We would like to thank the reviewer for their thorough and constructive feedback. Please find below our responses to RC1. Below we have provided RC1's comments (in black text) and our responses in red italic text. Where RC1 gave comments in paragraph form, we underlined key concerns in the paragraph and pasted them below with out associated response to ensure we addressed all of RC1's comments. Other than that we have addressed each one of RC1's comments in red italic text after each specific comment.

RC1

Major points:
This MS applied a machine learning-based DBD model to adjust DBD data and reevaluate the OC stock in the Irish Sea. They mainly compared two different ways to calculate regional OC stock. One is based on the empirical formula and unadjusted data; the other is to use a RF model in this study to generate the spatial distribution of DBD and OC stock. Their findings highlight potential overestimation of OC stock and the necessity to improve current models. Overall, this MS made a good point. However, I frequently felt it hard to follow when reading this MS, and much effort is need to make this MS easier to read. Major comments are as follows.

My most major comment is about the accuracy of the model. Although the adjusted DBD data align better with in-situ measurements, it is not convincing enough that the OC stock after adjustment is closer to the actual value. It is necessary to be clarified in different ways. Moreover, as shown in the main text, the study area lacks observational DBD data. Thus, it is questionable whether the adjusted DBD within the study area really improved the model performance and the accuracy of estimation. I also wonder the reason for just choosing the Irish Sea as the study area. It's better to emphasize these points in the main text and avoid possible vagueness.

Second, the advantages and applicability of this adjusted DBD model were not clearly illustrated. The prediction of DBD data is dependent on a lot of variables and may be difficult to scale to a larger scope. In contrast, the empirical relations are in very simple form and can be easily extended to other places. It is better to include the possibility of extending the scope of this model in the MS. Moreover, the cost and uncertainties should also be considered.

Finally, is this model robust to outliers? If not, you may need to perform data screening before model training and to see whether the performance is improved.

Responses:
1) However, I frequently felt it hard to follow when reading this MS, and much effort is need to make this MS easier to read.

- *The methods, results and discussion sections have been given a considerable rewrite with an emphasis on clarity for the reader. The changes made have focused on:*
    - *Shortening sentences and using clearer sentence structure*
    - *We have given the methods section a summary paragraph, which has been included at the beginning of the methods section.*

- *The predictor abbreviations have been changed to be more intuitive and easier to remember.*
- *Apart from these changes, does the reviewer have any specific suggestions to the structure, which would be much appreciated.*

2) Although the adjusted DBD data align better with in-situ measurements, it is not convincing enough that the OC stock after adjustment is closer to the actual value. It is necessary to be clarified in different ways.

- *We respectfully disagree with this comment. Organic carbon stock is not a directly measured value. It is calculated by multiplying OC content by dry bulk density (DBD) and sediment depth using the following equation:*

  OC stock = OC content X DBD X sediment depth

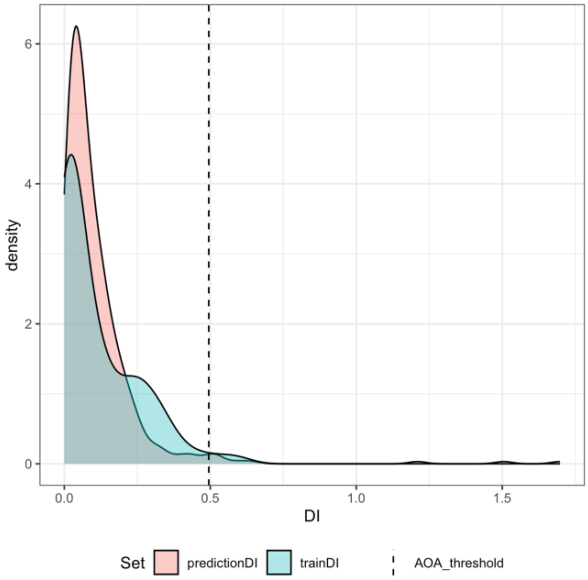
  We have improved the inputs to this equation (OC content and DBD) as illustrated in the original manuscript and therefore the resulting OC stock estimate will be improved, too. Both our adjusted OC content and DBD models showed reduced error compared to their unadjusted counterparts. This was mentioned in the original manuscript in the results section on lines: 277 to 278 and 283 to 285.
- *To clarify this point, we have added this text to lines 440 to 442: "In the equation for calculating OC stock (Eq. 10), DBD acts as a scaling factor that multiplies the OC content in the sediment by the amount of sediment (DBD). Therefore, it is likely that better predictions of OC content and DBD will result in more realistic estimates of OC stock."*
- *Also, we thank the reviewer for this comment and ask if the reviewer is able to provide practical advice on other ways to empirically show whether our final OC stock estimates are improvements or not.*

