

Review on manuscript

‘Comparative studies of pelagic microbial methane oxidation within two anoxic basins of the central Baltic Sea (Gotland Deep and Landsort Deep)’
submitted by G. Jakobs and colleagues

General comments

The introduction contains some information potentially irrelevant for the present study, so that there is potential for shortening (see specific comments).

In the manuscript I missed a brief discussion on known occurrences of aerobic methanotrophs within aquatic O₂-depleted zones. For instance minimum O₂ concentrations tolerable for aerobic methanotrophs, knowledge on methanotrophic populations in redox zones in other regions etc.

In addition, the origin of methane ascending in the water column, underlying geochemical processes and explanations for the significant differences in δ¹³C-CH₄ in anoxic waters in the two deeps investigated would be of interest for the readership of Biogeosciences.

I also missed a comparison of methane oxidation rates in the redox zone investigated in this study and those established for oxic and suboxic waters in other regions found in the literature. The difference in oxidative strength between oxic and suboxic regimes would be of interest.

I was slightly confused by inconsistent usage of varying terms for apparently identical matters (e.g. redox zone = oxic/anoxic transition zone?; oxic/anoxic transition = oxic/anoxic interface?; lower edge of redox zone = chemocline?). I strongly recommend unifying such terminologies for quick understanding.

Although I am not a native speaker I believe that the manuscript would benefit from having it checked for correct grammar, syntax and word choices. At places the manuscript suffers from redundant formulations and imprecise descriptions (see my specific comments).

Specific comments:

Page 12251

Title is not fully representative for the manuscript, because focus is laid on microbial methane oxidation in the redox zone (instead of anoxic basin), although data are additionally presented for the anoxic and the oxic water body as well

Page 12252

- lines 2-3 specify ‘differing environmental conditions’
- lines 4-10 due to length sentence hard to understand - potentially separate into two sentences. Indicate water depth for deep water masses, δ¹³C-CH₄ in surface water, O₂ conc. in redox zone
- line 18 specify ‘differing hydrographic conditions’
- line 19 potentially replace ‘oxic/anoxic transition zone’ by ‘redox zone’

Page 12253

- lines 11-12 because thermophilic MOB type X methanotrophs have not been identified in this study this sentence might be removed
- lines 15-16 sentence relevant?

- lines 22-24 because methane-related archaea were not investigated in this study, sentence might be removed
- lines 25-28 because this is general information sentence might be moved to earlier section of the Introduction

Page 12254

- lines 3-5 move sentence to top of paragraph
- line 19 'alternative' in this context unclear. With regard to which other organic matter degradation processes?
- line 21 remove 'described as'
- lines 21-23 potentially state typical vertical thicknesses of redox zones and oxygen concentrations
- line 23 'suboxic zone' = 'redox zone'? Unify usage of terms throughout manuscript (see remark on Abstract, line 19)
- line 27 In order to avoid confusion state that 'Gotland Basin' comprises 'Gotland Deep' and 'Landsort Deep' at the beginning of sentence

Page 12255

- lines 1-3 state concentration ranges
- lines 3-7 shorten sentence; remove: 'pelagic', 'activity related to the', 'under suboxic conditions'
- lines 11-16 statement of specific compound classes is apparently insignificant for the present study; relevance of second part of sentence for this study unclear
- lines 23-24 remove 'our work'; specify 'different environmental ... conditions'
- line 27 state nature of sample investigated by molecular analysis

Page 12256

- line 5 specify 'different basin structures'
- lines 10-13 it would be helpful for readers understanding if flow directions of saline water from the North Sea would be illustrated in Fig. 1B
- line 15 'decreasing' salt content unclear. With respect to distance from source?
- line 20 title of paragraph might be amended by 'and physico-chemical measurements' or equivalent
- line 21 remove brackets
- lines 22 remove 'procedures'

Page 12257

- line 19 replace 'distribution' by 'concentration'
- line 21 replace 'according to' by 'using' or equivalent
- line 22 replace 'first detection of hydrogen sulfide' by 'for samples virtually devoid of hydrogen sulfide' or equivalent

Page 12258

- line 7 remove 'phase'

