds. This perhaps warrants a brief discussion.

This point brought up by the reviewer is definitely valid. Currents play a fundamental role in the oxygen transport and in this way could affect oxygen depletion. In the manuscript it is explicitly mentioned that changes in circulation patterns resulting from climate change are not accounted for by the present 1D model formulation. Such an analysis would only be possible with 3D hydrodynamic simulation models for the larger North Sea area. Note that even such 3D models have their own problems in terms of boundary conditions and parameterization, which introduce additional uncertainties in simulations over the next 100 years. One such modeling study by Lowe et al. (2009) projects little qualitative changes in circulation patterns. Since currents in the Oyster Grounds area are weak at the moment (Van der Molen, 2002), we deliberately made the choice for a 1D model, focusing on temperature and wind effects and nutrient changes (and ignoring circulation changes).

The remark of the reviewer and our response will be included in the discussion of the model.

The upper and lower panels in Figure 5 have different time scales, yet their placement urges the reader to compare them directly. For example, the peak in Chl at around 100 days appears correlated to the decline in oxygen, which appears immediately below but actually happens later in time. I suggest rescaling the upper panel or positioning the two panels side by side.

The figure will be adapted taking the considerations into account

Review 2:

Hypoxia is extensively discussed in the introduction and mentioned several times throughout the manuscript. Yet, the hypoxic threshold is barely reached during the yearly oxygen minimum at Oyster Ground in the future simulations. This is not so much a criticism of the work but rather the way it is presented. The title

itself refers to hypoxia. There is plenty of merit and information in the study and no need to extensively discuss hypoxia when it is only encountered in a very minor portion of the simulations. The allusion toward increasing the "risk of hypoxia" is also a bit of a stretch. A decrease in oxygen concentrations ultimately increases the risk of hypoxia. The manuscript deals with a summer-stratified oxic site, and thus the title should reflect the nature of the site (something in the lines of "investigating the role of future climate forcings on bottom water O2 dynamics"). If the influence of climate change on hypoxia is indeed the focus of this paper, this site should be compared with a hypoxic (or seasonally hypoxic) site. Perhaps this is meant for future work, but as is, hypoxia should be discussed mainly in the context of the simulations in Figure 11.

The bottom water at the Oyster Grounds site in the central North Sea shows strong variations in oxygen concentrations between years. In some years, bottom water concentrations are high, while in some years, the bottom waters are on the brink of hypoxia (down to 60 µM). Accordingly, there is a real concern among water managers and policy makers that the Oyster Grounds (with one of the richest benthic fauna in the North Sea) may become hypoxic in the future (it only takes one year with very low O_2 concentrations to cause damage). A central goal in our paper is to examine how to explain such strong year-to-year variations, and whether the probability of low-O_2 years will increase in the future.

To accommodate the comment of the referee, we have changed the title to:

Impact of global change on coastal oxygen dynamics and risk of hypoxia

The manuscript emphasizes the importance of a decrease in oxygen concentrations due to a decrease in the oxygen saturation concentration resulting from an increase in temperature. While this effect is noteworthy, a 3-4 °C increase in temperature only produces a ca. 5% decrease in the oxygen inventory (Figure 10). This seems to imply that oxygen drawdown due to a change in oxygen saturation is not likely to induce hypoxia, but that other factors are more important.

It is indeed so that other parameters are important as indicated in the paper. Deoxygentation due to warmer water temperature (as a direct effect of a temperature increase) has an important effect on bottom oxygen dynamics although it is quite constant during the year. In systems which are now already partly hypoxic during summer, reduced saturation due to temperature increase, might enhance the hypoxia problem. But in general, changes in stratification definitely have also a very strong effect on the evolution of hypoxia since stratification mostly occurs when biological oxygen consumption is maximal and in this way they multiply each other’s effect. As the discussion in our manuscript stresses, nutrient controls on hypoxia are far stronger than climate controls, stressing the need for nutrient management of coastal zones.

This point will be more clearly elaborated in the discussion of the revised version.

The benthic-pelagic coupling is an important part of the paper, yet very little is mentioned about the feedback of sedimentary processes on the nutrient and oxygen dynamics in the water column. Are these effects are negligible? Also, no results are shown for the benthic simulations. What is the oxygen penetration depth? What are the trends in nutrient profiles? Do these agree with measured and/or reported data?