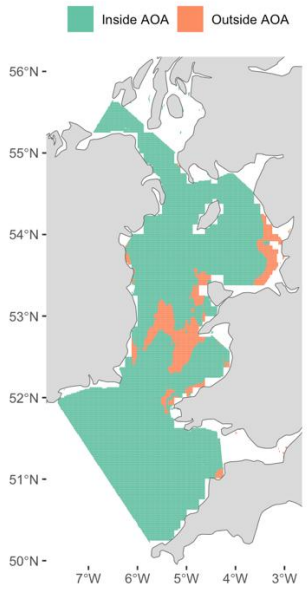
3) Moreover, as shown in the main text, the study area lacks observational DBD data. Thus, it is questionable whether the adjusted DBD within the study area really improved the model performance and the accuracy of estimation.

- *Yes, we agree with the reviewer here that a small amount of the training data, only 3% (18 of 750 data points), used to train the adjusted DBD model came from within the study area. However, we still maintain that our DBD model within the study area is more accurate than the unadjusted DBD prediction for the following reasons:*
  1. *We used data from the study area and surrounding geographic area, whereas the unadjusted version did not. The unadjusted DBD approach has frequently been used in previous modelling work (Diesing et al. 2017, 2019, Smeaton et al. 2021). However, this approach used observational data solely from the Mississippi-Alabama-Florida shelf (Jenkins 2005). Applying this relationship in the Irish Sea assumes global applicability of this relationship, which may not be the case. In contrast, our DBD RF model was developed using in situ data points from within our study area (only 3%) and the wider northwest European shelf. Additionally, in the revised manuscript we have added the following text:*
     - *On lines 326 to 330: We have carried out Area of Applicability (AOA) analysis to test whether our adjusted DBD model can be applied to our*

study area. AOA identifies where trained machine learning models can reliably make predictions. AOA analysis calculates a dissimilarity index (DI) between prediction points and training data, which quantifies how dissimilar training data and prediction data are.

- *On line 405 to 406: We found that 91.2% of the study area fell within the adjusted DBD model's AOA.*
- *Added on lines 472 to 474: Since >90% of the study area has predictor data comparable to training data, we can assume that the relationships 'learned' by the model during training are still applicable in the majority of the study area.*
- *We have also added AOA analysis figures in the supplementary material (Supplementary Information S5) to support these claims (figures below, which have been added to the supplementary information of the revised manuscript).*





- *Added on lines 462 to 465: "For example, unadjusted DBD was modelled from porosity using DBD data solely collected from the Mississippi-Alabama-Florida shelf (Jenkins 2005) and implicitly assumes global applicability of this relationship."*

2. *<u>The unadjusted DBD model assumed a constant grain density:</u> unadjusted DBD was modelled from porosity using the following equation:*
   DBD = (1 - porosity) X grain density
   This approach involved assuming a constant grain density (2650 kg m^{-3}) (Diesing et al. 2017). We have added this text in the discussion section of the revised manuscript on lines 465 to 468: "Moreover, the unadjusted DBD estimate assumed a constant grain size (2650 kg m-3), however, even within similar sediment types grain density can vary, marine mud grain densities can range from 2410 to 2720 kg m^{-3} (Opreanu 2003). "

Diesing, M., Kröger, S., Parker, R., Jenkins, C., Mason, C. and Weston, K., 2017. Predicting the standing stock of organic carbon in surface sediments of the North–West European continental shelf. Biogeochemistry, 135, pp.183-200.

Diesing, M., Paradis, S., Jensen, H., Thorsnes, T., Bjarnadóttir, L.R. and Knies, J., 2023. Organic Carbon Stocks and Accumulation Rates in Surface Sediments of the Norwegian Continental Margin. Authorea Preprints.

