Review of *Balancing water column and sedimentary ^{234}Th fluxes to quantify coastal marine carbon export*, by Healey et al.

This article provides quasi-seasonal coupled water column and surficial sediment sampling of Th-234 and POC to evaluate and refine the carbon budget in the Bedford Basin. I find the research necessary because, as highlighted by the authors, not many studies using the commonly applied approach of Th-234 to assess carbon export have been conducted in coastal areas. Additionally, the combination of water column and sediment measurements is not a usual approach either, yet it provides complementary data allowing to better understand the fate of the particle fluxes in coastal areas. By combining both types of sampling, the authors conclude that there is no major particle loss in the Beadford Basin and that the magnitude of the export and burial fluxes is similar to those reported in previous studies in coastal areas, which are relevant sites for organic carbon sequestration.

The paper is well presented, the text and the figures are clear and provide the necessary information to support their findings. I have specific comments regarding some aspects that need clarification or small corrections, but overall, the study is robust and contributes to the growing body of literature discussing carbon budgets in coastal environments.

Some specific comments are detailed below:

- **L111**: It mentions that the water samples were collected with 10L Nisking bottles and that, after Th-230 was added, 2L were processed for total Th-234. I believe the way it is written can lead to confusion, since it might look like 10L were collected, spiked and then 2L subsampled, which I believe was not the case.
- **L143**: Please specify the pore size used to obtain filtered and UV treated seawater (no need to specify in that line the pore size of QMAs since it is mentioned in L141-142)
- **L152-154**: "*For comparison, the POC:^{234}Th ratio on the small particle fraction was also calculated using Eq. 4*" is not correct. Please rephrase since Eq. 4 calculates POC flux, no ratios.
- **L151-154** and **Eq. 4** can be simplified by adding a subscript next to the ration in the formula so that the text just needs to say that POC fluxes are calculated using Eq. 4 using the ratios of the different particle fractions.
- **L157-165**: The first two sentences seem a bit repetitive and can be streamlined. I think the repetition of "*novel proxy and residual beta activity*" makes it look repetitive. Use the "abbreviation" Ra_{p243} instead after defining it at the beginning.
- **L169**: Can you provide the uncertainty of n_{p2} and the blank? These blank counts come from the dipped filters, correct? Also in that line, notice that cpm was used before and defined later.

- **Section 2.5** Excess ^{234}Th inventories requires more detail:
    - How thick were the sections of the cores (0.5 cm, 1 cm) and how far down where they cut/measured (6 cm, based on Fig. 8?)
    - How quickly were the cores cut after collection? Were they kept in a freezer until processing?
    - How were they dried? For how long approx.? Was the weight checked multiple times to ensure that the sediment was dry?
    - Was the dry weight corrected for salt content?
    - How much sediment was approximately used for the measurement?
    - How long were the samples measured for and how long after collection (since Th-234 has a 24.1 d half-life)?
    - How was the mean supported activity obtained? Did you remeasure all the sections or just certain ones? L465 suggests only section 4.5 to 6 was used as supported. Please provide more details.
    - What type of gamma detector was used? The gamma counting was done using the petri-dish, so it was not done in a well-type gamma counter, right? Mention it.
- **L191-192**: Please explain how the organic carbon samples were processed before measurements. Were they also fumed with HCl, as per filters?
- **L205**: Please provide a threshold of Chl-a or some definition for the blooms in the region or a usual range of Chl-a values during blooms. The text reads that a 11.1 mg/m^3 chl-a signal is a weak bloom but would be good to have some sort of a scale to assess that.
- **Figure 4**: "*Total particulate ^{234}Th is equal to the sum of the large and small particles*" Why is that sentence there for Th-234 and not for POC? Shouldn't the y-axes just be Particulate POC and Particulate ^{234}Th, since there are different size fractions represented in both plots?
- **L431**: "*POC export fluxes (Fig. 6) were calculated following Eq. 4 and using >51um ratios (Fig. 5*a)" it's correct, but not complete, because the export fluxes shown in Fig. 6 are also calculated using the 1-51um ratios from Fig. 5b. Please refine this paragraph to streamline it. You could cite both figures and then start talking about the small fraction fluxes, were no patter with depth was observed, and then talk about the large fraction fluxes, since they are discussed a bit more.
- **Figure 6**: The a) should be moved in front of "*Profiles of cumulative….*" since "*Bedford Basin 1D steady state fluxes in 2021-2024"* applies to the three panels. Make the y-axes to match between the three panels, otherwise it creates a visual distortion as if the POC ones were deeper. Why all the different symbols in the Th-234 flux? Pick one, as done for the POC fluxes based on particle size. Also, the R^2 shown in graphic a) is not explained. Maybe add the whole linear regression and cite the figure in the main text (L428).
- I am a bit confused regarding the information provided in Fig. 6 in the sediment part of panels b) and c) and what it is shown in Fig. 7. Isn't it the same data? Why show it twice? I would combine these figures as if Fig. 7 was a zoom-in of the sediment part of Fig. 6b and Fig. 6c. Please double check that the numbers match, I have the impression that,

