Reply to comments of Referee #2

We thank referee #2, Mr. V. Smetacek, for his useful comments that helped to improve the manuscript.

1. Eutrophication/ nutrient concentrations at Boknis Eck

   Nutrient concentrations in the Baltic Sea were in general variable due to riverine input, but all of the coastal and most of the "open" areas in the Baltic Sea were still considered as in poor to bad state due to eutrophication (HELCOM 2009: Eutrophication in the Baltic Sea, p. 111). Concentrations at Boknis Eck of Nitrate, which forms the major part of dissolved inorganic nitrogen, was concentrated in the range as reported for other parts of the Baltic Sea, e.g. Gulf of Finland, Bothnian Bay and Baltic Proper (HELCOM 2009: Eutrophication in the Baltic Sea, p. 23). The same applied to Phosphate, resp. dissolved inorganic phosphor (HELCOM 2009: Eutrophication in the Baltic Sea, p. 23).

2. Freshwater discharge at Boknis Eck: Could this have influence on e.g. nutrient concentrations?

   Indeed, there is evidence for groundwater seepage in the Eckernförde Bay (e.g. Bussmann and Suess, 1988, Con. Shelf Research), around 2 km southwards from the Boknis Eck Time Series Station. However, low salinities would be present in the bottom water, if this was the case at Boknis Eck Time Series Station. Bottom water salinities were at any time highest in the water column, which is why we do not assume any effect of groundwater seepage at the site.

3. Chlorophyll a measurements: Spectroscopically or fluorometer? Can chlorophyll a trends be assessed in a sampling interval of one month?

   Chlorophyll a had been measured spectrocopically until 2009, since then, a fluorometer technique was applied. In addition to Tab. 1, this is now addressed in the text as well, see Comment 1 to Referee #1.

   We added a sentence to address the valuable point that the trends in chlorophyll a are sensitive to the varying timing of the spring blooms that last shorter than the sampling interval of one month. However, we consider the general decreasing trend as still worth to report, as not only spring bloom chlorophyll a but the whole time series was considered.

   p.7633, l. 13: "Due to phytoplankton blooms lasting shorter than the sampling interval, trends in chlorophyll a are sensitive to the sampling date, as the peaks could have been missed. However, the general decreasing trend throughout the whole period of 56 years is still evident."

4. Driver of stratification and bottom water salinities compared to oxygen

   Bottom water salinity at Boknis Eck is already the salinity at 25 m depth, as this area is very shallow. This is now better clarified in the text (p. 7624, l.18).

Salinity does drive stratification to a greater extent than temperature in the Baltic Sea, but the additional development of a strong thermocline in April/March is evident from Boknis Eck data. There is evidence for a trend of more saline bottom water in April/March (sig. pos. trends in salinity 25 m TS), but whether or not this is due to advection or in-situ stratification cannot be assessed by the 1-D data, as addressed in the text at p. 7636, l. 8ff. The correlation between oxygen and salinity in the bottom water is not significant (added: p. 7625, l. 5).

5. Title

The title is supposed to reflect the main results derived from the long term assessment of the Time Series Station Boknis Eck: That the decline in eutrophication, that is evident from decreasing nutrient concentrations, still does not have the expected effect of bottom water oxygen increase. Instead, we hypothesized that physical factors such as temperature or prolongation of the stratification period led to an ongoing decline in oxygen concentration, therefore counteracting the effect of declining eutrophication. To highlight the "hypothesis character" of this statement, we formulated it as a question.

6. Breakdown of "fossil" organic carbon

Indeed, we would hypothesize that because microbial activity is enhanced due to higher temperatures, remineralisation (and therefore oxygen consumption) is increasing. This is one of the discussed possible reasons for the ongoing oxygen decline. However, this is a hypothesis derived from the time series at BE, not from laboratory experiments. Although publications exist that point into that direction (Hoppe et al., 2013), temperature increase as a reason for bottom water oxygen decline should be further tested at the location of BE.

p. 7637, l. 20: "Based on the observed temporal development of the physical and biological parameters at BE, we hypothesize that enhanced remineralisation due to temperature increase and a longer lasting stratification may enhance oxygen depletion."

7. Compare seasonal stages with Smetacek et al., (1984)

The seasonal stages are now compared more detailed to the stages previously described in Smetacek et al. (1984). Further, an even more detailed analysis of biological parameters are beyond the scope of this paper which aims to give an overview on longterm trends, but e.g. Hoppe et al. (2013) discussed a time series of biological parameters at Boknis Eck.
Now added:
p. 7632: "The four stages previously described in Smetacek et al. (1984) could be observed throughout the whole time span. They comprise a spring bloom, at BE indicated by high chlorophyll a concentrations in March, a herbivorous copepod maximum that could not be detected by the parameters discussed here, a third stage during summer stratification, which was here identified by low nutrient concentration and comparably high chlorophyll a concentrations, as well as an autumn bloom that varied in timing, again indicated by elevated

chlorophyll a concentrations. Smetacek et al. (1984) observed constant nutrient concentrations in winter and consequently, a similar bloom size each year during a 10 year period, which contrasted to the decreasing nutrient concentrations and decreasing chlorophyll a concentrations found over the longer period 1960/1986-2013."

8. Constancy of the ammonium bottom water peak

   The peak in bottom water ammonium appeared with a lag of 1 month after increased chlorophyll a concentration in the surface layer and was especially strong when anoxic conditions are present. This was consistent throughout the time series. Indeed we would argue the bottom water ammonium concentration to rise to due to sedimentation and recycling of nutrients, but direct measurements of e.g. sedimentation rate were unfortunately lacking. However, the increased sedimentation in stage 1 and 4 was evaluated in Smetacek et al. (1984), which matches the finding of recycling of nutrients indicated by the elevated ammonium in the bottom water as found at Boknis Eck.

   We added/changed the paragraph to:

   p.7632, l. 12: "The peak in bottom water ammonium appeared consistently with a lag of one month after increased chlorophyll a concentration in the surface layer and was especially strong when anoxic conditions were present. This may indicate remineralisation of organic matter after the blooms. The lag of one month after the dieback of algal blooms was in agreement with previous studies showing an increase in methane one month after an algal bloom in the bottom water found by Bange et al. (2010), that they also attributed to remineralisation. Ammonium accumulation is known to occur during the decomposition of organic matter, when further oxidation to nitrite and nitrate is hindered by low oxygen concentrations. "

9. Primary production in the surface layer vs. oxygen content in the bottom water

   The linkage between primary production and oxygen consumption in the bottom water results from the amount of detritus that is deposited after an algal bloom. The BSIOM-OXYCON model implements the oxygen consumption as dependent on primary production and has been extensively validated in Lehmann et al. (2014), so an approximation is possible on the basis of the available primary production data. We compared the output of the BSIOM-OXYCON model with the observations at Boknis Eck, and discrepancies could – among other reasons – also be a result of recycled production that was taken into account for primary production measurements at that time. However, the general trend found at Boknis Eck was reflected in the BSIOM-OXYCON model. Therefore we assume that recycled production did not bias the primary production measurements used for the model oxygen implementation in a way that affects the discussed trends and possible reasons.

10. Editing by native speaker

    The paper was edited by a native speaker.