Jenkins, C.J., 2005, Summary of the onCALCULATION methods used in dbSEABED, in: Buczkowski, B.J., Reid, J.A., Jenkins, C.J., Reid, J.M., Williams, S.J., and Flocks, J.G., 2006, usSEABED: Gulf of Mexico and Caribbean (Puerto Rico and U.S. Virgin Islands) Offshore Surficial Sediment Data Release: U.S. Geological Survey Data Series 146, version 1.0. Online at http://pubs.usgs.gov/ds/2006/146/

Opreanu, G., 2003. Porosity density and other physical properties of deep-sea sediments from the Black Sea. National Institute of Marine Geology and Geo-ecology.

Smeaton, C., Hunt, C.A., Turrell, W.R. and Austin, W.E., 2021. Marine sedimentary carbon stocks of the United Kingdom's exclusive economic zone. Frontiers in Earth Science, 9, p.593324.

4) I also wonder the reason for just choosing the Irish Sea as the study area. It's better to emphasize these points in the main text and avoid possible vagueness.

- *We acknowledge the reviewer's comment here that the reason for selecting the Irish Sea as the study area was not fully justified in the original version of the manuscript. We have added the following text to the 'Regional setting' section of the revised manuscript on lines 110 to 121:*

"The Irish Sea was selected as the study area due to its ecological and economic importance, making it a focal point for marine resource management and conservation. It is a cross-jurisdictional region bordered by both the UK and Ireland, where overlapping policy and management frameworks further elevate its relevance for spatial planning. The Irish Sea supports some of the highest fishing intensities in Europe, with bottom otter trawling in areas such as the 'Mud Belt' and the 'Smalls' reaching an annual average of 14 hours per km² between 2009 and 2014 (ICES 2014). These same areas account for the majority of Nephrops landings in Ireland and contribute significantly to the European market, with Nephrops caught within the Irish EEZ alone valued at €53.2 million (Gerritsen and Lordan 2014). Notably, Nephrops inhabit muddy sediments, which are associated with high OC stocks (Diesing et al. 2017; Smeaton et al. 2021). Although OC stock estimates exist for the Irish Sea, they are often either coarsely resolved or geographically limited in scope (Diesing et al. 2017; Smeaton et al. 2021), highlighting the need for refined spatial modelling. This is particularly important in the Irish Sea, where a lack of data on the impacts of human activities on marine sedimentary OC stocks has been identified as a barrier to incorporating OC into marine spatial planning frameworks (Allcock et al. 2024; Crowe et al. 2023). Moreover, the Irish Sea is a data rich-region making it well suited to test and apply the spatial modelling workflow developed in this study."

ICES. 2014. Second Interim Report of the Working Group on Spatial Fisheries Data (WGSFD), 10–13 June 2014, ICES Headquarters, Copenhagen, Denmark. ICES CM 2014/SSGSUE:05. 102 pp. https://doi.org/10.17895/ices.pub.5683

Gerritsen, H.D. and Lordan, C. 2014. Atlas of Commercial Fisheries Around Ireland, Marine Institute, Ireland. ISBN 978-1-902895-56-7. 59 pp.

5) Second, the advantages and applicability of this adjusted DBD model were not clearly illustrated. The prediction of DBD data is dependent on a lot of variables and may be difficult to scale to a larger scope. It is better to include the possibility of extending the scope of this model in the MS.

- *We thank the reviewer for this concern, the main advantage of the adjusted DBD model was that the DBD RF model more closely reflects actual DBD in the Irish Sea and thus (when combined with better predictions of OC content) would provide a more realistic estimate of OC stocks than previous estimates.*
    - *We have added this text on lines 483 to 493: "More reliable DBD estimates, as presented here, will result in more robust baseline assessments of marine sediment OC stocks, which are crucial to investigating the effects of human pressures on seabed OC stocks and whether managing these systems can result in meaningful emissions reductions. For example, more accurate DBD estimates can result in reducing the substantial uncertainties in CO_2 emissions from bottom trawling. Sala et al. (2021) and Atwood et al. (2024) both suggest that as a result of bottom trawling, significant amounts of CO_2 may be emitted from resuspending OC stocks in marine sediment. However, results from our study show baseline estimates of OC stocks may be substantially lower than previously reported. Additionally, impacts of trawling on marine sedimentary OC stocks has been identified as data deficient in the Irish Sea (Crowe et al. 2023), therefore in order to incorporate marine sediment OC in national marine spatial planning frameworks, more data are needed to further refine estimates to provide policy makers robust empirical evidence with which to base management decisions."*

