The St. Lawrence Estuary is holding its breath: But where exactly?

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The bottom water in the Lower St. Lawrence Estuary (LSLE) at the western end of the Laurentian Channel (LC) is hypoxic with dissolved oxygen (O_2) concentrations as low as 55 μmol L^{-1}. The O_2 concentration in the LSLE bottom water has decreased by 50% since 1930, corresponding to an average depletion of approximately 1 μmol L^{-1} per year. One half to two thirds of the oxygen depletion could be attributed to changes in the properties of the deep-water mass that enters the Gulf of St. Lawrence through Cabot Strait. The remaining O_2 depletion was attributed to an increase in the organic particle flux to the sea floor, possibly in response to eutrophication We measured the concentration and the stable isotope ratios of dissolved oxygen in the water column in the Estuary and Gulf of St. Lawrence to determine the relative importance of pelagic and benthic dissolved oxygen respiration to the development of hypoxic deep waters. The progressive landward decrease of dissolved oxygen in the bottom waters along the axis of the Laurentian Channel (LC) is accompanied by an increase in the ^{18}O:^{16}O ratio, as would be expected from O-isotope fractionation associated with bacterial oxygen respiration. The apparent O-isotope effect, $\varepsilon_{O\text{-}app}$, of 10.8‰ reveals that community O-isotope fractionation is significantly smaller than if bacterial respiration occurred solely in the water column. Our observation can best be explained by a contribution of benthic O_2 consumption occurring with a strongly reduced O-isotope effect at the scale of sediment-water exchange ($\varepsilon_{O\text{-}sed} \sim 7‰$). The value for $\varepsilon_{O\text{-}sed}$ was estimated from benthic O_2 exchange simulations, using a one-dimensional diffusion-reaction O-isotope model. Adopting this $\varepsilon_{O\text{-}sed}$ value, and given the observed community O-isotope fractionation, we calculate that approximately two thirds of the ecosystem respiration occurs within the sediment, in reasonable agreement with direct respiration measurements. Based on the difference between dissolved oxygen concentrations in the deep waters of the Lower St. Lawrence Estuary and in the water that enters the Laurentian Channel at Cabot Strait, we estimate an average respiration rate of 5500 mmol O_2 m^{-2} yr^{-1} for the 100 m-thick layer of bottom water along the Laurentian Channel, 3540 mmol O_2 m^{-2} yr^{-1} of which is attributed to bacterial benthic respiration.