Review process Link et al. (2012): Multivariate benthic ecosystem functioning in the Arctic - Benthic fluxes explained by environmental parameters in the southeastern Beaufort Sea**, bg-2012-473**

Authors' response to review Referee #2 (received April 19, 2013)

We would like to thank referee #2 for his/her efforts to review our manuscript. We acknowledge that he/she provided some general comments on putative methodological flaws of our study. We argue, however, that our methods for measuring benthic fluxes are appropriate for our ecological approach. Its main purpose is not to provide highly accurate absolute values to be used for geochemical budgets. Instead, we present an approach to use relative differences among sites to estimate and predict spatial patterns of benthic remineralisation based on environmental parameters. Estimating benthic remineralisation is important as it provides nutrients to the pelagic system. Our approach is important in the face of a changing environment because it will allow estimating at least relative changes of benthic remineralisation and its importance in the evolving Arctic ecosystem.

In the following we address each point raised by referee #2:

1) R2: "First, to have a saturated oxygen level in the overlying water above all cores from all stations means that in situ oxygen conditions were far from being maintained. Since it is very well known that oxygen has a strong influence on both magnitude and direction of benthic nutrient (and sometimes also oxygen) fluxes, this is not acceptable."

Reply: We'd like to point out that incubation chambers contained air-saturated oxygen levels only at the starting point of measurements. In the course of the incubation, oxygen consumption in the core decreased the O_2 concentration in the overlying water towards values that were close to in situ bottom-water oxygen levels (see Table S2). The oxygen levels in the incubations were thus never far from ambient levels. Without achieving oxygen saturation at the onset of measurements, oxygen levels could fall well BELOW in situ oxygen concentration, and possibly lead to hypoxic reactions, which do not occur in situ at our study sites. Moreover, it should be noted that most shipboard incubations involve acclimatization of cores on board, generally including replacement or addition of bottom water, and thus an exchange period of the overlying water with the ambient atmosphere (e.g. (Rysgaard et al., 1998;Clough et al., 2005;Davenport et al., 2012)). As in other studies, our cores were filled with bottom water collected the same day and at the same location and left to acclimatise in the dark. Incubations were stopped when oxygen levels had decreased by more than 20% to avoid anoxic conditions and biogeochemical transformations (Hall et al., 1989). The total amount of water withdrawn and replaced during nutrient sampling did not exceed 10% of the total overlying-water volume. This method has been used and published before (e.g., Renaud et al., 2007;Link et al., 2011).

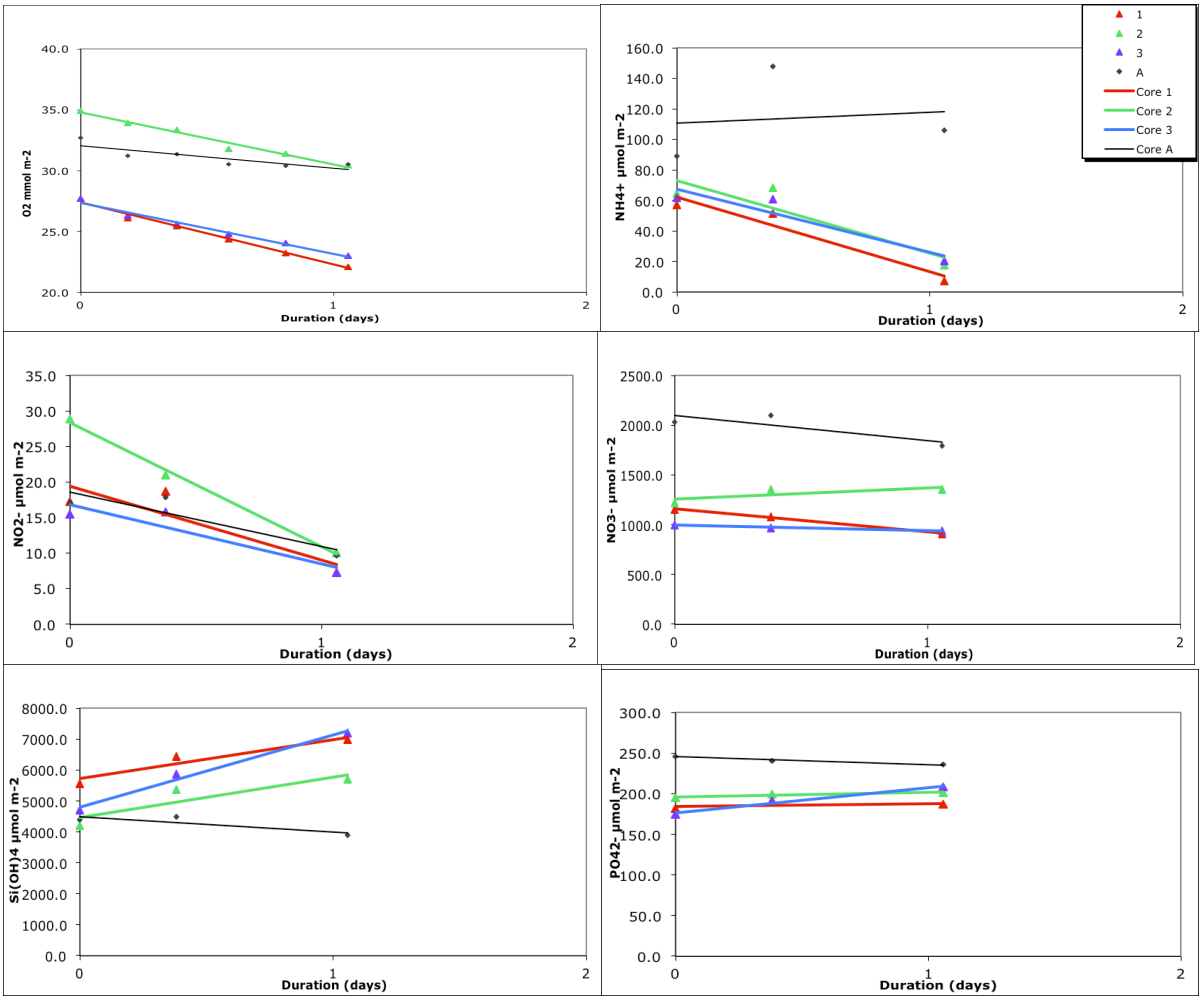
2) R2: " Second, to have only three data points in the calculation of each flux are way too few. The authors can in this way only get a very weak impression of the linearity of the concentration vs time plot from the flux incubations, and a poor estimation of the flux. [...] Also, one or a few figures showing the development of solute concentrations versus time during flux incubations should have been shown as well as a Table with the fluxes, and a better description of how fluxes, and the uncertainty of them, were calculated from the incubation data. The figure with fluxes in the MS is obscure, and it is very hard to see what the flux rates really are in that figure."