- *The reviewer also commented that the DBD model had many inputs and would be difficult to scale to a larger scope. We agree with the reviewer on this point. This approach could mostly be applied to data-rich regions. Moreover, one of the aims of the manuscript was to use substantial amounts of legacy data to improve predictions, which the authors feel has been achieved evidenced by improved model performance metrics in both adjusted OC content and DBD models. In addition, as more data becomes available in data poor regions, RF modelling of DBD can be used to obtain more reliable estimates of marine sediment carbon stock. These points are now mentioned from lines 586 to 593 in the revised manuscript.*

6) Moreover, the cost and uncertainties should also be considered.

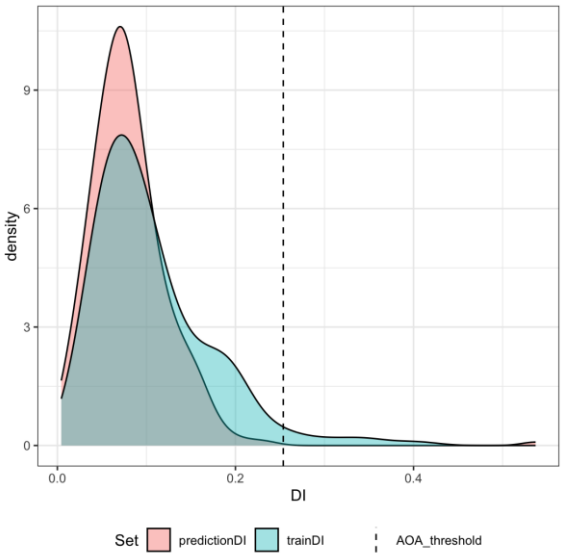
- *We agree with the reviewer regarding the uncertainties; we did not discuss the uncertainties enough in the original manuscript. We have now added:*

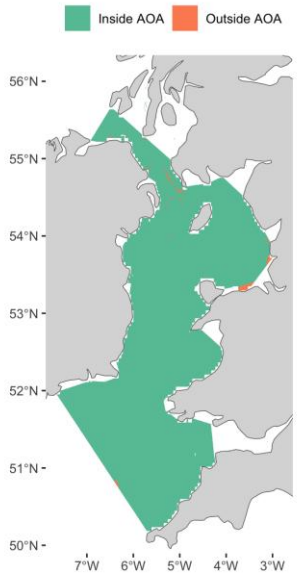
- *Area of applicability (AOA) analysis, which describes the extent to which our adjusted models (OC content and DBD) should be able to perform as expected within the study area, have been added throughout the text. Text describing the rationale of AOA analysis (lines 329 to 333), the findings from it (lines 407 to 412) and its implications (lines 580 to 581) have been added throughout the revised manuscript.*
- *Text in the methods (lines 320 to 325) and discussion (lines 565 to 573) sections of the revised manuscript to highlight the uncertainties of the modelling approach. This new text aims to clarify the uncertainties considered as part of this study, and those not considered and justification for not including them and their implications for uncertainty in OC stocks.*

- *Regarding cost, we are not entirely sure what the reviewer means. Does the reviewer mean the economic cost of training adjusted models using legacy data? Or the economic cost of collecting more data? We would appreciate some clarity from the reviewer on this point.*

7) <u>Finally, is this model robust to outliers? If not, you may need to perform data screening before model training and to see whether the performance is improved.</u>

- *We performed AOA analysis for our adjusted OC content and DBD models as described between lines 329 and 333 in the revised manuscript. AOA analysis of the OC content model showed 99.5% of prediction data points' were within the AOA threshold for similarity (figures below, which have been added to the supplementary material of the manuscript). Text to clarify this has been added to lines 408 to 409 in the revised manuscript.*