for example, Jan_2024 >51um POC flux shown in Fig. 6b is higher than when plotted in Fig. 7a

- **L462-463**: It is confusing to say that the EQ depth was always ~4.5cm and then write that the majority of $Th_{xs,0}$ was confined to the top ~2-4.5cm. Also, looking at Figure 8 (please cite figure in that first sentence), the largest excess is found in the upper 1.5 cm.
- **L463**: "*Excess ^{234}Th in the EQ was variable*". There should not be excess ^{234}Th at the equilibrium depth. Do you mean above the EQ?
- **L467**: "*were consistent with core depth between 0 – 4 cm*". Not sure what do you mean. Are you referring to the concentrations and percentages found in those depths in other similar cores? Or do you mean that concentrations did not vary in the upper 4 cm of this study's cores? What concentrations and percentages of POC did you find between 4 cm and 6 cm? Was POC only measured in the upper 4 cm? There are POC:Th ratios deeper than 4 cm, were they extrapolated?
- **Figure 8**: Please polish the caption for panel b). The a) should be placed before "decay corrected". b) says "*$POC:^{234}Th_{xs,0}$*" but the title says "*$POC:^{234}Th$*". Also, no need to explain the supported in the caption, it has been explained in the main text and it is not shown in the figure.
- **L559-560**: Could you expand on Lampitt (1985) statement? I understand the previous sentence about the fact that the ratios would be higher if there was resuspension of the top sediments, but I feel like Lampitt's sentence is not properly integrated in the discussion or lacking some more information. Not only the composition of the particles in the sediment-water interface facilitates resuspension, but hydrodynamics are also crucial, meaning that, even if those particles are lithogenic and not detrital, with enough hydrodynamics they can be resuspended. Lampitt's 1985 study area is also 4000 m instead of the 70 m at Compass Station. Not sure it is the best comparison to make, unless you want to explain a bit more.
- **L567-569**: Boetius et al. 2013 talks about large algal chunks found at depth fresh and seen by cameras, not sure they refer to measuring fluorescence along the water column and finding high values at depth, so I am not sure the comparison applies. In any case, I would assume the deeper fluorescence signals found in this study are due to mixing, having some surface phytoplankton reaching deeper layers. Yet, blooms take place when water column presents higher stratification. Did you do isotopic analyses on the POC samples?
- **L567-573**: A high particle load is mentioned. Is that based on visual assessment (the water looked turbid) or there was some kind of measurement done that would indicate that (e.g., light penetration).
- **L580-582**: Bolanos et al. (2020) citation refers to importance of small phytoplankton in terms of biomass. Mention it.
- **L583-584**: Cite the reference for the *Synechococcus* statements.
- **Fig. 9**: Please clarify y-axis, I don't think I understand it and it is not described in the caption.
- **L605**: Just to clarify, the 8 dots that are above the detection limit had 0 RA_{P234} from the large fraction, so those values are entirely from the small fraction particles or the

difference from the detection limit value and the RA_{P234} value in those cases is coming entirely from the small particles?

