

Interactive comment on “Nitrous oxide water column distribution during the transition from anoxic to oxic conditions in the Baltic Sea” by S. Walter et al.

S. Walter et al.

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The authors describe a very interesting data set of N₂O, oxygen and nitrate concentrations measured during an untypical (dynamic) hydrographic situation in the Baltic Sea right after a salt water inflow. Samples from all major Basins and from shallow and deep sites were sampled and analysed. Furthermore the authors try to calculate production rates and explore the transport pathways and the mechanism of generation of the N₂O. These are crucial questions since N₂O can be generated from microbial nitrification as well as denitrification or it could have been imported to the Baltic with the inflowing water. Combined with the complex stratification of the water column at the time of sampling the interpretation of data is a real challenge. The authors try to explain which of the various processes may have caused the observed N₂O patterns and they have

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structured the manuscript in relatively short subchapters. A clear ranking whether the age of the water, the mixing, the microbial activity, or the environmental settings are responsible is hardly been made but would facilitate the major message.

In our opinion we showed clearly, that an in-situ production is mainly responsible for the observed N₂O distribution (most probably by nitrification processes). We also discuss the importance of environmental settings, especially the oxygen and nutrient concentrations, and the hydrographic features; however, we do not see the possibility for a “ranking” of these highly related factors.

The scientific question the paper addresses is not formulated in the introduction and may be this is the reason why the paper lacks some clarity.

The scientific question was: how are the N₂O concentration and the distribution influenced by a North Sea Water inflow event. This is mentioned in the second sentence of the abstract and also at the end of the introduction.

Although a wealth of information is presented (or may be because of that) the paper esp. the discussion is a little difficult to read and aspects are repeated in different paragraphs with slightly different conclusions (e.g. on pages 741 and 745 the authors refer to Rönner 1983 but first the oxygen concentration second the nitrifiers are assumed to be more important).

The data presented are indeed complex and there seem to be no simple discussion /interpretation possible. Nitrification activity and O₂ concentrations are closely related: Low O₂ result in high N₂O formation by nitrifiers and vice versa. The two statements/conclusions mentioned by the referee just illustrate that point, and, in our opinion, are not misleading.

Finally, the authors conclude that according to previously published data the major generation pathway for N₂O in the Baltic Sea is nitrification. This information needs to be more clearly presented in the abstract, which gives a lot of information but is not

concise to this point.

We agree with the referee and changed the text.

Since an inflow usually follows the deep basins from west to east and encircles Gotland clockwise, it may be checked whether this can be confirmed by the available data and how this is mirrored in the N₂O profiles.

We can clearly distinguish whether a basin is ventilated by North Sea water or not, and we also see this feature in the N₂O profiles. Especially Fig. 6 and 7 show that the North Sea water has already reached station 271 in the eastern Gotland Basin (anoxic before the inflow), but not station 284 in the western Gotland Basin (still anoxic). The N₂O concentration below the thermocline switched here from values above the equilibrium (oxic) to near zero (anoxic). See also page 741, line 3-12. Therefore, we do not see a need to modify our discussion. By the way, the inflow encircles Gotland anticlockwise and not clockwise as stated by the referee.

The first part of the discussion tries to relate the concentrations to the water bodies and their age, but overall this seems not so well organized.

The N₂O concentration is not related to the age of water masses, the age of water masses was used only for the calculation of $\delta^{15}\text{N}_{\text{N}_2\text{O}}$ (see page 735, line 16). Section 4.1 shows some hydrographic features as an explanation for observed N₂O pattern. Here we especially argue why an in-situ production of N₂O is assumed rather than an advection with North Sea Water.

The relationships between $\delta^{15}\text{N}_{\text{N}_2\text{O}}$ and NO₃ or O₂ as shown in the discussion are either logarithmic or linear and I have not understood why different functions have been chosen? Does this imply different generation pathways or different kinetics of the reaction?

The chosen functions represent the best fits of the data and do not imply an interpretation of formation pathways and /or kinetics of the reaction. The figure captions

have been modified.

Minor points are: The chapter 1.3 is entitled “Definition of water masses” but gives rather a description of the layers instead of water mass definitions. Overall this chapter should be shortened and become part of 1.2.

We agree with the referee, rearranged the title and merged it with part 1.2.

Page 732 Study area: the first paragraph belongs to the methods and is no site description.

We agree with the referee and changed the text.

Page 734, line 8 what are free-flow bottles?

We agree with the referee and changed the text to “Niskin bottle”.

Page 735 line 9, salinity is not measured by a CTD sensor.

We agree with the referee and changed the text.

Page 736, line 5, how was H₂S measured and O₂ and NO₃?

We agree with the referee and changed the text.

Line 16, it must have been station 271 instead of 272.

We agree with the referee and changed the text.

3.1 the well mixed stations can hardly be called basins, since they are so shallow.

We agree with the referee and changed the title.

Page 741, line 10 and 13, Figs 6 and 7 show different relationships between N₂O and nitrate or oxygen.

??? It is not clear what was meant by the referee.

Page 746, line 22 “N₂O production by the inflow” is hardly possible, it is rather nitrifica-

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tion. This is misleading interpretation of our text. The complete sentence reads: “Thus, the observed elevated N₂O concentrations in the Baltic Sea basins result from a stimulation of N₂O production by the inflow, most likely by advection of oxygen” We do see why to modify the sentence.

Page 748, line 14, comparable to what?

Text was changed to “low in comparison to published nitrification rates from other oceanic areas (see e.g. Bianchi et al. 1999)

The conclusion is more a summary and could be omitted.

We agree with the referee and changed the text.

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