Reply: Flux data is published in Table S1 with the original version and first submission of the manuscript found online. We agree that exact fluxes are hard to read in Fig. 2, which is why we had added Table S1 with the exact data.
Calculating fluxes based on three measurements is an accepted method in determining benthic remineralisation for ecological questions (Robert et al., 2013;Richard et al., 2007), and in biogeochemical studies, four measures have been accepted (Rysgaard et al., 1998;Michaud et al., 2006). With this approach, we assume constant solute exchange with time during the incubation period. We interpret the fact that the oxygen fluxes, computed based on five or more (non-invasive) measures in time, were always linear, a good evidence of constant exchange rates across the sediment-water interface. We acknowledge that more measures of nutrients would have been desirable for higher confidence in linearity. But we decided for a trade-off between exerting minimum disturbance of the incubation (minimum of three water samples per core) and obtaining maximum information (three points to calculate nutrient fluxes, instead of only two; see e.g. Thrush et al., 2006;Rossi et al., 2008). For your information, we here insert a table with all calculated fluxes (as in Table S1) and the R^2 of the linear regression slopes used to calculate fluxes (Units are **mmol m^{-2} d^{-1}** *for O_2 and* **µmol m^{-2} d^{-1}** *for nutrients). This table shows that the majority of fluxes could be calculated as a linear distribution with high confidence. Having three replicates per site allows for statistics, and is thus a strength that counteracts against single measurements with low confidence.*

