

RC1

General Comments – paragraph evaluating overall quality of the article

This paper utilizes measurements of the artificial radionuclides ^{129}I and ^{236}U from seawater in Baffin Bay and the Labrador Sea, in order to trace the origins and interactions of various water masses present in the region. The use of these artificial radionuclides as water mass tracers can provide new insights compared to previous tracer studies in the region that have employed nutrient concentrations (e.g. the nitrate to phosphate ratio), stable oxygen isotopes, as well as temperature and salinity measurements. This study provides a substantial contribution to furthering knowledge of water mass formation and interactions between Arctic-outflow waters from the Canadian Arctic Archipelago and the subpolar North Atlantic.

One general comment that I have is that the calculation of mixing fractions is not explained very clearly. I think that simply stating that a “mixing fraction = length A/B” without clearly defining what A and B are (points? Line segments?), is not thorough enough for a scientific paper. I would be happy to see clearer language used around the calculation of mixing fractions (I provide an example sentence from Leist et al. (2024) that I think is more clear, in my other specific comments). As another option, providing some example equations within the methods section could also help. This clarity issue comes up again throughout the discussion section, and I have made specific comments below about where I think the text lacks clarity in regards to this.

A minor general comment that I have, throughout the manuscript, is that when referring to smaller passageways or water bodies in the Canadian Arctic, such as Davis Strait, Lancaster Sound, Nares Strait, and Baffin Bay, you do not need to include “the” before their names in sentences. However for Seas or Oceans, “the” should be included before their names (e.g., the Labrador Sea, the North Atlantic Ocean). The authors are currently inconsistent about this throughout the text, please check for consistency.

We sincerely appreciate the constructive feedback and thoughtful observations. We have incorporated these comments to a new version of the manuscript, and we hope the revisions have improved the clarity and accuracy of this new version. The general changes following the reviewer advice are:

- (i) *We included a description of the mixing fractions in methods section (with a general equation to define it), and the resulting fractions have now been clearly incorporated both in the discussion and Figure 6.*

- (ii) *we have carefully revised the manuscript to address the placement and usage of the definite article “the” throughout the text.*
- (iii) *Revised and included additional literature, which we had previously overlooked.*
- (iv) *A further change concerns the water mass classification. Following Lehmann et al. 2022, the Transition Water was redefined as T_{max} , while the Transition Water mix is now referred to as Transition Water.*

Specific comments:

Paragraph 2 of the Introduction (lines 32 to 38): I think it should be clarified here that the West Greenland boundary current system consists of two components: (1) the West Greenland Coastal Current (WGCC), which transports fresh and relatively warm PSW from the Arctic Ocean, and represents the continuation of Arctic outflow waters from the EGC, and (2) the West Greenland Current (WGC) which transports warm and salty WGIW at depth, and is a shelfbreak jet (see introduction of Huang et al. 2024 for details on this distinction). It is the WGC that bifurcates into two branches in the northern Labrador Sea, with the majority of the current being diverted westwards across the northern Labrador Sea, and only a limited amount continuing north into Baffin Bay. I suggest adding these details into your introduction.

We thank the reviewer for the comment and changed this paragraph accordingly:

L35-48: *From eastern Davis Strait, the northward-flowing West Greenland Current system (WGC, dark red arrows, Fig. 1A) transports two components along the Greenland shelf. The fresh West Greenland Shelf Water (WGSW, dark red), transported by the West Greenland Coastal Current, and the warm and saline West Greenland Irminger Water (WGIW, light green arrow Fig. 1A), is confined in a shelfbreak jet (Lin et al., 2018; Curry et al., 2014; Huang et al., 2024; Gou et al., 2022). The WGSW originates from the East Greenland Current (EGC, dark red arrow East of Greenland, Fig. 1A), which outflows Fram Strait and flows south along the Greenland coast, carrying fresh and relatively warm Polar Surface Water (PSW) from the Arctic Ocean (Sutherland et al., 2009). After rounding the southern tip of Greenland at Cape Farewell, the EGC is joined by WGIW at depth. The warm and saline WGIW originates from the North Atlantic Current (NAC, black arrows Fig. 1A), carrying water from the subtropics (Cuny et al., 2002). Towards the northern Labrador Sea, the current system of west Greenland becomes baroclinically and barotropically unstable due to the steep continental slope, leading to large anticyclonic eddies. The eddies are known as Irminger Rings and carry both the WGSW and WGIW offshore into the Labrador Sea (Chanut et al., 2008; Zou et al., 2024; Gelderloos et al., 2011). In the northern Labrador Sea, the WGC bifurcates into two*

branches, with one continuing north into Baffin Bay, and a larger branch following the bathymetry of the Labrador Sea, turning westward towards the Labrador Shelf (Myers et al., 2009; Huang et al., 2024; Gou et al., 2022)

