We thank the reviewer for the time taken to read and positive comments on the manuscript. We were happy to elaborate on the methodology of deriving bioturbation rates, and to implement the suggested changes to figures and tables. In addition, we took up the suggestion to make a sort of summary figure, to serve as the figure for the abstract.
The changes were applied in track changes in the manuscript, and copied in this reply to individual answers. With these changes, we hope to have replied to this review in a satisfactory manner.

1. **Reviewer's comment:** Despite this, I guess that the authors should make an effort to better explain how the bioturbation rates were calculated. As far as I can see, this information is not fully included in the manuscript and this could be crucial to understand how much and whether the abundance, biomass and (functional) diversity of the benthos in the parameterization sites have been taken into account. In my opinion, this information is also necessary because the results, though contextualized according to the different sediment granulometry of the experimental sites and C fluxes, do not seem to have been analyzed eliminating the covariate effect of water depth, which controls benthos abundance, biomass and diversity, which, in turn, could respond differentially to bottom trawling disturbance (as indeed postulated in the discussion).

   Reply: A more specific description of how the biodiffusivity constant *Db* (~bioturbation rate) was estimated based on porewater nutrient profiles has been added in the methodology section, as follows: "*bottom water, as well as process rate parameters that were derived following a 2-step steady state fitting procedure (Table 3). Using the measured DIC flux as the upper boundary organic carbon input flux, the O_2 flux and porewater profiles of O_2, NO_3^-, and NH_4^+ were first fitted manually by tweaking a limited set of model parameters. The degradation rate of refractory material (rSlow), and the biodiffusivity constant Db were constrained by fitting NH_4^+, and O_2 profiles. Mechanistically, decreasing the bioturbation rate Db reduces the build-up of NH_4^+ with depth, increases the oxygen penetration depth, and changes the shape of the NO_3^- profile (deepening the NO_3^- peak).*" This is thus a pure biogeochemical approach to bioturbation, in which the biodiffusivity constant is assumed to be the product of indeed biomass, abundance, and functional diversity, but the latter are not considered separately. However, this is indeed important information to consider when deciding on real-case management steps, as a variety of studies have indicated the role of life-history and behavioral traits of individual species in their response to trawling (e.g., Tillin et al., 2006; Rijnsdorp et al., 2016; Pitcher et al., 2017; Hiddink et al., 2019).
   We performed tests to see if (part) of this information could be implemented in more detail, based on known species communities in the specific areas. The complexity of shifting species communities, unknowns about individual species behaviors, and most importantly the difficulty to translate all this information to a model of sediment diagenesis, prohibited us from doing so successfully. This last step would be of high value to the field of benthic ecology and biogeochemistry in general, and requires extensive research.
   In the end, the meta-study of Sciberras et al., 2018 provided a "blanket" formula that could be used, assuming that a culling of organism equates to a culling of bioturbation.

2. **Reviewer's comment:** As mineralization rates, as correctly postulated in the manuscript, are dependent also on the relative importance of refractory and labile/semi-labile fractions of OC, it could be interesting to see addressed the effects of bottom trawling on the two fractions, though this could be the object of a "sister" manuscript.

   Reply: This is (shortly) mentioned on lines 208 – 213, "*A redistribution of organic carbon was visible in the upper cm of the sediment, where organic carbon concentrations were higher in the impacted than in the baseline simulation (example in the cutout of the top 5 mm shown for MudH, Figure 5). In FineL, MudL and MudH the ratio of labile organic carbon (FDET) to semi-labile organic carbon (SDET) increased between 25 and 34 % (Figure S3, supplement). This effect was only noticeable in the upper 0.2 – 0.5 cm, below this depth values of this ratio in all trawling frequencies converged to 0, due to the depletion of labile organic carbon.*"
   In our model, bottom trawling causes a depletion of the carbon build-up in the sediment. As organic carbon generally becomes less reactive with age (~ depth in the sediment), the total organic carbon pool becomes more reactive when less organic carbon gradually builds up to deeper layers. In the most extreme case (as an example), there is almost no organic carbon in the sediment due to continuous, chronic resuspension. If fresh organic carbon is then deposited on the sediment-water interface, the labile organic carbon will proportionally make up a considerable part of the total organic carbon pool.
   Since also the other reviewer noted interest in changes to the reactive carbon pool, we added the figure (see below) to the supplementary information, and refer to this figure on line 235: "*In FineL, MudL and MudH the ratio of labile organic carbon (FDET) to semi-labile organic carbon (SDET) increased between 25 and 34 % (Figure S3, supplement).*"

We choose not to include the specific effect of this shift towards more labile organic carbon near the surface as a topic for extended discussion, for 2 main reasons: (1) the drastic changes to the total organic carbon pool and availability of reactants in general have a far greater effect on mineralization processes. (2) The significance to this pertains more to the temporal (sub-annual) dynamics of organic matter mineralization, which was consciously left out of this manuscript. It would indeed be more suited for a sister-manuscript, in which seasonal dynamics and management implications thereof are discussed.

