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Uncertainty in the evolution of northwestern North Atlantic circulation leads to diverging biogeochemical projections

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Changes to volume transport and dye tracer distributions

The along-shelf volume transport is shown in Figure S1 for the present-day and the two future scenarios. Transport in present-day and ACM-DFO is similar with negligible changes at all locations along the shelf. In ACM-GFDL, along-shelf transport at the SF1 and SF2 sections is drastically reduced (by 63% and 73%, respectively). The drastic reduction in southwestward along-shelf volume transport is consistent with the disappearance of LS dye along the Scotian Shelf in ACM-GFDL (Figure 2, Figure S2), and with LS waters being replaced by Slp-D waters on the Scotian Shelf (Figure 3, Figure S2, Table S1).

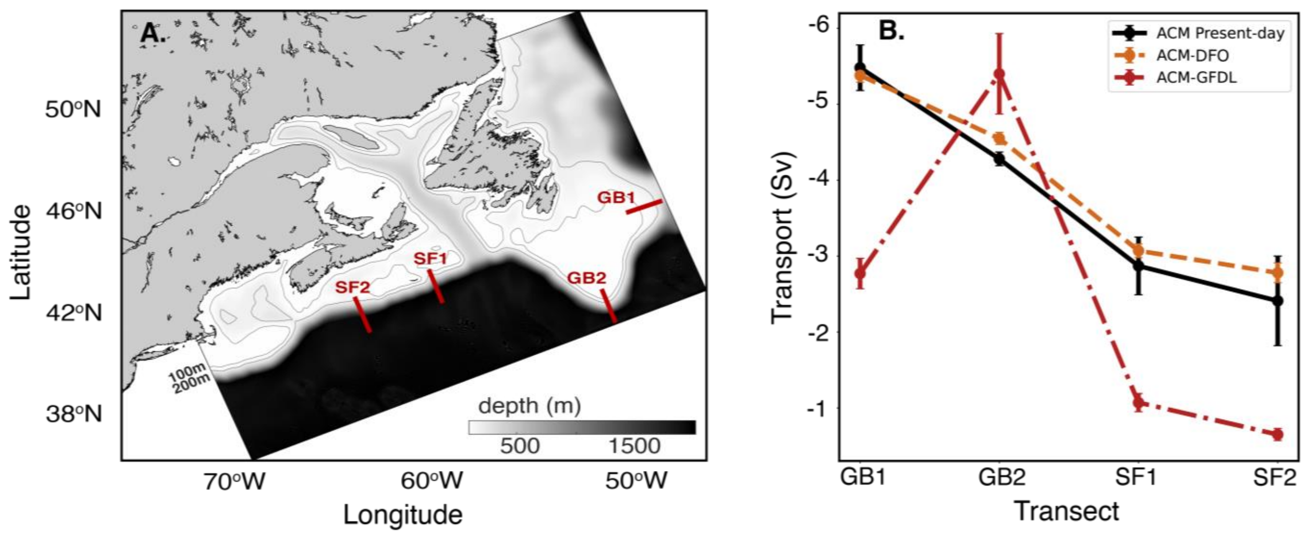

Figure S1: Southward volume transport (Sv) along the shelf of the northwest North Atlantic. Panel (A) indicates the transects the transport was calculated across. Panel (B) compares the average volume transport at the four transects along the shelf between present-day (black), ACM-DFO future scenario (light orange) and ACM-GFDL future scenario (dark red). Volume transport was calculated in the top 500m and only southward transport was considered.