3.3 Methane oxidation rates

This section requires some re-organization to separate information on water sampling from those dealing with the tracer preparation and labeling procedure which in the current version of the manuscript are intermixed. To achieve a better readability the chapter might be separated into sub-chapters

- lines 16-17 remove '(Glasgerätebau....sealing material)

- lines 19-20 move sentence to top of paragraph
- line 21 remove 'gas'
- lines 27-1 (page 12259) explain 'residual tracer liquid'

Page 12259

- lines 10-11 exemplify 'dissolved inorganic carbon compounds'
- lines 11-12 remove 'previously'
- line 20 define 'oxygenated' and 'oxygen-deficient' with regard to O₂ concentrations
- lines 24-25 'The standard deviations are given as error bars in' might be removed
- line 25 replace 'performed' by 'obtained' or similar

Page 12260

- line 3 define 'dpm'

Page 12261

- line 10 'field studies': a single cruise only is mentioned in the Method section
- lines 11-12 data of water densities are not presented in the manuscript
- line 14 replace 'different distinct peaks with two maxima' by 'two peaks' or equivalent
- line 18 replace 'suboxic zone' by 'redox zone'; indication for lower boundary of redox zone (143 m) based on O₂ concentrations unclear, since lowermost sample analyzed for O₂ concentrations is located at approx. 100 m
- line 22 clarify 'suboxic zone (redox zone)'; see comments on usage of various terms above
- line 25 remove 'based on the fact'

Page 12262

- lines 16-17 Because methane oxidation rates were determined in relatively high resolution at comparably low standard deviation, it might be worth to mention that rates peaked at two depth intervals in the redox zone (as was also found for the Landsort Deep)
- line 18 refer to Fig. 4 with respect to turnover rate constant; explain why methane turnover at Gotland Deep is restricted to the redox zone, while at Landsort Deep it takes also place in shallow waters belonging to the oxic zone
- line 23 potentially give more information on the meaning of the fact that 'pmoA genes could not be detected' for readers inexperienced in this field

Page 12263

- line 12 insert 'stable carbon' before 'isotopic shift'
- line 17 refer to Fig. 4 with respect to turnover rate constant
- lines 19-20 remove 'This time'

Page 12264

- line 3 replace 'Pelagic' by 'Microbial'; sentences 1 (lines 3-5) and 3 (lines 6 – 8) may be combined by specifying trends in concentration distribution and stable carbon isotope pattern that are indicative for methane consumption in first sentence
- lines 8-11 What might be explanation for decreasing CH₄ concentrations with depth between ca. 100 and 125 m at Landsort Deep, while δ¹³C-CH₄ values remain relatively constant in this depth interval?
- line 11 indicate depth interval considered in this sentence

- line 16 'outstanding position' with respect to what?
- lines 19-21 state potential reason for the much lower CH₄ in GD or refer to respective subsequent chapter

Page 12265

- line 1 word choice: turnover rate constant was not detected in but calculated for the LD
- line 8 'involved' in what
- line 10 replace 'within' by 'of the'
- lines 11-14 sentence should be streamlined for better readability; replace 'studies' by 'study'; indicate depth ranges for lower redox zones
- lines 15-18 How does the assumption of microbial methane oxidation correspond to the fact that no pmoA genes could be amplified for samples from GD?
- line 18 'positive products' correct expression?
- lines 19-21 remove 'pelagic'; specify 'assess the methane oxidation'; because processes specifically taking place in the chemocline ('transition to anoxic conditions') were not highlighted in the preceding chapters, this statement is somewhat confusing here
- line 21 exemplify 'side effects'
- lines 24-25 specify 'methane concentration and isotope patterns' (see also my comment on relatively constant d13C-CH₄ signatures in redox zone at LD)
- line 29 remove 'could be'

Page 12266

- line 1 statement of a stronger extent of disturbance at the GD compared to LD requires reference
- lines 4-5 remove 'identified'
- lines 8-9 reference 'Mau et al., 2012' is not correct at this place because that study considered seepage off Costa Rica
- lines 20-22 statement relevant for this study? If the authors intend to keep the sentence it should be amended by information on the chemical nature of the respective Black Sea water body inhabiting such microbes.
- lines 22-25 statement is repetition of pages 12262 (lines 20-23) and 12263 (lines 18-19)
- lines 26-27 indicate subject (microbial population, water column?) for which structural stability is considered; indicate subject for which lateral intrusions (water mass?) is assumed. In my opinion the relation between lateral water intrusion and low diversity of microbial population requires some more detailed explanation.

