Comment to manuscript «The changing composition of the Gulf of St. Lawrence inflow waters observed from transient tracer measurements » by Gerke et al.

By M. Jutras

Gerke et al provide here a new and very useful estimate of water age distribution in the St. Lawrence System. This is the first assessment based on transient tracers in this region, and it helps answer important questions of the circulation and how it is changing.

1. First of all, I have a question regarding the role of vertical mixing along the Laurentian Channel. On Fig. 4C, right panel, we see that the age is strongly dependent on the density, with older (hence NACW-rich) waters at depth. In Fig. 5 of Jutras et al. (2020), the results from the eOMP suggest that LCW and NACW are not mixed when they enter the Laurentian Channel, and that they mix as they move inland. More specifically, LCW progressively mixes with NACW on the 27.25 isopycnal, which would result in waters getting younger as they move inland along that isopycnal. Therefore, I would suggest to show the results of the water mass analysis also for different densities, as was done for the rest of the results (with figures like 4c and 3a-d, or maybe using a vertical transect along the channel), since this might influence the interpretation of the results that the rejuvenation of waters as they move inland is due to temporal changes in the water mass composition.

<u>Response:</u>

We thank M. Jutras for this insightful suggestions regarding other density layers along the Laurentian Channel. Our study focused on the σ_Θ = 27.26 kg/m^3 isopycnal because the sampling strategy for transient tracers targeted this deep water layer.

However, by analyzing mean ages and computed water mass fractions at other densities within the deep water, we observe that older water resides at depth while younger water is found closer to the Cold Intermediate Layer (CIL). This vertical structure appears to influence the 27.26 isopycnal, with water ages increasing along the Laurentian Channel transport inland (see Figure).

Despite this, LCW remains present throughout the deep water of the Laurentian Channel in 2022, while pure NACW is only found at the bottom near Cabot Strait.

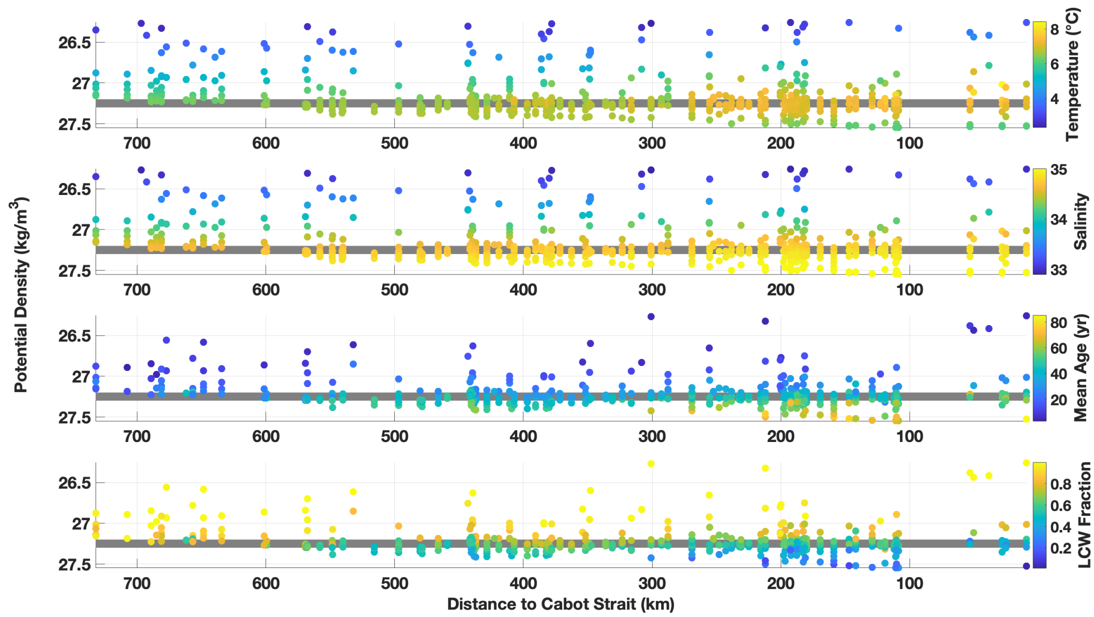

Figure: Display of different variables throughout the Laurentian Channel (shown as distance from Cabot Strait, where greater distance corresponds to locations farther toward the Lower St. Lawrence Estuary). From top to bottom: Temperature, Salinity, Mean Age and LCW fraction within the deep water ($\sigma_\Theta > 26.25 kg/m^3$), with the shaded area representing the density surface of $\sigma_\Theta = 27.26 kg/m^3$.

<u>Suggested changes in manuscript:</u>

In the revised manuscript, we intent to add this or a similar plot plot along with a brief description of the analysis, noting that vertical mixing also plays a role. Nevertheless, the influence of LCW remains evident throughout the deep water of the Laurentian Channel.

2. Second, I was wondering if the effect of turbulent mixing on SF6 and CFC-12 concentrations had been estimated, and if there could be some contamination by surface waters that would make the waters younger as they move inland. This effect is mentioned in the discussion, but the magnitude is not quantified.

<u>Response:</u>

Turbulent mixing was not examined and accounted for in the calculations. However, its effect is expected to be minor because the cold intermediate layer effectively separates the deep water from the younger surface waters. This was also stated in Jutras et al., 2020: "While the contribution of the CIL is important for the intermediate waters of the Laurentian Channel (100–150 m depth), the

deep waters (below 150 m) are composed almost exclusively of a mixture of LCW and NACW (see Section 3.1)". Additionally, our analysis focuses on data within the Laurentian Channel and does not extend into the Lower Estuary. Mixing of deep water towards the surface along the continental shelf would primarily affect surface waters and is unlikely to significantly alter the age of the deep water we analyze. This upwelling also primarily takes place at longitudes of the Lower St. Lawrence Estuary, and we only consider data east of this region.