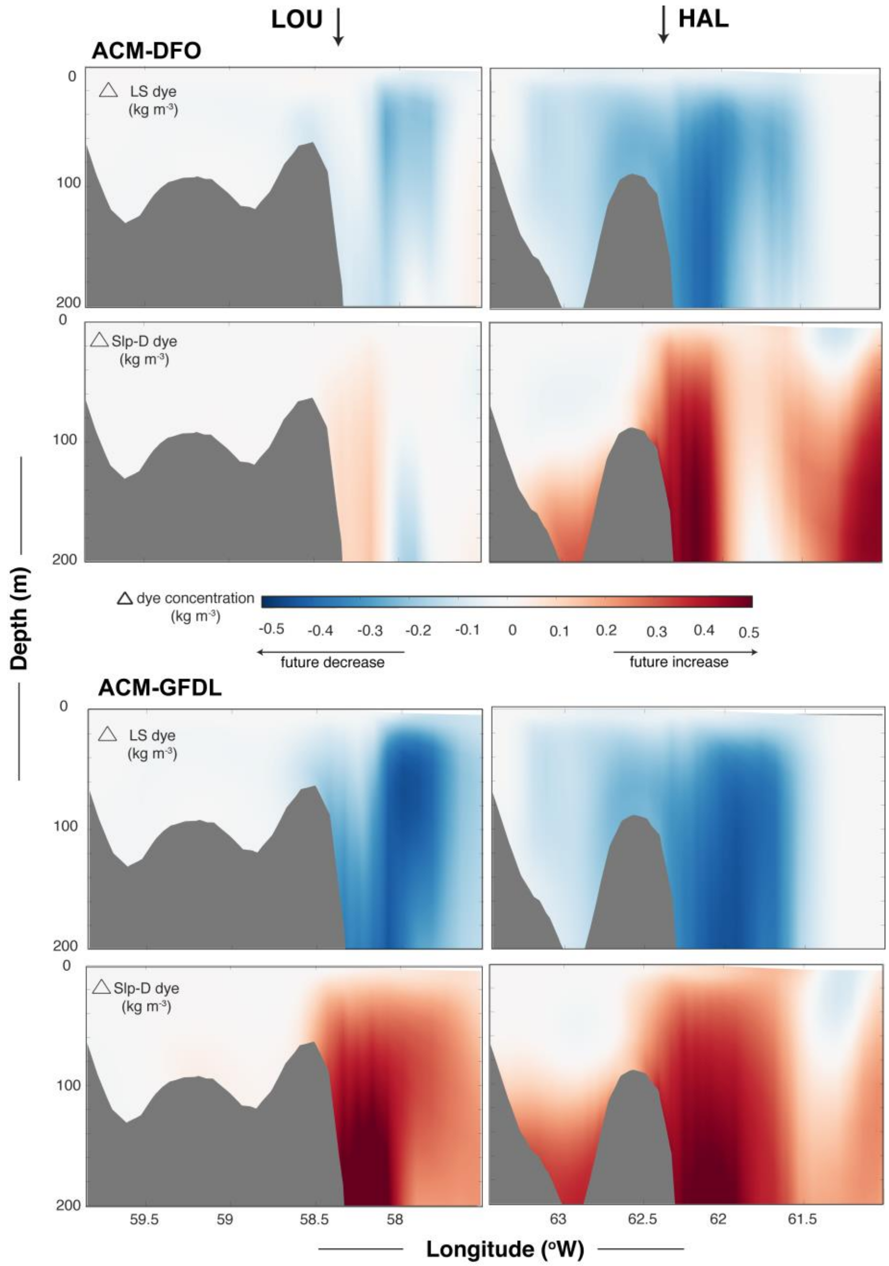

Figure S2: Changes in LS and Slp-D dye concentration in 2 transects (indicated in Figure 2) along the Scotian Shelf. Negative values (blue) indicate a decrease and positive values (red) indicate an increase in LS dye concentrations in the future. Top panels are ACM-DFO scenario and bottom panels are ACM-GFDL scenario.

Future changes to endmember T, S and DIC

Although every ocean end member warmed (Figure S3) the most notable warming is in Slp-S (~+2^{o}C) and ENS (+0.75^{o}C); the latter also became slightly fresher (by ~ 0.2). The other end members (LS, Slp-D) warmed by <0.5^{o}C and freshened by < 0.1 salinity units on average. As a result, the mixing polygon is similar between the present and future. The shelves (GB, SS, GoM) all have larger changes in T and S compared to the end members, particularly in terms of warming. GB has fewer differences between the scenarios, with similar warming (by about 1 to 1.5^{o}C) but larger salinity changes in ACM-GFDL with decreases of about 0.45 in ACM-GFDL vs 0.05 in ACM-DFO. The SS and GoM are both warmer in ACM-GFDL– 1^{o}C in ACM-DFO versus 2 to 2.5^{o}C in ACM-GFDL. The mean changes in SS salinity are the same in both scenarios (decreasing by about 0.05; Figure 6a) but the GoM becomes saltier in ACM-GFDL by 0.25 versus fresher in ACM-DFO by about 0.05 to 0.1. More specific changes to surface and bottom water temperature and salinity are described in Table 1.