Page 12267

- line 1 citations are incorrectly positioned because at present state they appear to support own interpretation
- line 3 'disturbed' in respect to what?
- lines 8-9 calculation of individual sulfate concentrations from continuous water salinity profiles requires better explanation
- line 11-16 section bears potential for condensation
- lines 12 specify 'affected by errors'
- line 19 title might be amended by the matter that is mixed
- lines 20-23 separate into two sentences
- line 24 emphasis should be placed on biogeochemical processes rather than scientific interest

Page 12268

- line 3 indicate approx. water depth of 'lower edge of redox zone'
- line 4 specify 'this zone'
- line 8 processes related to 'boundary effects' deserve some better explanation. Why are boundary effects restricted to water column above 300 m water depth?
- line 11 define ' K_p '
- line 12 'its'?
- line 13-14 'coastal boundary layer' should be illustrated in Fig. 1
- lines 13-16 terms 'high-energetic coastal processes' and 'transfer of larger energy flux densities' require some better explanation
- line 17 give information about distribution/thickness of coastal boundary layer
- line 17 indicate reference parameter for 'increasing'
- line 18 remove 'Towards the bottom'
- line 18 in case values for vertical mixing rates are available, they should be stated here
- lines 23-28 terms 'basin interior' and 'basin boundary' require better explanation. Which units assigned for these terms result in an unitless ratio WV/BB? Relation between 'basin interior' and 'water volume (WV)' requires clarification; exact values for WV and BB should be stated for both, GD and LD, along with respective references
- lines 24-25 sentence appears to be incomplete

Page 12269

- line 1 unify terminology ('anoxic deep water' vs. 'anoxic zone')
- line 3 specify 'our dataset; specify depth interval of 'upper anoxic zone'
- line 5 'methane gradients' incomplete term
- lines 10-11 remove 'observed'
- line 13 'though the absolute values ... factor of 4.' incomprehensible
- line 16 title of chapter might be amended by the matter that is intruding
- line 17 turbidity in the water column caused by mineral precipitation is not restricted to stratified water bodies such as in the Baltic Sea. Turbidity was also observed to correlate with oxidation of reduced metal species discharged at hot vents in the open ocean (see e.g. Marbler et al., 2010 and others). Sentence might be re-phrased accordingly.
- lines 22-23 clarify relation 'abundance of bacteria' and extent of water column turbidity'; define 'deep pool'

Page 12270

- lines 3-4 remove 'our data shows that'
- line 6 specify 'dynamic conditions within the redox zone'
- line 9 insert 'signal on top of the redox zone'
- line 12 'in that transition zone' unclear
- lines 15-16 use abbreviation 'T-S' introduced in line 13 instead of 'temperature and salinity profiles'
- line 22 specify 'different environmental settings'; remove 'pelagic'
- line 27 because there is in my opinion no evidence from this study that the 'hydrographic conditions have no influence on the methanotrophic population' I suggest rephrasing this sentence according to 'hydrographic conditions apparently do not promote development of a higher diversity of methanotrophic communities' or similar

Page 12271

- lines 1-2 specify ‘considerable differences of microbial methane turnover in redox zones in both deeps’
- line 3 give idea on location of ‘deep methane pool’

Table 1 Reference to Table 1 is missing in text

Figures

Figure 1

- Fig. might be enlarged to full page size
- Position of numbers for longitude misleading (see Figs. 1A and 1C)
- Orientation of profile in 1C might be illustrated in Fig. 1B; direction of Fig. 1C might be mirrored;
- Flow directions of water masses mentioned in the text at several places should be illustrated in Fig. 1B

Figures 2 and 3

- annotate oxic, suboxic and anoxic zones in figure
- color coding (blue, green, black) used in Figs. 2B and 3B, respectively are difficult to differentiate in the printout version; use different symbol shapes at least
- color coding used for gene expression analysis in Figs. 2C and 3C, respectively, cannot be