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Short-lived radium isotopes on the Scotian Shelf: Unique distribution and tracers of cross-shelf CO_2 and nutrient transport

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Radium (Ra) isotopes have become a common tool for investigating mixing rates on continental shelves, and more recently have been used to quantify the release of dissolved compounds enriched in pore-waters into the water column. We present results from Ra sampling of the Scotian Shelf region of the Canadian northwestern Atlantic Ocean, which reveal cross-shelf Ra distributions that are unique compared to other coastal regions. We explain the observations of lower 224Ra activities near the coast, relatively high activities at large distances offshore (>100km), and gradients in both offshore and onshore directions by inferring the regional geomorphology, as well as shelf bathymetry and circulation patterns. Ra gradients are used to calculate individual estimates of eddy diffusion in both the cross-shelf (KX) and vertical (KZ) directions using 1-D eddy diffusion models. Enhanced vertical mixing above offshore banks allows for Ra enrichments in offshore surface waters, while horizontal dispersion of this bank-related signal can transport Ra off the shelf break in surface waters, and towards the shore beneath the surface mixed layer. Similar onshore gradients in CO_2 and nutrient species combined with Ra-derived KX values can yield onshore carbon and nutrient fluxes in subsurface waters, which in turn supply the CO_2 outgassing from the Scotian Shelf. Our results thus provide constraints for cross-shelf transports of carbon and nutrients on the Scotian Shelf in order to guide mass balance or model based budget approaches in future studies.