Line 85-86: I would also suggest citing Bamber et al. (2018) "Land ice freshwater budget of the Arctic and North Atlantic Oceans: 1. Data, methods and results" JGR:Oceans *Reference has been included in L94 and L148. We thank the reviewer for pointing to this manuscript.*

Line 165-167: I am a bit confused by this sentence – are both stations NS89 and NS79 represented by the orange square in northern Nares Strait in Fig. 1B? And the orange circles represent southern Nares Strait stations NS102 to NS114 and NS107? This could be phrased more clearly.

The description of the sampling location has been rephrased to L171-174: In northern Nares Strait, two stations were sampled: one depth profile (50-345 m, RA28), and one surface station (RA34). Both are represented in Fig. 1B as one unfilled orange square. In the southern Nares Strait, three stations were sampled: RA44, RA48, RA50, of which only RA48 is a depth profile (70-600 m). These stations are represented in Fig 7B as unfilled orange circles.

Last paragraph of section 2.2 (lines 190 – 203): Many of the water mass definitions in this paragraph do not match the defined ranges of conservative temperature (CT) and absolute salinity (SA) given in Table A1. Please make sure they match for consistency, or where they may differ provide some clarification as to why. For example, in Table A1 West Greenland Irminger water (WGIW) is defined as $CT > 3.5$ and $SA < 34.2$ but in this paragraph it is defined as $CT > 4$ and $SA > 34.7$.

We thank the reviewer for noticing this inconsistency. The CT and SA values from section 2.2 have been revised and all values are consistent with Table A1.

Line 211: I understand the concept of how mixing fractions are calculated along mixing lines between end-member values, but I don't find it to be very clear from this sentence. Especially the "(fraction = length A/B) with A and B being end-member values". Since this is not a real equation, just the concept of it that you are trying to convey. I looked at Leist et al. (2024) and I preferred this sentence from that paper, I find this more clear: "The water mass fraction is calculated by dividing the distance between the sample and one endmember by the total distance between the two endmembers". I think this wording gives the reader a better idea about how to reproduce the method.

We thank the reviewer for the constructive feedback on one of the key parts of this manuscript. The concept of calculating a mixing fraction has been changed accordingly and is now explained as follow 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 the endmembers.

Line 212: In this sentence do you mean that end-members were calculated as the mean of sample values in a certain CT and SA range? This is stated a bit more clearly on lines 215-216, but I think it should be stated earlier in this first paragraph of section 2.3. And how exactly were the estimated fractions rounded? I think this sentence could be phrased more clearly.

*We have rewritten this sentence and it now reads as follow: **L232- 237:** In this study, each endmember has a distinct and characteristic value for temperature, salinity, and 129I and 236U concentrations (see details on each endmember in Section 4.1).*

In most cases, the 129I and 236U concentrations of the endmember consist of an average concentration of several samples collected in this and previous studies, with an associated uncertainty that corresponds to the standard deviation of the average values (see Table A2). Considering the two endmembers as the primary water-mass sources, the resulting water mass is treated as a mixture of the two.

Line 292-294: The part of this sentence that states “...with a clear influence from low-tracer Pacific water” didn’t make sense to me, because a Pacific water end-member is not shown in tracer space on Figure 4. It made sense once I saw the Pacific end-member in Figure 5 tough.

We concur with the reviewer that this sentence was misplaced. We have removed it from this line as it did not significantly contribute to the description of the location of cold Arctic Water within the binary mixing model .

Section 4.1.1: As I was reading the first paragraph of this section, describing how the various end-member values were defined, I was wondering about the depth range used to define each end-member. For example, the NAC end-member and ISOW are both defined in the region east of the Reykjanes Ridge, but they have very different depth ranges (and T/S properties; Table A1). I see that the depth ranges for each end-member are listed on Figure 5B – perhaps just a mention in the text that the depth ranges relevant to each end-member can be found in Figure 5B would be nice.

