

Surface and subsurface progress of ocean acidification in the Canada Basin of the Arctic Ocean from 2003 to 2019

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The Canada Basin of the Arctic Ocean is considered the region of the world's open ocean most susceptible to Ocean Acidification. During 2003-2007, CaCO_3 saturation state (Ω) in the surface water of the Canada Basin decreased at a rate 10 times faster than other open oceans and reached $\Omega < 1$ (undersaturation). This was caused by the extensive melting of thick multi-year sea ice during this period, which diluted surface water and enhanced air-sea CO_2 exchange. Below the surface, there is another layer of $\Omega < 1$ water at around 100-200 m, corresponding to the layer of Pacific Winter Water (PWW). The subsurface $\Omega < 1$ has expanded in the last few decades due to retreat of sea ice and change in water circulation caused more PWW advection. However, previous studies were based on data only in surface water or in limited region of the Canada Basin. The present study analyses repeat hydrographic observations covering a large part of the Canada Basin to reveal temporal changes in the total thickness of aragonite undersaturated water (USW) in the 0-300 m of the Canada Basin from 2003 to 2019. Surface USW thickness increased from 0 m in 2003 to 19 m in 2019. The main cause of this was freshening until 2012. After 2013, thickening of surface USW was mainly due to increased uptake of anthropogenic CO_2 promoted by exposure of surface water to the atmosphere by melting of sea ice. This suggests that surface water of the Canada Basin now reaches aragonite undersaturation without a large freshening effect and that the presence of surface USW has become ubiquitous in the Canada Basin because of the progress of OA. In the subsurface layer, USW thickness increased from 87 m in 2003 to 129 m in 2019. Most of this is likely caused by the progress of OA in the upstream shelf regions, due to increased CO_2 uptake from the atmosphere and increased respiration. Thickenings of the PWW layer due to enhanced Ekman pumping and lateral flux convergence also explains about a quarter of the subsurface USW thickening. As a result of the thickening of both surface and subsurface USW, the percentage of USW in the 0-300 m of the water column increased from 35% in 2003 to 59% in 2019 at the mean expansion rate of 1.8% per year. The replacement of oversaturated water to USW occurred mostly at the surface layer and the layer below 190 m. Interestingly, the thickness of oversaturated layer between surface and subsurface USWs did not decrease, despite the thickening of both USW layers. This keeps the window of suitable layer for calcifying organisms such as *L. helicina* who distribute mainly in the top 150 m layer.

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