Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.37644

Stable Preformed pCO_2 and pH in the Cold Intermediate Layer of the Gulf and Lower St. Lawrence Estuary over Two Decades of Rising Atmospheric CO_2

WILLIAM A. NESBITT[1], RUTH MUSGRAVE[1], ALFONSO O. MUCCI[2], GWÉNAËLLE CHAILLOU[3], TOSTE TANHUA[4] AND DOUGLAS WALLACE[1]

[1]Dalhousie University
[2]McGill University
[3]Université du Québec à Rimouski
[4]GEOMAR Helmholtz Centre for Ocean Research Kiel

The upper layers of the ocean are typically expected to track rising atmospheric CO_2 as a result of air-sea gas exchange, leading to progressive acidification of surface and recently ventilated subsurface waters. Atmospheric pCO_2 has increased by ~40 µatm between 2003 and 2023 (~380 to ~420 µatm). We assess whether this atmospheric increase is recorded in the Cold Intermediate Layer (CIL) of the Gulf and Lower St. Lawrence Estuary, a water mass that forms in the Gulf of St. Lawrence (GSL) during the winter, flows landward and persists beneath the brackish summer surface layer at depths down to ~150 m. Using a harmonized 20-year (2003-2023) biogeochemical dataset, we reconstruct a time-series of the preformed carbonate chemistry of the CIL to assess how anthropogenic CO_2 has propagated into this seasonally-ventilated water mass. Preformed dissolved inorganic carbon (DIC_0) and total alkalinity (TA_0) were calculated by removing the imprint of microbial remineralization using apparent oxygen utilization (AOU). Preformed pCO_2 was then computed for the CIL (50 – 150 m) at the inferred ventilation temperature ($T_{vent} = T_{min}$). Surprisingly, preformed pCO_2 in the CIL was nearly invariant at ~395-405 µatm over two decades. Likewise, the DIC_0, TA_0, and pH exhibit no secular increase. This stability is concomitant with a previously documented ~1°C warming of the winter mixed layer. The absence of an increasing preformed CO_2 signal suggests that winter-time ventilation is insufficient to allow the CIL to track the atmospheric CO_2 increase. We hypothesize that this decoupling may reflect (i) incomplete winter air-sea equilibration during CIL formation and (ii) the influence of the preconditioned, relatively poorly-ventilated Labrador Current waters entering the GSL through the Strait of Belle Isle. The results indicate that renewal timescales, source-water pathways, and restricted air-sea exchange can delay or modulate transfer of anthropogenic CO_2 into some shallow water masses found in seasonally-ventilated marginal seas. These processes make it difficult to predict subsurface acidification and evaluate the effectiveness of deliberate, regional marine carbon dioxide removal strategies.