- *In addition to AOA analysis, response data (OC content and DBD) were screened prior to being used in RF models. Below is a more detailed explanation of the data screening steps taken for response data and the corresponding lines in the revised manuscript where these inclusions have been mentioned. OC content and DBD data were:*

- *filtered to the top 10 cm of sediment profiles to account for only surficial sediment OC stocks (from line 162 to line 164)*
- *geographic locations were inspected to ensure all points fell within the study area (from line 167 to line 169)*
- *Response data were smoothed prior to training. Point data that fell within the same grid cell were averaged (Wei et al. 2022) (from line 169 to line 170)*

- *In the revised manuscript the stability of our models was tested. We have added text to describe the analysis in the methods section (lines 315 to 318): "Model stability was also tested by examining prediction consistency across repeated runs using the final selected predictors. We looked at prediction stability in the highest and lowest 15% of predicted values, we specifically chose this threshold as this is the range most susceptible to the effects of outlier." We have also added text to the results section that refers to the added analysis on model stability (lines 409 to 412): "RF model stability analysis revealed that a prediction stability of 95% was achieved with only 29 trees (the models were trained with 500 trees), indicating highly consistent predictions across runs. This low tree requirement suggests the RF models are not overly sensitive to variations in the training data"*

Wei, Y., Qiu, X., Yazdi, M.D., Shtein, A., Shi, L., Yang, J., Peralta, A.A., Coull, B.A. and Schwartz, J.D., 2022. The impact of exposure measurement error on the estimated concentration–response relationship between long-term exposure to PM 2.5 and mortality. Environmental Health Perspectives, 130(7), p.077006.

Line comments

L15: "over geological timescales". More studies of continental shelves are about modern environments. The focus of this MS is also in the upper 10 cm of the sediments and is not associated with geological timescales.
We have removed the term 'over geological timescales'

L15-18: "Shelf sediments can also be subject to…". This sentence is not related to the main content of this MS.
We would like to kindly disagree with the reviewer. The aim of this sentence is to provide context and background as to why it is important to understand the OC stock in marine sediments. Even though this sentence is not related to the main content of the manuscript, it is important to provide background as to why there is a need to study marine sediment organic carbon stocks. In this context, substantial anthropogenic pressures may release the organic carbon that has been sequestered in marine sediments.

L18: Correct to "reduction".
This typo has been corrected.

L19: What data gaps? Clarify.

We have rewritten this sentence clarified in the text reasons why spatial models, specifically marine sediment organic carbon stocks, may have reduced utility. The sentence now reads: "Spatial models offer solutions to identifying organic carbon storage hotspots; however, regional predictions of OC often use global scale predictors which may have biases on smaller scales."

L22: "comparatively few". Compare to what? It would be better to use phrase like "sparsely" and to emphasize current data is not enough for an accurate estimation.
We agree with the reviewer's comment and have rephrased the sentence to align more with the suggestion. The edited sentence is as follows: "Moreover, estimates of dry bulk density (DBD), an important factor in calculating OC stock from sediment OC content, have large uncertainties due to a lack of in situ data for robust spatial predictions."

L22-25: "We compared…". This sentence is too long and can be broke up into two. You can also change the way of narrative. 1) Introduce the previous method and the shortcomings. 2) Compare your new model to the previous one.
We have rewritten this sentence to incorporate the reviewer's feedback. The sentence text now reads: "We compared the performance of two spatial models of OC stock in the Irish Sea. The first used unadjusted predictors and a commonly used empirical relationship to estimate DBD. The second spatial model incorporated bias-adjusted predictors and a machine learning DBD model trained on in situ DBD data."

L25: Clarify the depth of estimated OC stock.
We have now clarified in the text that we were referring to the top 10cm of sediment.

L28: Correct to "emphasize".
We have reworded to "highlights"

L30: It may not be necessary to repeatedly mention "policy makers". First, lower regional OC stock is contradictory to their focus. Second, the long-term variation trend (instead of the stock) and the feedbacks to climate change are more important.
We have removed the mention of policy makers in this instance

L31: "addressing uncertainties". This phrase is odd.
We have rephrased this part of the sentence to: "underscores the importance of reducing uncertainties"

L32: Managing the carbon sequestration potential is not directly mentioned in the main text.
We agree that carbon sequestration potential was not discussed in the text. Therefore, we have rephrased the sentence to: "…key parameters to better understand and manage OC storage potential of marine sediments."