- **Section 4.4** I appreciate the authors revisiting Black et al (2023) POC:Th data and discussing the discrepancies observed. They could have avoided it and focus only on their current dataset, but instead they highlight the substantial differences and mention the potential sampling artifacts causing the extremely elevated ratios in that previous work.
- **L648**: Table 3 does not show other biogeochemical measurements, it shows estimates of POC export fluxes by others using other methods.
- **L654**: Also similar to modelled POC flux reported in Black et al. 2023, based on the data shown in Table 3.
- **L662-663**: I obtain slightly different burial rate, which leads to slightly different burial efficiency. Minimal differences, but please double check the numbers.
- **L671**: Add at the end of the sentence "i.e., export efficiency". The following sentence starts talking about export efficiency and not ThE-ratio and might seem like they are different things for those not familiar with the thorium approach.
- **L672-673**: It is the other way around, export/production = ThE; as stated in L676: "*divide the mean POC… by the mean NPP*"
- **L677**: 29.4 mmol C m^{-2} d^{-1} / 66 mmol C m^{-2} d^{-1} = 44.5% not 49% Please double check the numbers. L679 also mentions 49% ThE ratio and in the conclusions. Also check the burial efficiency reported in the conclusions (see my comment for L662-663).
- **Table 3**:
    - The value reported by Hargrave and Taguchi (1978) is under "*Particulate flux*" and the units are in mmol C m^{-2} d^{-1}. If it is not POC flux (otherwise I assume it would have said it) it should be total C to match the units reported. Is that the case? Please specify it in the title: "total C flux" or provide the necessary information as a table foot note.
    - The fluxes in the sediment reported in Black et al. 2023 are not shown in this table due to their extremely high values because of the particle sampling method used there, correct? It would be good to expand the first sentence of section 4.5 to explain the summary table 3, what was included in it and what not, and why.

Technical comments:

- **L124 Eq. 1** and **L126 Eq 2.**: Make sure the superscripts are shown as such for ^{238}U and ^{234}Th
- **L166**: Eq. 5 uses Ra_{p243} but later on, in L603-605 RA_{P243}. Check, this term is used in other lines not cited here.
- **L190**: Multiplied by
- **L191**: Add (OC) after "Organic carbon" since it is used later in L194, or write it entirely in L194.

- **Figure 2 panel E**: The image definition of this panel is worse than the others. Also, please provide the y-axes titles in the corresponding side of the graph. The legend is split but not the actual titles. The vertical line on the right side of the panel looks odd. Can it be just the actual y-axis with its values? Also, the font size of the y-axes is much smaller than for the other panels. L281, T, S, O have not been defined before, add them in the previous line.
- **Figure 2**: Add depth [m] also in panels B, C and D.
- **Table 1**: Nowhere in the text nor in the caption it is defined what LSF or SSF stands for. One can figure it out, but it would be good to add the whole wording in the caption.
- **L404**: please cite the number of data point considered ($p < 0.01$, n= X)
- **Figure 5**: The legend is the same for both panels, even though the shape of the symbols is different for large and small particles, correct? The same symbol could be used while highlighting the size fraction a bit more (maybe add it to the title?).
- **L425**: "*spring summer 2019*" missing an "and"
- **L436**: BB for Bedford Basin is only used here and in L657-658. I would just right the whole name in those lines.
- **L436**: *"…that this event brought additional…*" remove "it"
- **L474** cites only Fig.6b and 6c but it could also cite Fig. 7. Although, see my previous comment regarding the combination of these two figures in one.
- **Figure 8**. I don't mind the different symbols for the different sampling periods (although this is not done in the previous figures) but they seem to have different size? It could be an optical effect due to the different shape/color, but the dark blue triangles seem bigger than the rest.
- **L511**: ^{234}Th appears as ^{234Th}
- **L590**: It says "Jan 2022" but in all other instances the whole months it is written down, i.e., January. Same in L619 and L620.
- **L603-605**: Caption of Figure 9 – the residual activity here it is expressed as RA_{P234}, different than in L166. Check the whole text and make sure to be consistent.