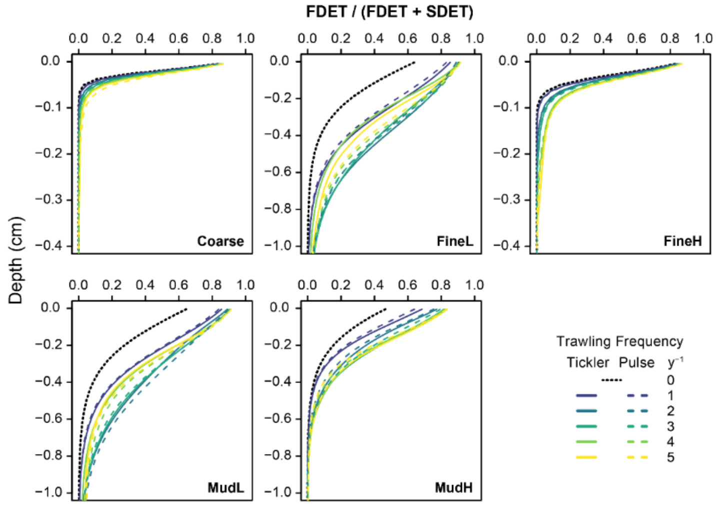
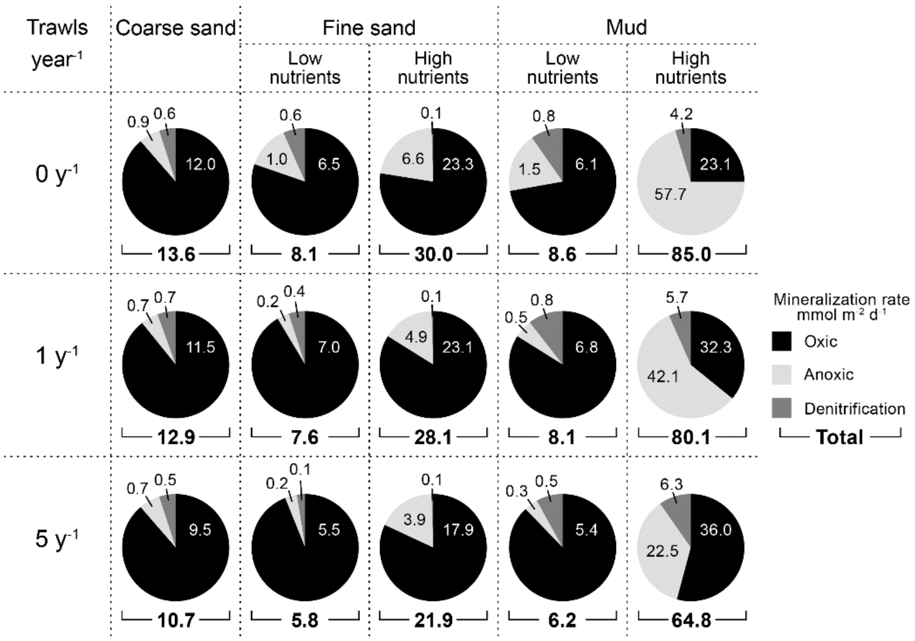


Figure S 1: Annually averaged modelled quality of the reactive organic carbon pool in the surface sediments (note different depths on y-axis between figures for visualization purposes). The carbon quality (x-axis) is represented as the proportion of fast degrading detritus (FDET, labile org. C) in the summed labile and semi-labile org. C pool (FDET + SDET). Black dotted line is the 0 trawl default, full and dotted coloured lines are tickler and pulse gear respectively, with increasing trawling frequencies as different colours.

3. **Reviewer's comment:** Technical suggestions: Despite all of the figures are necessary and informative, a (qualitative) graphic panel of differences and tendencies of mineralization rates along the trawling frequency gradient in the different environmental contexts (sediment type and depth) would help a lot the general reader to recap the results.

   Reply: We have implemented this change by replacing tables 5 and 7 with graphical alternatives, and suggesting a summary-type figure as the graphical abstract.
   Given the nuance in some of the results (e.g. changes to denitrification, initial decreases and then increases in porewater solutes and vice-versa, this would again become a quite large figure. To compromise, we suggest to use the following figure as the figure for the abstract. This figure shows the changes to total, and relative mineralization rates at 1 and 5 trawls y^{-1}. Since there is little/no difference between gear types, this is based on the tickler chain gear results.



4. **Reviewer's comment:** The number of tables could be reduced, moving some of them in the supplement material. Figures' and Tables' numbering (and their order of reference in the main text) need an accurate check and correction.