*We thank the reviewer for this observation and Section 4.1 has been revised to the following: **L350:** Table A2 summarises all endmembers used in this study, including their geographic locations, depth ranges, tracer*

concentrations, temperature and salinity values, the number of samples included, and the relevant references.

Line 350: This sentence mentions a diamond with a black outline in Fig. 5B – but the symbol is missing from the figure.

We thank the reviewer for highlighting this. The symbol has been added with the label “Tracer-free” next to it.

Line 374: Here it is stated “fraction PSW-EGC = A/B , Fig. 6A, see section 2.3 for fraction calculation”. I can see that the capital letters for A and B are on Figure 6A, but it looks like A, C, and D represent the length of dashed arrows? And I assume that B is supposed to represent the entire length of the line between the NAC and PSW-EGC end-members? I would appreciate if the definitions of A, B, and other letters could be clearly defined in the text for the reader, so that there is no confusion about the calculation. I think this also needs to be clarified earlier in the methods section 2.3.

This valuable comment aligns with feedback from RC2 and has been addressed in the revised methods section and the description of the fraction calculation. Throughout the discussion and Fig. 6 the capital letters (e.g. A, B, C) have been removed and the endmembers considered for mixing have been indicated. Additionally mixing fraction between the endmembers are now indicated along the mixing lines in shown in Fig. 6.

Lines 377-378: This sentence states “...consistent with estimates from Huang et al. (2024) for southern Baffin Bay (160 m out of 600 m)...”. I'd like some clarify on what these depths indicate – I believe you are referring to the thickness of the WGSW layer in the total water column, as was presented in Huang et al.? Please clarify what these depths are indicating.

*The sentence has been corrected to **L443**: This is consistent with the estimated 160 m thickness of the WGSW layer within the upper 600 m of the water column in southern Baffin Bay, as reported by Huang et al. (2024),...*

Line 380: This is again in reference to my earlier comment that I would like it to be clearly stated what C and B represent. *Please see explanations above.*

Line 387: In this sentence the fraction of PSW-EGC = $1-D/B$. Why is this formula for the fraction of PSW-EGC different from those at line 380 and 374? *Please see explanations above.*

Line 389: Similar to my earlier comment about depths stated from Huang et al. (2024) – what do these depths represent? *The Sentence has been changed to **L454**: Furthermore, Huang et al. (2024) observed a 200 m thick WGIW layer within the upper 500 m in central Baffin Bay.*

Section 4.3 title: Should this title say Baffin Bay Mode Water, instead of bottom water? Since BMW is discussed in the final paragraph of this section. I would be interested to read more about the interpretation of the very low tracer concentrations of BBBW though. *We thank the reviewer for pointing this out regarding the BBBW. The Title has been changed to "Origin of Transition Water and Baffin Bay and Bottom Water", adding a discussion of BBBW. It now reads as follow:*

L501-509: *Finally, the deepest waters in Baffin Bay, also known as Baffin Bay Bottom Water (BBBW) (Fig. 4B, dark purple squares), remain tracer-free. Low tracer concentrations are consistent with observations by Bourke et al. (1989), which show that convection or cascading do not contribute to BBBW formation, and is further consistent with its long ventilation time of up to 455 years based on tritium and ^3He measurements (Top et al., 1980). Other studies have posited that Atlantic Water from the Canada Basin may contribute to BBBW formation (Rudels, 1986; Rudels et al., 2004), but this interpretation is incompatible with high tracer concentrations in the Canada Basin (Payne et al., 2024), which would manifest as elevated ^{129}I and ^{236}U concentrations in BBBW.*

Line 409: Again, could E and F be defined more clearly in the text? And would the fraction of AAW (CB) be equal to $1 - E/F$? I have the same comment for Lines 463, 467, 486, 488, 510, 511 and 532 in relation to Fig. 6B and 6C. Line 486 does provide a bit more clarification that "L" represents a line, maybe K should be a dashed arrow similar to G? *Please see explanations above.*