Station	Core	O_2	R^2	NH_4^+	R^2	NO_2^-	R^2	NO_3^-	R^2	$Si(OH)_4$	R^2	PO_4^{2}	R^2
390	1	-9.51	0.96	-44.61	0.98	-25.84	0.71	-785.06	0.16	-352.13	0.00	-41.07	0.27
390	2	-11.47	0.98	281.00	0.80	-4.28	0.20	-597.91	0.07	3494.65	0.95	23.25	0.13
390	3	-10.59	0.92	443.30	1.00	14.39	0.16	-378.09	0.00	2478.59	0.47	-44.26	0.71
690	1	-8.84	0.99	-30.80	0.50	-43.57	0.84	-345.32	0.77	1171.44	0.80	-46.35	0.00
690	2	-8.13	0.99	-66.95	0.78	-15.90	0.99	-631.51	0.26	1082.16	0.69	-57.66	0.11
690	3	-8.47	0.96	31.38	0.99	-29.15	0.99	-324.24	0.94	947.69	0.98	-39.14	0.09
260	1	-5.41	0.95	21.24	0.95	-7.10	0.25	10.59	0.06	2092.55	0.95	17.29	0.52
260	2	-4.29	0.92	60.89	0.99	-7.49	0.94	21.24	0.07	1347.74	0.81	27.55	0.69
260	3	-3.42	0.97	-53.54	1.00	-7.94	0.98	41.35	1.00	1377.07	1.00	15.51	0.93
110	1	-0.98	0.98	4.35	0.98	-3.24	0.77	90.24	0.91	867.21	0.97	3.21	0.07
110	2	-1.31	0.99	-13.74	0.83	-3.51	0.29	-27.85	0.75	763.65	1.00	0.38	1.00
110	3	-0.70	1.00	5.19	0.88	-1.99	0.10	-22.68	0.97	599.41	1.00	-0.85	0.99
140	1	-3.26	0.99	-56.18	0.93	-2.76	0.79	16.45	1.00	1776.83	0.92	13.24	0.23
140	2	-2.41	0.98	-54.90	0.82	-9.93	1.00	362.94	0.62	1798.87	0.80	15.24	0.92
140	3	-2.33	0.98	-48.62	0.88	-0.77	0.85	193.84	0.98	2819.58	0.98	40.67	0.98
680	1	-4.32	0.96	-10.52	0.96	-3.37	0.87	-238.66	0.75	1283.23	0.88	11.08	0.50
680	2	-5.04	0.97	6.75	0.83	0.18	0.00	-120.99	0.81	1356.21	0.95	19.59	0.81
680	3	-4.45	0.98	-13.49	1.00	-3.08	0.76	-158.03	0.96	1232.46	0.98	17.25	0.05
345	1	-0.53	0.96	1.02	0.93	-0.65	0.46	92.78	0.17	437.34	0.64	13.40	0.55
345	2	-0.54	0.94	-2.68	0.81	-0.45	0.55	-2.08	0.83	329.21	0.00	9.32	0.86
345	3	-0.81	0.98	3.25	0.58	3.40	0.87	25.01	0.63	481.38	0.23	6.20	0.78
235	1	-0.86	0.95	-16.58	0.75	-1.39	0.06	-24.75	0.63	363.63	1.00	-0.37	0.90
235	2	-0.62	0.95	-14.16	0.91	-2.09	0.02	132.52	1.00	457.30	0.99	5.90	1.00
235	3	-0.52	0.85	-16.37	0.74	-1.71	0.94	-26.89	0.29	314.54	0.96	0.56	0.54

As an example we also provide plots of nutrients fluxes from Station 140. The plots show the change of quantity in the nutrient (or oxygen) standardized per area (to correct for different volumes of water in the core) over time. Each plot shows the flux for the three sediment cores and the control core (A; water only), which was subtracted from the flux value of each core to obtain fluxes corrected for methodological errors. Different starting quantities result from slightly different concentrations and water volumes. The small table below shows nutrient concentrations of each core at the start of incubation at site 140.

	O_2 µM	NH_4^+ µM	NO_2^- µM	NO_3^- µM	$Si(OH)_4$ µM	PO_4^{2-} µM
Core 1	333.64	0.69	0.21	13.952	67.15	2.19
Core 2	329.42	0.61	0.27	11.552	39.76	1.84
Core 3	329.42	0.73	0.18	11.927	55.97	2.08
Core A	343.90	0.89	0.18	15.281	32.99	1.85



3) R2: Thirdly, to freeze samples for dissolved silicate during storage is not recommended since it will very likely cause sample artefacts such as irreversible polymerisation (giving incorrect concentrations).

Reply: We agree that our method of measurements may have led to artefacts. The polymerization of silicate is a well-known artefact particularly in fresh waters and water with low- salinity as coastal and estuarine waters (Burton et al., 1970;Macdonald and McLaughlin, 1982;Macdonald et al., 1986). Even after filtration through 0.7 µm (to minimize biogenic Si dissolution), further storage at ambient temperatures would still allow microbial processes that could severely bias colorimetric analysis (Aminot and Kérouel, 2004). Therefore, we decided to freeze samples, based on the premise that this will lead to biased absolute silicate values but that a valid comparison of relative among-site differences is still possible. Moreover, we used control cores with water only to correct for methodological errors.

4) The MS also contains numerous other errors such as unclearly written text, scientifically incorrect statements, too many speculations not supported by observational evidence or data, and sometimes lack of citing key references.

Reply: We would happily correct any incorrect statements, modify unclear text passages and integrate further information that had not come to our attention before, if the reviewer had provided more details on it. If data has not been provided in the manuscript or supplementary material at this point, we will do our best to provide it.

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