   Reply: This has been implemented as follows. Tables 5 and 7 have been moved to the supplementary material (now resp. Table S1 and S2). In place of Table 5 is now a slightly adapted version of Figure S2, previously in the supplement, showing averaged nutrient profiles per trawling intensity for each location. There is now also a figure to replace Table 7 (please see below), that shows the same information graphically. To make space for these figures, we chose to remove Figure 4, the range in porewater concentrations throughout the year, to the supplement.

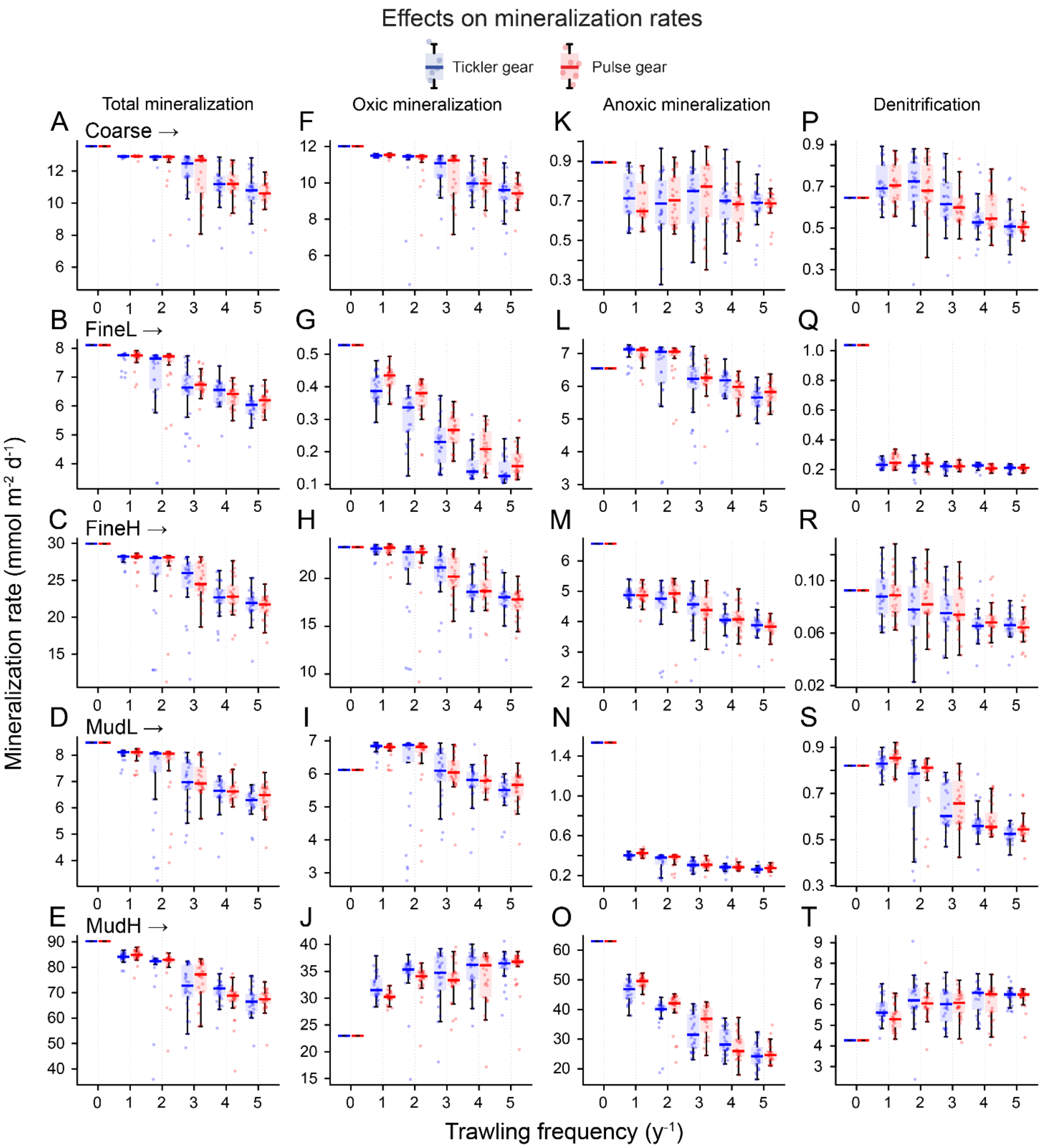


Figure 1: Rates of total mineralization (A - E), and the three main mineralization processes (F - J: oxic; K - O: anoxic; P - T: denitrification) (y-axis, mmol m^{-2} d^{-1}) for each gear type (blue boxes: tickler gear; red boxes: pulse gear), and for increasing trawling frequency (x-axis, y^{-1}). Note different scales on y-axes.