L35-36: You may need to cite one or two more references. For example, Hedges and Keil (1995), Burdige (2007), Bianchi et al. (2018).
We thank the reviewer for these literature suggestions. We have added two citations to this sentence: Bianchi et al (2007) and Hedges and Keil (1995).

L37: Hage et al. (2022) is about the OC burial flux in the Upper Cretaceous deltas (~75 Ma). It is far longer than the timescale of millennia.
We have removed the Hage et al. (2022) citation and instead added Smeaton et al. (2021).

L42-45: This sentence is too long and is not well joined.
We have reworded this sentence into two sentences and improved their clarity. The text now reads: "Global estimates suggest that OC stocks in continental shelf sediment, ranging from 256 to 274 PG, are up to nine times that of coastal vegetated habitats (Atwood et al. 2020) Although still heavily debated, emissions from human pressures on marine sediments may be substantial (Hiddink et al. 2023; Sala et al. 2021)."

L47-51: This sentence is too long as well. I suggest breaking it to two sentences.
We have reworded this sentence as well and broken it up into two sentences. The text now reads: "Subcontinental and national scale OC stock estimates have been conducted. For example Diesing et al. (2017) reported that the Northwest European continental shelf holds between 230 and 880 Tg of OC in the top 10 cm of the sediment column, while Smeaton et al. (2021) estimated that between 456 and 592 Tg of OC were stored in surficial (0 – 10 cm) marine sediments within the United Kingdom Exclusive Economic Zone."

L55: "OC per unit of s area". Typo? In addition, this sentence is too complex.
We have corrected the typo in this sentence and tried to simplify the sentence.

L56: How can DBD adjust the OC content? Maybe OC stock. Clarify.
Yes, we thank the reviewer for noticing this mistake. It should be OC stock instead of OC content. We have now changed this mistake.

L67-71: I wonder the reason for introducing the application of bias adjustments in climate models. It would be better to present the application of bias adjustments in more related fields.
We thank the reviewer for this comment. We introduced the concept of bias adjustment by referencing climate modelling because this field has developed and rigorously tested these methods to correct systematic biases in large-scale model predictions, often when downscaling to regional contexts. While bias adjustments are well-established in climate science and its applied fields, for example, agricultural impact assessments, they remain underutilised in other areas of spatial environmental modelling, including marine sediment OC stock estimation. Our intention was to draw from this robust methodological framework and apply it to a novel context where global-scale predictors are similarly prone to regional biases. We have clarified this rationale in the revised text.

L77-78: Temperature and salinity are not key factors in this MS.
We have changed the examples given in this sentence to parameters more associated with OC stocks. The sentence now mentions sediment properties and chlorophyll-a.

L87: How to verify the OC stock estimate is improved?
Organic carbon (OC) stock is not directly measured but is instead calculated by multiplying OC content, dry bulk density (DBD), and sediment depth. Because of this, it is not possible

verify whether our adjusted OC stock estimates reflect the true values. However, we assume that improvements to the components of this calculation (OC content and DBD) would result in more accurate OC stock estimates. We have now rewritten this part of the introduction to clarify this.

L88: Change to "was developed by".
We have made the change suggested by the reviewer here.

L89: dash between "un" and "adjusted". Keep consistent through the MS.
We have removed that typo

L100: Correct the refs.
We have removed the mistake in the citations.

L104-105: Maybe detail how to define the inshore area.
As suggested by the reviewer, we have defined how the inshore area is defined in the revised manuscript.

L111: Is 10 cm adopted in most of related studies? It would be better to consider and illustrate the corresponding timescale.
Quantifying the top 10 cm of OC stocks has become the standard in similar larger scale OC stock estimates. We have added this clarification in the text. Additionally, we have added an approximate estimate to the length of time the top 10cm corresponds to, based on sedimentation rates in literature.

L115: It is better to include the number of observations (e.g., n=50). Is the conversion equation developed exclusively from surface sediments?
We have included the number of samples used in the conversion equation as well as clarifying that these samples were from surface sediments all within the top 10 cm of sediment profiles.

