

RC2

In this paper, Leist et al. combine two artificial radionuclides (^{129}I and ^{236}U) with conservative seawater properties (temperature and salinity) to characterize water mass origin and distribution in Baffin Bay, Davis Strait and the Labrador Sea. The study describes an interesting and comprehensive dataset and provides novel insights into our current understanding of water mass mixing and circulation in Baffin Bay and the Labrador Sea.

General comments:

This manuscript describes a new tracer combination for the study region. Mixing processes and source water attributions, however, have previously been reported for the various passages draining into the Baffin Bay (Nares Strait, Jones Sound, Lancaster Sound), as well as Baffin Bay and Davis Strait based on a range of different tracers (e.g., $\delta^{18}\text{O}$, nitrate-to-phosphate ratios, carbonate chemistry, nitrate isotope ratios). Yet this current manuscript provides limited reference to this previous literature (beyond Huang et al., 2024), particularly in Nares Strait and the CAA. I think this study would benefit from a broader discussion of the literature and how their new estimates quantitatively compare with previous findings from different tracers (e.g., Jones 2003, Muenchow et al., 2007; Lehmann et al., 2022; Shadwick et al., 2011; Sherwood et al., 2021; Azetsu-Scott et al., 2012).

While I do understand the concept of how the mixing fractions were derived, I find the description not very intuitive and difficult to follow. I would suggest adding actual equations or specific examples to increase clarity. Also, while described in the methods section, I was surprised that the mixing fractions were not discussed in the results. I suggest to briefly discuss the derived fractions in the results and add them to a summary table either to be included in the main text or the appendix.

We sincerely appreciate the comments from Reviewer 2. We have carefully revised the manuscript to improve its clarity and accuracy following the comments from both reviewers. In particular, the description of the fraction calculation now includes an explicit equation, and the resulting fractions have been redefined in both the discussion and Figure 6. Additionally, we have incorporated some relevant literature that we had originally overlooked. Finally, the water mass classification has been updated: following Lehmann et al. (2022), Transition Water is now defined as T_{max}, while the former Transition Water mix is referred to simply as Transition Water. A Table summarizing the water mass fractions has been added to the appendix as Table A3. We referred to it at the beginning of the discussion.

Specific comments:

Line 43: Change to Arctic origin (capitalize). . *changed accordingly*

Line 50: Correct to '... are present primarily at the surface of Baffin Bay...'. *changed accordingly*

Lines 82-84: Consider referencing some more recent studies (later than 2011) to discuss 'recent' events. *More recent literature has been added L90: Glacer et al._(2020), Vandecrux et al. (2024), Gardner et al. (2011)*

Line 90: 'Despite Davis Strait's critical role as a changing freshwater source to the subpolar North Atlantic (Shan et al., 2024),...'; This is a bit of a confusing sentence. Consider rewriting. *We have rewritten this sentence and now reads as follow: L98: Despite Davis Strait's role as a freshwater source to the subpolar North Atlantic (Shan et al. 2024, Azetsu-Scott et al.2012, Huang et al. 2024), the freshwater dynamics of both Davis Strait and Baffin Bay remain poorly constrained.*

Line 105: This argument comes out of the blue, given that no description has been given on nutrient or carbon dynamics and the potential influence of different water masses. Either elaborate or remove. *Has been removed*

Line 115: Add space '...seawater(Christl...'. *changed accordingly*

Lines 159-164: Add description of symbols to figure caption. Also consider adding depth range of profiles at different locations, similar to description of NS102 and TCA. *We appreciate your feedback. L167, has been revised accordingly e.g. This included a depth profile in central Baffin Bay (Fig.1, red square, depth range: surface - 2377 m),*

Lines 207-220: Consider adding equation for mixing model to section 2.3 to increase clarity. *Thank you for your comment. This issue was also raised by RC 1 and has been addressed in L237.*

The mixing fraction f is estimated as:

$$f = \frac{\|\vec{a}\|}{\|\vec{b}\|}$$

were, \vec{b} is the vector connecting the two endmembers (mixing line), and \vec{a} is the vector connecting a given sample to one of endmembers.

Lines 224-225: 'The results of ¹²⁹I and...'; I'd suggest moving this sentence to the methods sections (2.1). *Moved to L195.*

Line 350: Symbol indicating tracer-free data depicted in Fig 6, but not visible in Fig. 5B as suggested here. Please add. *The symbol for tracer-free data has been added.*

Line 358: The authors switch between 'Canada Basin' and 'Canadian Basin' (mentioned here). Stay consistent and refer to Canada Basin throughout the manuscript (and figures). *The comment has been fully addressed in the updated version of the manuscript.*

Line 377-384: Previous studies have discussed potential cascading events along the WGC, leading to the sinking and intrusion of shallow WGSW to > 300 m depth in Baffin Bay (e.g., Marson et al. 2017; Lehmann et al., 2019). I'm curious if such a process aligns with the observation of a significant contribution of WGSW and tracer-free water discussed here. *We included it in the discussion of Transition Water see L485: Ultimately, Transition Water forms through the evolution of TrWTmax toward colder, fresher waters, which results in less 236U and higher 129I due to mixing with WGSW (Figure 6A, dashed line connecting TrWTmax with WGSW). WGSW may entrain Transition Water through cascading along the Greenland Shelf (Marson et al., 2017).*