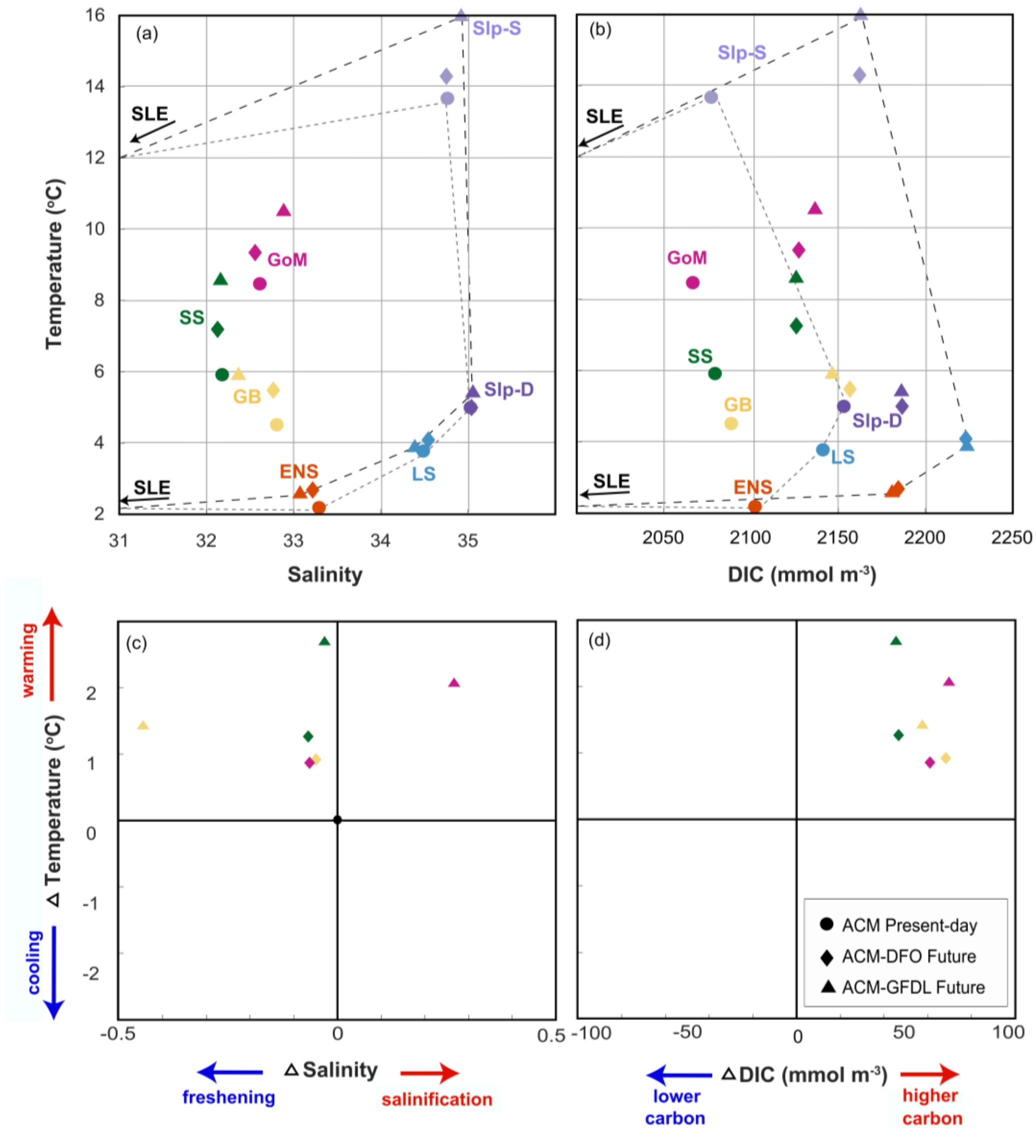

Figure S3: (a) T-S and (b) T-DIC diagrams, with different symbols indicating different simulations. Dashed lines connect endmembers and indicate the bounds of the mixing polygon. Arrows indicate where the St. Lawrence Estuary (SLE) endmember lies outside of the figure bounds. Panels (c) and (d) indicate changes in temperature, salinity and dissolved inorganic carbon (DIC) between the future and present-day values (future minus present).

Air-sea CO_2 flux

All regions (GB, SS and GoM) experience large increases in their annual air-sea CO_2 flux estimates (Table S3). Overall differences in the air-sea CO_2 flux between the two scenarios are relatively small compared to the total increase in surface air-sea CO_2 fluxes from present-day. The regional model does tend to slightly overestimate surface *p*CO2 at present day (Rutherford et al., 2021) and the DIC deltas may overestimate future DIC concentrations, therefore the magnitude of outgassing reported is potentially overestimated. However, the overall finding that atmospheric forcing is the dominant control on setting future air-sea fluxes is a robust result.

Table S1: Annual air-sea CO_2 flux for Grand Banks (GB), Scotian Shelf (SS) and Gulf of Maine (GoM) from the present-day ACM simulation, and the two future scenarios: ACM-DFO and ACM-GFDL. Positive values indicate outgassing (ocean to atmosphere); negative values indicate ingassing.

	Air-sea CO_2 Flux (mol C m^{-2} yr^{-1})		
	GB	**SS**	**GoM**
Present-day	-1.3 ± 0.3	+ 1.7 ± 0.2	-0.5 ± 0.2
ACM-DFO	+ 4.2 ± 0.6	+ 3.6 ± 0.4	+ 2.6 ± 0.4
ACM-GFDL	+ 5.4 ± 0.2	+ 3.8 ± 0.2	+ 3.1 ± 0.2