Line 481: Doesn't cold Arctic water show the strongest WGSW influence? As evidenced by point "a" in the middle of the Northern Line (65% WGSW), as stated on line 462. Whereas the greatest WGSW contribution to Arctic water at point "e" is 30%. *The discussion has been rephrased to L546: In Arctic Water, contributions of WGSW are observed in central Baffin Bay (light brown square in Fig. 6B), highlighting the strong stratification in this region. On the western flank of the Northern Line, there is an influx of low tracer water (light brown circles in Fig. 6B), probably due to mixing with 50% of Pacific Water (if mixing between Pacific and NS_{South} is considered). These mixed waters remain confined within the BIC and are transported southward.*

Line 509 and 525: This sentence states "Labrador Sea Water (red symbols Fig. 6C)..." I am unsure if you are referring to the points labelled as LSW or LS Surface in Fig/ 6C? To me, the LSW triangles appear an orange color, and LS Surface appears a dark orange. *We thank the reviewer for pointing to the problem of having similar colors in the same panel. The color of LSW has been changed to blue, to better differentiate between LSW and LS surface.*

Line 520-522: I believe another possible mechanism that might lead these two surface samples (indicated by “g” in Fig. 6C) to have relatively higher ^{236}U (in the range of DSOW) is a contribution of cold AW. Rysgaard et al. (2020) showed evidence for a southward current along the southwest Greenland coast, which transports Baffin Bay Polar Water (referred to as cold AW in this manuscript) as far south as 64 degN latitude. I see that you already consider/discuss that Arctic water and cold Arctic water from the Labrador Current would only likely play a very small role (lines 523-524), but what if there is another southern transport on the east side of Davis Strait?

*We thank the reviewer for suggesting further analysis and literature review. The further analysis showed a geographical misplacement of the samples in the previous discussion. The samples are located at the western Labrador Sea and are now discussed within the context of Arctic and cold Arctic Water. See **L557-559**: As the Labrador Current continues southward along the Canada Shelf, two surface samples (red triangles Fig. 6B) originating south west of the AR7W Line suggest further mixing between WGSW, Nares Strait and/or Lancaster Sound outflow and a low tracer component, probably NAC.*

Technical corrections:

We thank the reviewer for reading our manuscript and providing constructive comments, also regarding technical corrections. We have thoroughly revised the text to improve fluency and readability. Grammatical errors and typographical issues have been corrected, and several sentences have been restructured to enhance clarity and precision.

For the title of this article, it should end with “**the** Labrador Sea”. *changed accordingly*

Line 37-39: I found this sentence difficult to read as currently worded, I suggest changing it to: “In the northern Labrador Sea it bifurcates into two branches, with one continuing north into Baffin Bay, and another (larger) branch following the bathymetry of the Labrador Sea, turning westwards towards the Labrador Shelf.” *changed accordingly*

Line 42: The BIC current in Figure 1A appears light red in color to me, with the LSW appearing orange, and the NEADW yellow. The WGSW current is dark red. *Colors indicate the main water masses and are changed to blue for LSW, and brown for BIC, to allow for better differentiation.*

Line 43: “transports fresh water of Arctic-origin” – Arctic should always be capitalized.

Line 48: Make it more clear that the depths listed in brackets are sill depths for each Arctic-outflow passageway Changed to, **L54**: *Waters exiting the Arctic Ocean enter Baffin Bay through the shallow 55 sills of Nares Strait (220 m, Jackson et al., 2014; Rabe et al.,*

2010), Lancaster Sound (125 m, Peterson et al., 2012) and Jones Sound (125 m, Melling et al., 2008; Pelle et al., 2024).

Line 50: "surface of Baffin Bay and along the BIC" *changed accordingly*

Line 60: should be "bathymetrically **steared**" not stirred. *changed accordingly*

Line 64: I think this line should read "...approximately 6-8% **of LSW**" to be more clear. *changed accordingly*

Line 116-117: I suggest changing some wording in this sentence to "...from the global fallout from nuclear weapons testing in the 1960s, and liquid releases from nuclear reprocessing plants in Sellafield (UK) and La Hague (France)..." *changed accordingly*

Line 184: Spelling should be "Zenodo" not Zenode. *changed accordingly*

Line 197: I believe the word "overlying" should be used here instead of "overflowing" to indicate that BBMW sits on top of BBBW. *changed accordingly*