L130-132: Again, why do you only choose the Irish Sea to test the model?
We agree with the reviewer that in the original manuscript we did not provide enough justification for selecting the Irish Sea as the study area. In the revised manuscript, we have added a paragraph from lines 110 to 124 detailing why the Irish Sea was selected as the study area.

L138-141: It would be better to illustrate the reason of choosing these parameters. Availability or likely influence on OC stocks.
We have added text to clarify the reason for the list of predictors in section 3.1.2 "Predictor data"

L141: Is the Q-Q mapping method sensitive or tolerate to outliers and extreme distribution? Clarify.
We acknowledge that QQ mapping can be sensitive to extreme values, particularly when observational data are sparse or contain outliers. We have added clarification in the text to reflect this limitation and referenced Casanueva et al. (2020). To mitigate this, observational

data were smoothed prior to interpolation and QQ mapping to reduce the influence of extreme values. We have added this text between lines 220 and 222.

L214-217: This sentence is too long.
This sentence was rewritten in our general rewrite to make the manuscript as a whole easier to follow. This sentence is now split into two sentences of the revised manuscript.

L226: Were the standard deviations directly summed up? Need clarification.
Yes, the standard deviations were summed. We have rewritten the model uncertainty paragraph (lines 303 to 317, Section 3.7) to more clearly describe the model uncertainty process.

L239: It may be confusing to use both OC reservoir and OC stock. You may need to change the phrase.
We would like to keep the phrasing of OC stock and OC reservoir, both these terms have previously been used in related work. Diesing et al. (2024) used both OC stock and total reservoir when referring to the total OC stock in the study area.

*Diesing, M., Paradis, S., Jensen, H. et al. Glacial troughs as centres of organic carbon accumulation on the Norwegian continental margin. Commun Earth Environ **5**, 327 (2024). https://doi.org/10.1038/s43247-024-01502-8.*

L245: This section (4.1.1) may be inappropriate in Results part. Maybe better in Methods part.
As suggested by the reviewer this text has been moved to the methods section. The text that related to predictor data (OC content and DBD) was moved to "3.1.1 Response data", while the sentence that related to predictor data availability was moved to 3.2 "Bias adjusting predictors".

L289-290: How do you estimate the uncertainty of OC stock?
The uncertainty in OC stock was estimated by multiplying the total uncertainty in OC content with the total uncertainty in DBD and sediment depth. The following equation was used:

OC stock uncertainty = OC content uncertainty X DBD uncertainty X sediment depth X cell area

We have now clarified this in the text between lines 352 and 358.

L302-304: It would be better to point out the overestimation is within the study area. This conclusion can only be drawn after applying this adjusted DBD method to wider scope.
We have changed this sentence to only refer to the study area.

Line 310: Delete comma before "compared to" and add comma before "and".
This sentence has been rewritten and the commas have been corrected.

Line 320: What is "OC storage dynamics"? You may change it to "OC storage variability".
We have reworded this to align with the reviewer's suggestion.

Line 328: Add “other” before “coastal sediments”.
We have included this suggestion

Line 329: change to “sand, coarse sediments and mixed sediments”.
We have made this change

Line 329-331: The interlamellar area of clay minerals may be more important for OC adsorption (e.g., Kennedy et al., 2002). Just a note.
We thank the reviewer for this comment and agree that interlamellar surface area of certain clay minerals, particularly smectite, can be critical for OC preservation. We have modified this sentence to acknowledge the importance of interlayer surfaces.

Line 334-345: Refs.
We have corrected the typo with these references.

Line 346: Space “(2024)” and “estimated”.
We have now added a space

Line 350: You can also take a look at the bedrock lithology in the study area. If it is dominated by sedimentary rock, significant petrogenic organic carbon associated with coarse fractions may explain the anomaly.
This comment raises the question of carbon provenance which, whilst a relevant and interesting topic, is outside the scope of this study. Generally, a number of factors need to be considered as part of a carbon provenance study. The composition of bedrock can be one of these factors. However, in relation to this study and this study area, bedrock is highly variable, and generally poorly constrained by sampling, across the Irish Sea, and is often found at significant depth (>40m) beneath a sequence of unconsolidated Quaternary sediments, which themselves can be the product of eroded glacial till. As a result, environmental factors at the seafloor and in the marine environment, including input from terrestrial sources in nearshore settings, likely play more of a role than bedrock lithology in this case.