Lines 405-420: The authors indicate that none of the previous studies considered the pathway of Atlantic-origin water through the CAA, while providing a somewhat speculative explanation of how Atlantic water from the Canada Basin may contribute to different water masses in Baffin Bay. The propagation of Pacific- and Atlantic-origin waters through the CAA, including corresponding mixing fractions and proposed mixing mechanisms, have previously been described based on more detailed sampling throughout the CAA (e.g., Lehmann et al., 2022 and references therein). Similarly, contributions of Atlantic (and Pacific) water have also been described for the Nares Strait outflow into Baffin Bay (e.g., Muenchow et al., 2007). In addition, previous studies have also described significant recirculation of northern Baffin Bay and Nares Strait water within Lancaster Sound (i.e., westward flow towards western CAA in northern section of Lancaster Sound (e.g., Colombo et al., 2019; Lehmann et al., 2022). This recirculation potentially contributes both Atlantic and Pacific water entering Baffin Bay through Nares Strait and Jones Sound to the Lancaster Sound. The manuscript would benefit from a more detailed discussion of these previous findings, and how the novel results presented in this current study fit into this broader context. *We thank the reviewer for pointing to these references which have been crucial to improve the quality of the manuscript. Section 4.1.2 has been revised considering the suggested literature.*

Line 439-420: The contribution of Canada Basin Atlantic water to BMW and BBW (through Nares Strait) has previously been discussed by e.g., Rudels et al. (2004) and Bailey (1956). *L493 has been adapted accordingly: which aligns well with a tracer signal of "old" water according to Fig. A1. The relatively high 236U and very low 129I displayed by BMW indicate the presence of AAWCB and align with observations 500 by Rudels et al. (2004) and Bailey (1956). However, based on the available tracer data, it is not possible to differentiate if the AAWCB originated from Nares Strait, as indicated by Rudels et al. (2004) and Bailey (1956) or from Lancaster Sound.*

Lines 446: 'The Radionuclide tracers'; no capital R. *changed accordingly*

Lines 450: Please elaborate on why 'Transition Water mix' is considered a distinct water mass rather than a mix between two. *Based on your comment we decided to rename the water masses to Tmax (previous Transition Water) and Transition Water (previous Transition Water mix) similar to Lehmann et al. 2022.*

Figure 1: I suggest adding a legend (e.g., different symbols in 1B) and additional details to figure caption to better explain the map. For example, it is not clear what the difference is between solid and dashed arrows, and what the blue star in 1A refers to. *The description of the caption has been extended and reads now as: Figure 1. A) Map of the study area showing the main surface water mass circulation (solid lines), intermediate-depth circulation (dashed lines), and deep circulation (dotted lines), adapted from Curry et al. (2014) and Dale et al. (2024). Ocean current names are written in black, while specific water mass names are written in colour. Black icons indicate the locations of nuclear fuel reprocessing plants at Sellafield (UK) and La Hague (France), and the blue star marks the location where the input function is defined.*

Figure 2 caption: This should be 'central Baffin Bay' in both cases. *changed accordingly*

Figure 3 caption: 'The water masses are based on...'. Please correct. *changed accordingly*

Figure 4: Solid symbols are color-coded based on water masses. I understand this is based on ranges in T/S listed in Table A1? I would suggest adding a few more details to the figure caption describing the water mass attribution. Also, the grey star symbols in A) do they fall outside of defined water mass ranges or why are they not color-coded? If so, please state that in the caption. The grey crosses in B) are not referenced in either the legend or the caption. Please add details.

We have now adapted the Figure caption following the reviewer's comment. Figure 4. Overview of hydrographic and tracer data. A) Temperature-salinity (T-S) diagram, showing the distribution of water masses as listed in Table A1. B) 129I vs. 236U plot for all samples. Water masses are equally colour-coded both in A and B, while grey stars represent samples

that could not be assigned to a certain water mass. The grey crosses indicate the sample uncertainty. C) Map of the study area with symbols marking the sampling locations; the symbols correspond to those used in panels A and B to indicate sampling provenance

Figure 5: Symbol for 'Tracer free' not visible. Also, correct figure caption to 'Figure 5. A) Location of each endmember...', and 'Arctic Atlantic Water in Canada Basin'. *Changed accordingly*

Figure 6: I find it confusing how the data were split between the subplots (e.g., density/depth range versus region?). Also, the angle of dotted lines seems somewhat random. Please add additional details to the caption for clarification. *The caption and plot has been revised to: ...The number along the mixing lines denote the mixing fraction. The water masses presented in the Panels are selected based on their tracer properties. **A)** maximum tracer concentrations in the study region represented by the T_{max} in western Baffin Bay and Davis Strait, West Greenland Shelf Water (WGSW), West Greenland Irminger Water (WGIW), and Baffin Bay Mode Water (BBMW), additionally Transition Water (TrW) is shown; **B)** Mixing occurring in Baffin Bay Arctic Water (AW) and cold Arctic Water (cold AW). **C)** Mixing observed in the Labrador Sea:...*

Table A1: Values for T and S don't align with values stated in paragraph 2.2 on water mass classification (Lines 190-200; e.g., WGIW, AW, cold AW, NEADW,...). Please double-check. *Section 2.2 has been updated according to the Table A1*

Table A2: It would be useful to add depth or density ranges for each endmember, either here or elsewhere in the manuscript. We thank the reviewer *for pointing this out. The depth range of the endmember has been added to the endmember Table A2.*

Figure A1. ^{129}I and ^{236}U are given in units of at/kg throughout the rest of the manuscript. I suggest adapting the units here to stay consistent with the rest of the manuscript. *changed accordingly*