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Interactive comment on "Macroalgae contribute to nested mosaics of pH variability in a sub-Arctic fjord" *by* D. Krause-Jensen et al.

Anonymous Referee #2

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Krause-Jensen et al. measured the inorganic carbon chemistry in a Greenlandic fjord, and by measuring O2 as well, they are able to evaluate and distinguish tidal and photoautotrophic influences. They examined the inorganic carbon chemistry from the planktonic community down to surface of macroalgae and they also examined seasonal differences. It should be pointed out that some previous studies, already measured the fluctuations in inorganic carbon concentrations in coastal habitats (Delille et al. 2000, Middelboe and Hansen 2007) and related them to photoautotrophic activity, but the detailed analysis of this study is completely new. Furthermore, the Arctic with its particularities has in this context never been examined before. The methods are timely and well explained. Concerning the presentation of the results I would suggest to provide also pCO2-data in the text, to allow an easier comparison with previous works from photosynthesis researchers. For researcher focusing on aquatic photosynthesis

the pCO2-value is of particular relevance (This might be a very personal point of view, but still I would like to give this advice). Generally, but in the discussion I would suggest to pay more attention to the effects of ocean acidication on non-calcifying algae/ animals. These are often overlooked and receive too little attention compared to calcifying species. However, in your study, where you focus on Arctic fjords, where kelps are the most important key-stone species you should mention the known OA-effects on kelp and in my opinion even highlight it in your discussion. The paper is very well written and beside the mentioned suggestions for improvements I only have some minor remarks, which potentially might help to improve the paper and broaden its audience. I hope that you consider them constructive. In Summary, I enjoyed reading the paper and recommend the publication after a minor revision.

Page 4909 Line 5: Why do you limit yourself to calcifyers? Also non-calcifying organisms will, in particular photoautotrophs will be strongly influenced by lowered pH? I recommend mentioning them. Page 4910 Line 20: Gordillo and Mercado 2011 named this problematic in 2011, consider citing them. (Gordillo and Mercado2011, Inorganic carbon acquisition in algal communities:are the laboratory data relevant to the natural ecosystems? Photosynth Res (2011) 109:257–267) Page 4911 Line 8: A reference to Delille et al. 2000 and Middelboe and Hansen et al. 2007 is much more appropriate. Line 14: What about non calcifying organisms, such as the kelp, the key-species of the ecosystem you are investigating. Kelps growth can be stimulated by OA (Olischläger et al. 2012), but its reproduction can be OA-insensitive (Olischläger et al. 2012), or hampered by OA (Roleda et al. 2011, Xu et al. 2015). Furthermore OA affects the competition between understory red algae and kelps

(Connell and Russell 2010) You are examining kelp habitats, in my opinion you should mention the known pH-effects on kelp, in particular of species with the Arctic distribution. (Roleda et al. 2012 ,Ocean acidification and seaweed reproduction: increased CO2 ameliorates the negative effect of lowered pH on meiospore germination in the giant kelp Macrocystis pyrifera (Laminariales, Phaeophyceae) Global Change Biology,

18, pages 854–864, Olischläger et al. (2012) Effects of ocean acidification on different life-cycle stages of the kelp Laminaria hyperborea (Phaeophyceae) Bot Mar 55, 5, 511–525, DOI: 10.1515/bot-2012-0163, Xu et al. (2015) Effects of CO2 and Seawater Acidification on the Early Stages of Saccharina japonica Development, Environ. Sci. Technol., 2015, 49 (6), pp 3548–3556, DOI: 10.1021/es5058924 Connell S, Russell BD (2010) The direct effects of increasing CO2 and temperature on non-calcifying organisms: increasing the potential for phase shifts in kelp forests, Proc. R. Soc. B 2010 277, 1409-1415

Page 4915 Line 1: Can you define kelp habitats, species depth, density? Species would be most important

Page 4916 Line 14: Saccharina longicruris or Saccharina latissima? See figure 8, where you write latissima, Page 4918 Line 27: Could you describe the light attenuation underwater, in my experience in Arctic fjords in summer the underwater light regime is strongly influence by melting river plums. You describe a river flowing into your fjord, therefore I asked myself if there were pronounced river sediments plums above your algae habitats? Sometime, kelp algae can even be densely covered by sediments, which might affect their photosynthesis and thereby influence on the local pH.

Page 4922 Line 25: The growth season of kelp in the Arctic is difficult to address, since Arctic brown algae accumulate C-storage metabolites during spring summer and grow in winter (Dunton and Schell 1986). In peak summer many adult species do not show vegetative growth and tend to fuel their reproduction. At least in the high Arctic this reproduction phase is decreasing or has already ended in September (Olischläger and Wiencke 2013). Furthermore, arctic kelps tend to store more of their photosynthates in preparation for the polar night. This potentially might affect their respiration rates (Olischläger et al. 2014) and be relevant for your data. Hence algae might be already preparing for the overwintering and growth season, showing reduced metabolic activity. In my opinion you should consider discuss these informations in relation to your pH/O2-profiles.

Dunton KH, Schell DM (1986) Seasonal carbon budget and growth of Laminaria solidungula in the Alaskan High Arctic. Mar Ecol Prog Ser 31:57–66 Olischläger M, Wiencke C (2013a) Seasonal fertility and combined effects of temperature and UV-radiation on Alaria esculenta and Laminaria digitata (Phaeophyceae) from Spitsbergen. Polar Biol 36:1019–1029 Olischläger M, Iniguez C, Gordillo FJL , Christian Wiencke (2014) Biochemical composition of temperate and Arctic populations of Saccharina latissima after exposure to increased pCO2 and temperature reveals ecotypic variation. Planta Volume 240: 1213-1224, DOI 10.1007/s00425-014-2143-x

Page 4925 Line 10: I remember a talk from Frank Melzner, where he showed that mussels grow at very low pH-conditions, but were in good physiological conditions with well calcified shells as long as they had enough to eat. This was different when the mussels were starving. I hope this is correct in the way I explained it. Consider, have a look at Frank Melzners papers or contact him.

Page 4926: Increased primary production? In my eyes depending on the habitat, Fucus, subjected to high pCO2 showed a negative growth response (Gutow et al. 2014). Laminaria hyperborea responded with increased growth (Olischläger et al. 2012). Potentially, this statement is too general. Consider being more specific and provide references. Furthermore, the response is apparently dependent on the influence of further environmental factors, such as light, nutrients temperature

Gutow et al. (2014) Ocean acidification affects growth but not nutritional quality of the seaweed Fucus vesiculosus (Phaeophyceae, Fucales) Journal of Experimental Marine Biology and Ecology, 453 , pp. 84-90 . doi:10.1016/j.jembe.2014.01.005 Olischläger et al. (2012) Effects of ocean acidification on different life-cycle stages of the kelp Laminaria hyperborea (Phaeophyceae) Bot Mar 55, 5, 511–525, DOI: 10.1515/bot-2012-0163

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