Due to limited data availability, few field data was available to calibrate the benthic model. To our knowledge for example, no porewater nutrient data is available for the Oyster Grounds. Therefore it was chosen to calibrate the model based on flux data especially oxygen fluxes. Fluxes predicted by the model are comparable with fluxes measured by Neubacher et al. (2011). The simulated oxygen penetration depth (OPD) varies over the season, but the average OPD is 0.4 cm which is less than the 0.55 cm reported by Neubacher et al. (2011) (average from February to October, but the summer stratification was missed in this study).

Field data shows that benthic mineralization accounts for 15-40 % of the mineralization in the Oyster Grounds (Boon, 1998; Upton, Nedwell, Parkes, & Harvey, 1993). This modeling study shows a contribution of around 37 % which lies within the range indicated by field measurements. This indicates that benthic mineralization does play an important role in oxygen dynamics as indicated in the manuscript.

What are the ammonium flux values required to maintain a constant nitrogen pool?

The ammonium flux required to keep the nitrogen pool constant due to losses by denitirifcation is 0.8 mmol N m^{-2} d^{-1}. The field study by Neubacher et al. (2011) showed a loss of 0.4 mmol N m^{-2} d^{-1} due to denitrification.

Oyster Ground is located in a specific region within the North Sea and should not be equated to a generic site in the "Central North Sea". It is characterized by muddy sedimentation and influenced by the nutrient-rich

south North Sea and English Channel waters. Just northeast of this location, however, within and north of the Dogger Bank, sedimentation, bathymetry, and currents are different. Furthermore, the benthic pelagic feedback at Oyster Ground should be remarkably different from semi-enclosed shelves (e.g. in the Baltic Sea, Black Sea) where stratification and nutrient release from the sediments may become more important factors in terms of oxygen depletion.Upwelling sites will also be characterized by very different physical and biochemical dynamics. The results from Oyster Ground should thus be placed in the proper environmental context.

Our intention was not to claim that the results obtained here for the Oyster Grounds are directly transposable to sites in the Central North Sea, or for that matter, to very different coastal areas like the Black Sea. However, when we used the term "generic" in the text, we intended that the model analysis approach adopted here is generic, and hence can be transferred and implemented at other sites (we will adapt the text to avoid this misunderstanding). At the same time, we believe that the current detailed study of bottom O_2 dynamics at the Oyster Grounds includes findings that are insightful for coastal systems worldwide: i.e., nutrient controls on hypoxia are stronger than climate controls. Climate effects on bottom O_2 dynamics (e.g. saturation effects) will be fairly generic, while clearly, nutrient dynamics is more site specific. These aspects will be clarified in the text.

An increase in temperature is the major driver of the oxygen drawdown in future scenarios. How does temperature (seasonality) affect the predicted turbulent mixing coefficient? What is the magnitude of this value?

Changes in temperature indeed have a strong effect on stratification and mixing and in this way affect the bottom oxygen dynamics. Mixing coefficients vary strongly between 0.4 and 10^{-5} m^2 s^{-1} depending on the season. The turbulent mixing coefficient shows strong variation over the year, showing strong mixing in the winter period and stabilization of the water column (and low mixing coefficients) in the summer period. But it is important to stress that next to temperature, wind stress also plays a strong role on the mixing coefficient as indicated as well by Soetaert *et al.* (2001).

Fig. 10 deserves a more objective interpretation. I understand that the authors do not believe in the plausibility of a 10% increase in the wind intensity over the coming 100 years, but as they have performed the simulations and other studies have predicted an increase in the wind intensity, they should address these results appropriately. It is evident that during winter and spring the oxygen drawdown is not attenuated by an increase in the wind intensity, but in these periods the stratification is minor (Figure 8). Nevertheless, this increased wind intensity greatly reduces the late summer stratification (the time when future hypoxia is predicted to occur). This needs to be discussed in the text.

Climate models show much less consensus on evolution in wind intensity compared to the temperature increase. Consequently making a projection how wind might affect bottom oxygen concentrations is difficult. To illustrate however how changes in wind might have an effect, an increase by 110 % was investigated. The increased wind intensity indeed reduces the late summer stratification (the time when future hypoxia is predicted to occur) as shown in Fig 10, and the discussion of this issue was rather brief. We will adapt the text likewise to provide a more balanced discussion of this effect.

Specific comments

The specific comments will be incorporated in the text.

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