<u>Suggested changes in manuscript:</u>

We do not intent to change the analysis for this point, but we will clarify this in the manuscript, mentioning that surface water is unlikely to effect the deep water at this isopycnal and depth.

3. Just a thought, but could the θ and Sp water mass analysis be used to "correct" for changes in age due to changes in water mass composition, and then use the age estimates to deduce the advection time along the Laurentian Channel?

<u>Response:</u>

The temperature and salinity are incorporated in the mean age calculations, as they are included in the analysis of the partial pressure of SF_6 and CFC-12. Therefore, changes in temperature and salinity are already included in the mean age used for the water mass composition calculation.

<u>Suggested changes in manuscript:</u>

Nothing to add/change within the revised manuscript.

Specific comments:

4. It is not clear what information the zooms on narrow density ranges provide in Fig. 3c-d and 4d. They might not be necessary.

<u>Response:</u>

The zooms on narrow density ranges are intended to highlight the $\sigma_\Theta = 27.26$ kg/m^3 isopycnal, which was the main sampling focus for both tracers during the campaigns. This density surface provides the lowest uncertainty due to the number of measurements, and forms the basis for the water mass analysis

presented later. The values included in the water mass analysis are the ones shown in these 3e/f and 4a.

<u>**Suggested changes in manuscript:**</u>

No changes are planned in response to this comment, as the zoomed-in plots are essential for emphasizing the key isopycnal and supporting the subsequent analysis from our point of view.

5. In Fig. 6b, it would be relevant to mention if there are enough data points to confirm if the trend is statistically significant, using a statistical test. It looks like the trend would change significantly if for instance the last point was removed, which suggests that the trend is not statistically significant. There is significant lateral variability in water properties across Cabot Strait due to the circulation (as we can see on some of the maps), which could contribute to the variability observed here. Colouring the data points with longitude or distance from one end of the channel could allow to see if this explains part of the variability instead of temporal variability.

Response:

Thank you for raising this point. We assessed the slightly negative slope in the linear analysis and found it is not statistically significant. The 95% confidence interval of the slope includes zero, indicating the trend could be absent or even slightly positive. Furthermore, a sample size analysis using Fisher's z-transform (a method to asses the statistical significance of correlations) indicates that detecting a trend of this magnitude with 80% statistical power would require approximately 500 datapoints, whereas our analysis only contains 45.

Color-coding the data points by longitude, as suggested, is a good idea. Although just based on the calculation, the values present in 2018 come from datapoints furthest away from Cabot Strait. Nonetheless, we attach the plot including longitude as a color code here.

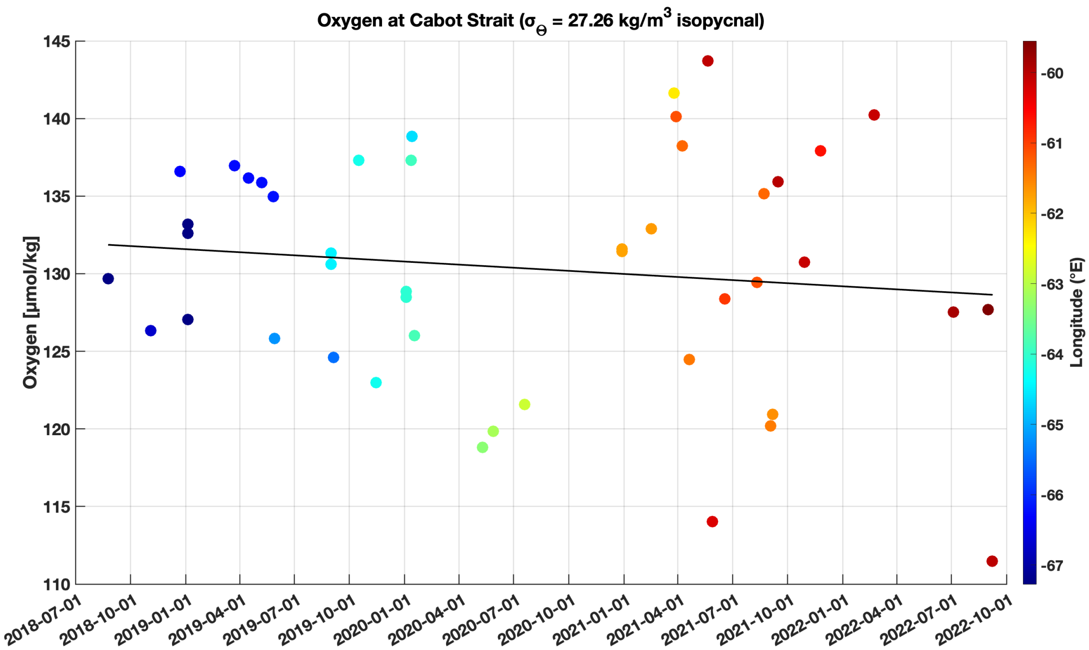

Figure: A proxy timeseries of dissolved oxygen at Cabot Strait from 2018 to 2022. The color code shows the actual longitude of the measurement, with samples located further west in blue and closer to Cabot Strait in red.

<u>Suggested changes in manuscript:</u>

In the revised manuscript we intent to move the oxygen plot to the supporting information and include a brief mention of the statistical analysis there. In the main text, we will add the arising uncertainty, when referring to this possible slight decrease in the oxygen over time.