Referee 1

Interactive comment on "A Sedimentary Carbon Inventory for a Scottish Sea Loch (Fjord): An Integrated Geochemical and Geophysical Approach" by C. Smeaton et al.

Anonymous Referee #1 Received and published: 11 July 2016

Fjords (lochs) have been shown to be significant global sinks of carbon, especially with respect to their relatively small area on earth. In this study, Smeaton et al. conducted a seismic survey and collected sediment cores from Loch Sunart, a loch system on the west coast of mainland Scotland. The authors stated that lochs on Scotland mainland are comparable to some of the fjords in Norway, Canada, and Fiordland, and therefore, the methods and results from this study could likely be applied in studying other fjord systems. By using seismic data and sediment cores, the authors present a detailed method for calculating the inorganic and organic carbon budget in Loch Sunart. The authors further compared the carbon inventory with the peat & soil inventory in Scotland, which has been well studied. They concluded that Loch Sunart has a much higher area-normalized burial rate of carbon than peat & soil systems on land, and therefore suggest that lochs should be treated as a standalone system when studying carbon dynamics. The manuscript is well organized and well-written; I believe with some moderate revision, this manuscript would be suitable for publication. Please see the suggested changes below.

We thank the referee for these very positive comments; it is encouraging to note the external peer-review support for our arguments to suggest the stand-alone nature of these global systems and their underestimated significance as carbon sinks in comparison to adjacent terrestrial sinks.

Page 1, line 24: in or is? is

Page 1, line 26: are or area? area

Page 2, line 5: check citation format & changed to and

Page 3, line 13: What this statement is based on? Reference to a paper by Norgaard-Pedersen et al. (2005) has been added to highlight the fact that data exist to show significant amounts of IC present in these buried sediment sequences.

Page 5, line 18: where or were? were

Page 6, line 16: Any reference for this method? To what I know, this method is not commonly seen while doing OC analysis. Reference to a paper by Loh et al. 2008 has been added, outlining the methodology used.

Page 7, line 3: Apparently, SARs are not the same during glacial and interglacial time period, and how do you justify this point? If you use constant SAR from LGM to modern, then you would overestimate Holocene SAR. This is true, but one of the reasons that we did not focus on SARs, was that the constraining chronologies from the available sediment cores did not provide good

constraints on the glacial and deglacial portions of the stratigraphy and therefore one must acknowledge that the uncertainties will be large. However, if one adopts an approach based on well-defined seismic units, as we have done, there is far less ambiguity in the methodology.

Page 7, line 14&15: check the sentence. were.

Page 10, section 3.2: the radiocarbon dating of core 2833 in Baltzer et al. (2010) is poor in the lower part of the core. Time dating of 17041 at ~7 m depth is from LGM, however, there is no evidence showing the dropstone presented at the bottom of the core is whether from H1 or H2. It is likely that core 2833 goes back to ~25,000 years, especially considering that presence of the fifth horizon in the inner basin & middle basin, which is likely the boundary of LGM (H1). Please justify this point. We thank the referee for these interesting suggestions, but would note that current understanding of the regional ice sheet dynamics for this sector of the NW European shelf would support the refree's inferences. First, the reported age from MD04-2833 is a calibrated age of 17041 +/-312 cal BP; this is consistent with the known timing of regional ice stream deglaciation back towards the present coastline (Clark et al., 2012). The reported age is therefore consistent with the transition from ice grounding within the fjord to a marine, ice-free environment. The referee speculates whether or not "clasts" within the underlying diamict below this basal marine age of 17041 +/-312 cal BP may represent "dropstones" associated with Heinrich Layers. Given our current understanding of the last British and Irish Ice Sheet dynamics (e.g. Scourse et al., 2009), the possibility of Heinrich or Heinrich-like events at this time within these fjord environments is extremely unlikely, since they represent the major conduits for the ice streams which extended as far offshore as the continental shelf break.

Page 11, line 18: What is this? Line deleted as it was from previous version of paper.

Page 12, line 12: The number of decimals might be too high, unless if you can justify it. The figures have been changed to scientific notation rounded to 2 decimal places.

Page 12, line 17: check gramma We have corrected the grammatical construction of this sentence.

Page 13, line 20: How the negative number is calculated? This was a typo, which has now been removed; this is not a negative number.

Page 13, line 20&21: This sentence is not supported by the data. We have corrected these numbers, which should read as follows in terms of their OC:IC ratios 4, 1 and 0.42.

Page 14, line 25&26: and also area < 10 m deep? We don't understand the referee's comment; we refer to a published study (Burrows et al., 2014) where the authors only accounted for sedimentary C stock within the surface 10 cm – our point is that this approach grossly underestimates the full depth sediment C stock.

Discussion: Although this paper is more of a methodology paper, I still think it might be interesting to make comparison to some other fjords globally in the aspects of sedimentation rates, carbon accumulation rates, and distribution pattern of carbon along fjords. Smith et al. (2015) summarized all global fjords, however, there is no OC accumulation rates from Scottish fjords yet. By making a comparison of the results in this manuscript to other fjords, even just fjords in NW Europe, it would make the paper more interesting. I would assume Scandinavian fjords would be different to Scottish

fjords in carbon accumulation rates, etc. We thank the referee for this very constructive comment; we had originally intended the focus of this manuscript to be methodological, but we are persuaded that the global comparisons to which the referee alludes would be usefully incorporated. Therefore, we have revised the manuscript accordingly (please see similar suggestions from referee 2, where we provide the detailed information on our responses)

Page 15, line 23: check gramma Brackets and question mark removed as they were part of a previous version of the paper.

Page 16, line 25: What defines long-term here? Based on the data, the loch sediment chronology only goes back to ~17,000 yrs. To avoid potential confusion, we have removed this statement and instead added text to describe glacial/interglacial cycling processes on erosion/deposition to the adjacent shelf/slope.

Fig. 6: not sure if it is better to show the thickness of each unit, other than the depth of each horizon because the thickness is more interesting and more related while calculating carbon budgets. We acknowledge that the underlying data in figure 6 represent an important step in our methodology to calculate sediment volumes; unfortunately – the programme used to generate these plots does not easily lend itself to generating the thickness plots which the referee mentions. For this reason, we agree with the referee that the differences in unit thicknesses are not immediately apparent and have therefore moved figure 6 to the supplementary materials section (where it can be viewed to understand the underlying methodology).

Fig. 8 is not cited in the manuscript. This figure is now cited in the text on page 12 line 24.