Line 390: Change to “The data collected was…”.
This sentence was rewritten in our rewrite and this text is no longer present in the revised manuscript.

Line 394: The number of observational DBD data is not enough for drawing conclusions without a doubt.
We respectfully disagree with the reviewer on this point. Our adjusted DBD model is both valid within the study area and an improvement on the widely used porosity/DBD empirical relationship. Area of Applicability (AOA) analysis (which we included in the revised manuscript) highlights that >90% of the study area is comparable to in situ data the DBD RF model was trained on. While only 3% of the data used to train the DBD RF model was within the study area, this is still an improvement compared to the widely used porosity to DBD empirical relationship that is widely used. The empirical relationship was developed using

data points solely from the Mississippi-Alabama-Florida shelf and assumes this relationship is globally applicable.

Line 409: There lacks a direct relation between OC storage estimation and management in the main text. Clarification is needed.
As suggested, we have clarified the link between our OC stock estimates and marine management. We have explicitly highlighted the relevance of improved model accuracy for marine spatial planning and policy development. The text now emphasizes that more locally robust OC stock estimates can guide seabed conservation planning and carbon vulnerability. mapping. We have added the following text to the discussion section:

Lines 447 to 451: "These improvements in OC stock estimation are directly relevant to marine spatial planning, particularly in the context of managing OC stocks under climate and biodiversity targets. More accurate and regionally relevant OC stock estimates can improve the reliability of national assessments, help prioritise areas for protection, and inform industry activities, such as offshore renewable energy development and fisheries management."

Lines 595 to 600: "Overall, our findings suggest that marine sedimentary OC stocks could be lower than previously estimated, with implications for marine spatial planning and nature-based climate solutions. Improved OC stock estimates can support more informed seabed management by identifying areas with higher carbon vulnerability or conservation potential. a conclusion with important implications for seabed management. The findings suggest that adjusting improved model inputs based on in situ data, may help refine and reduce uncertainties in model predictions to be more locally relevant."

Figure 2: The range of color bar is too broad at present. Most OC data is within 0-2%.
We agree with the reviewer and this figure change will be made when the fully revised manuscript is submitted

Figure 4: Too many plots in one figure. You can consider putting some plots in the Supplement.
We agree with the reviewer and this figure change will be made when the fully revised manuscript is submitted

Figure 5 and Figure 6 can be combined into one figure.
We agree with the reviewer and this figure change will be made when the fully revised manuscript is submitted

Typo

L55: "OC per unit of s area" to "OC per unit of area".
This typo has been corrected

L201: "RF's" to "RF".
This typo has also been corrected.

References cited

Bianchi, T. S., Cui, X., Blair, N. E., Burdige, D. J., Eglinton, T. I., and Galy, V.: Centers of organic carbon burial and oxidation at the land-ocean interface, Org. Geochem., 115, 14–25, https://doi.org/10.1016/j.orggeochem.2017.09.008 , 2018.

Burdige, D. J.: Preservation of organic matter in marine sediments: controls, mechanisms, and an imbalance in sediment organic carbon budgets?, Chem. Rev., 107, 467–485, https://doi.org/10.1021/cr050347q , 2007.

Hage, S., Romans, B. W., Peploe, T. G. E., Poyatos-Moré, M., Haeri Ardakani, O., Bell, D., Englert, R. G., Kaempfe-Droguett, S. A., Nesbit, P. R., Sherstan, G., Synnott, D. P., and Hubbard, S. M.: High rates of organic carbon burial in submarine deltas maintained on geological timescales, Nat Geosci, 15, 919–924, https://doi.org/10.1038/s41561-022-01048-4, 2022.

Hedges, J. I. and Keil, R. G.: Sedimentary organic matter preservation: an assessment and speculative synthesis, Mar. Chem., 49, 81–115, https://doi.org/10.1016/0304-4203(95)00008-F , 1995.

Kennedy, M. J., Pevear, D. R., and Hill, R. J.: Mineral surface control of organic carbon in black shales, Science, 295, 657–660, https://doi.org/10.1126/science.1066611 , 2002.