Line 232: A range is given for ^{129}I , but ^{236}U is stated separately for north and south. Could also present ^{236}U values as a range, since the reader can see which location has the lower/higher value in Figure 2. *Changed to, L260: (AW, 129I: 60-85×10⁷ at/kg, 236U: 11-14×10⁶ at/kg)*

Line 281: Should have a bracket before "Fig. 4A and B indicated by black circles)." *changed accordingly*

Line 302: The Labrador Sea surface water (LS surface) symbols in Figure 4 appear as a dark orange to me, while the LSW appears as a lighter orange. *Colors are changed to blue for LSW and red for LS surface*

Line 305: Should reference Fig 6C here I believe. *changed accordingly*

Line 310: Sentence should end with "concentrations", plural for both tracers. *changed accordingly*

Line 330: Spelling of "reprocessing". *changed accordingly*

Line 366: This sentence should say "...with cooling and salinification in winter and **freshening** in summer". *changed accordingly*

Line 390: I believe this sentence should say "...due to the limitation of the mixing **of** two endmembers in the tracer analysis." *changed accordingly*

Line 454: This sentence should say "For WGSW, the mean and standard deviation were derived **from**..." *changed accordingly*

Line 455: This sentence should say "Cold Arctic Water **generally has** higher tracer concentrations..." *changed accordingly*

Line 465: Spelling of polynya. *changed accordingly*

Line 497: I suggest rephrasing the statement to be "Therefore, AAW originating from either Lancaster Sound or Nares Strait needs to be considered." *The discussion of Transition Water (mix) has been moved to section 4.3, and is now located at L 485. The nomenclature of Transition water mix is changed to Transition Water, while the initial Transition Water is now described as T_{max} following Lehmann et al., 2022.*

Line 505: Sentence should read "In a previous study by Leist et al. (2024) using ¹²⁹I and ²³⁶U **in** the Labrador Sea..." *changed accordingly*

Line 535: This sentence refers to the ²³⁶U maximum on the mooring line – perhaps reference Fig. 3 to support this statement, and the "x" symbol is missing in the given ²³⁶U value here (scientific notation). *changed accordingly*

Line 557: The sentence that starts on this line, I would rephrase as "At the same time, our results show that West Greenland Shelf Waters feed into Arctic waters in central Baffin Bay, while cold Arctic Waters largely originate from Nares Strait and mixes with West Greenland shelf water." *changed accordingly*

Line 560: Sentence starting on this line, I would re-phrase as "South of Davis Strait, our results show that Transition Water...". I would also consider mentioning in this sentence that TrW might also provide a contribution to NEADW. *changed accordingly*

Technical corrections on Figures:

Figure 1: In this figure caption I would state “Appendix **Table A1**”, similar to the caption for Figure 6. Also, perhaps clearly state that ocean current names are stated in black text, while specific water mass names are in colors. *changed accordingly*

Figure 3: In panel (B) BBBW is labeled, but then in panel (F) BBMW is labeled in the same place. I am assuming this label should be the same between the two panels? Also the caption for Figure 3 should read “²³⁶U concentrations (**E-H**)” and “The water masses are based on Curry et al...” *changed accordingly*

Figure 5: Check spelling of Canada Basin in the label on the top left of Fig. 5B. *changed accordingly*

Figure A1: Please indicate where the data for this plot was obtained – would also be helpful to reference the data source in the text somewhere between lines 115 – 120. Also, spelling of “input” in the figure caption is incorrect. *changed accordingly and the following references were added to the figure caption and L134: Wefing et al., 2021; Payne et al., 2024*

Figure A3: The lower-case theta symbol on the y-axis of panel A usually represents potential temperature, and conservative temperature is represented by a capital theta symbol. Should the figure caption state potential temperature instead of conservative temperature? Another suggestion for this figure is to add shaded ranges of the CT/SA bounds of Transition water, to clearly highlight how long these measurements fall within the definition of that water mass. *changed accordingly*

Figure A4: The figure caption should be adjusted to state that “Section plots of Absolute Salinity (A-D) and Conservative Temperature (E-H), along the Northern Line (A,E), Mooring Line (B-F), Northern Labrador Sea Line (C,G), and AR7W Line (D,H). Many of the panels were referenced incorrectly in the figure caption, please check. *changed accordingly*