The study by Healey et al., investigates the water column ^{234}Th – ^{238}U disequilibrium and surficial sediment inventory of excess ^{234}Th to constrain the particulate organic carbon (POC) export and burial in Bedford Basin. The integration of water column and sediment data to quantify the POC fluxes is appreciable.

Authors conducted quasi-season sampling from 2021 – 2024, capturing the seasonal dynamics over three-year period. The water column and sedimentary ^{234}Th fluxes and POC fluxes along with bottom sediment depositional POC fluxes are in close agreement which verifies the estimates of POC fluxes in water column and mostly contributed by the vertical setting of particles. The study is comprehensive with proper methodology.

We thank reviewer 2 for their time and very helpful comments. Below, we answer each of the reviewer's comments. The reviewer's comments are in blue; our responses are in black. We agree with the reviewer's concerns and have addressed them in a revised manuscript. Overall, the reviewer's comments have made the manuscript much stronger, especially the discussion of potential NSS effects.

- Though the Bedford Basin is relatively small, the data from a single central station might not capture the lateral heterogeneity or edge effects. In the center, as shown by the data, the POC contribution is mostly from the primary production or vertical setting of particles, however, the lateral contribution of the particles cannot be ignored, especially in this shallow fjord. It can be discussed in the manuscript in general regarding the overall basin for wider implications.

Response: Indeed, our data are from a single, centrally located station in the Bedford Basin and we agree with the reviewer that lateral heterogeneity could potentially contribute to ^{234}Th and POC dynamics in this shallow fjord system. However, we anticipate that lateral impacts are small, as explained below. In the revised manuscript, we have added a statement in the discussion (section 4) that (a) acknowledges the limitation, (b) assesses its potential magnitude (see below) and (c) emphasizes that spatially resolved sampling across the Basin would be valuable in future studies. We propose that future efforts sample a transect from the outer harbour, and/or edges of the Bedford Basin to the central Compass Station in order to fully capture spatial heterogeneity and better assess the contribution of lateral inputs on both ^{234}Th and POC flux.

The Bedford Basin is connected to the Halifax harbour & open Atlantic, and therefore one might expect some addition of total ^{234}Th from these waters into the Bedford Basin. Although lateral impacts are not directly measured in this study, we anticipate that they are small for the following reasons:

Modelling efforts (Shan and Sheng, 2012) used particle tracking in the Bedford Basin and Halifax Harbour to demonstrate that ~ 80% of the particles that originate in the basin stay in the basin. The model implies that the observations in the central basin predominantly reflect vertical production and settling. Lateral exchanges occur only episodically during storms and strong tidal phases, but do not constitute a persistent flux pathway. Additionally, Shan et al. (2011) find that the sill between the Bedford Basin and the outer harbour largely prevents mixing below 20 – 30 m water depth. We performed a simple first-order estimate of lateral advection using observed basin current velocities (surface ~ 0.2 cm s^{-1}, subsurface <1 cm s^{-1}; Shan and Sheng, 2012; Burt et al., 2013), a 1 km basin scale, and small cross-basin gradients in ^{234}Th (0.01–0.03 dpm L^{-1}). This analysis suggests that lateral fluxes contribute typically < 10%, and maximally 20%, of the vertical flux depending on layer and assumed gradient. Additionally, based on numerical passive tracer experiments, Shan and Sheng (2012) estimate the e-folding flushing time of 40 – 90 days in the upper and entire Bedford Basin respectively. In our study, we find the residence time of particulate ^{234}Th to be 18 ± 7 days, which is substantially shorter than, or at best comparable to, the advective flushing timescale. Thus, while episodic lateral exchanges may occur during storms or intrusions, multiple lines of evidence suggest that vertical production and settling dominate ^{234}Th-POC dynamics in the Bedford Basin.

In our revised text, we explain in more detail the points discussed here and highlight lateral heterogeneity and edge effects in our discussion.

The hydrological parameters of the basin show similar patterns for different years and seasonal variations. The mixing and stratification are seasonal and the importance of absence of winter mixing and spring blooms in relation with steady state 1-D Model needs to be further discussed. The limited direct measurements of nepheloid layers and primary production weakened mechanistic interpretation of persistent ^{234}Th deficits. Although 1-D steady state model is assumed in this study, the system shows several seasonal dynamic features, especially intrusion and spring bloom. The authors have included a paragraph of discussion about the NSS contribution for < 3%, but it doesn't justify this datasheet. The authors should describe how the absence of NSS might impact the fluxes especially during different seasons and spring bloom for this study.

Response: We thank the reviewer for this important comment. We agree that the Bedford Basin is a seasonally dynamic system with winter mixing, spring blooms, and episodic intrusions, all of which can potentially influence particle fluxes and ^{234}Th distributions. Like many ^{234}Th studies, our study used steady state assumptions due to the logistical constraints associated with field sampling. While we recognize that NSS conditions likely occur during certain periods, the application of the 1-D steady-state model allows for consistency and comparability with previous studies. In a revised version of the manuscript, we have expanded the discussion of NSS as follows:

- In section 4.3, we have expanded our discussion to address how our steady-state fluxes could be impacted by spring bloom and intrusion events.
- We apply a theoretical non-steady state sensitivity to our two spring profiles. Assuming a non-steady state term of 0.003 dpm L^{-1} d^{-1}, the NSS correction is 7.8% of our reported SS ^{234}Th flux. To also include an upper boundary spring bloom scenario, we also tested a larger non-steady state term of 0.01 dpm L^{-1} d^{-1}. The resulting NSS correction is ~ 25.8% of the spring SS estimate we report. We also quantify and outline in 4.3 how these potential NSS contributions change our POC flux estimates.
- We briefly discuss and estimate the possible NSS contribution from intrusion events.

In conclusion, though we did not directly measure NSS impacts, we now report theoretical NSS fluxes in the revised manuscript and expand on their implications in the Bedford Basin. We note that repeat sampling (every 1–4 weeks) remains the preferred way to quantify NSS explicitly when feasible. We suggest that future work in the Bedford Basin should consider following a NSS sampling scheme to better constrain ^{234}Th derived fluxes. Additionally, use of other shorter-lived tracers, such as Bismuth-210 ($t_{1/2}$ = 5 d) can capture even finer resolutions (hours-days).

I appreciate the authors for nice graphs and figures; however, the authors should include the ^{234}Th profile data along with errors even if it's in supplementary data.

The ^{234}Th profile data with errors are shown in Figure 3. However, the errors are small , so they might have been mistaken for symbols by the reviewer.

Fig 6 a. There is no need to include the R^2 value as this is cumulative fluxes and R^2 values doesn't have any meaningful essence.

We agree with the reviewer that the R^2 value does not provide additional scientific meaning in this context, as cumulative flux inherently increases with depth. We have removed the R^2 value in the figure.

Overall, the manuscript is valuable, relevant and methodologically sound. Incorporating these suggestions, addressing spatial heterogeneity would provide clarity and enhance the impact of this manuscript.

Works cited:

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