Circulation controls on the biogeochemistry and climate of the glacial Pacific

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Overturning circulation plays a key role in setting the climate and nutrient regimes of the high latitude oceans, as well as CO_2 exchange between the deep ocean and the atmosphere. Today the North Atlantic and North Pacific have notably different circulation regimes, with vigorous deepwater formation in the Atlantic and only limited intermediate water formation in the Pacific. This is also reflected in the biogeochemistry of these basins, with low nutrient concentrations in the North Atlantic due to input of oligotrophic subtropical waters, and high nutrient concentrations in the North Pacific due to upwelling of nutrient-rich deepwater.

During the last glacial maximum (LGM) it is generally thought that deepwater formation in the North Atlantic shoaled to intermediate depths. However, there is less concensus on the LGM circulation of the North Pacific, with some authors suggesting more stratified conditions [1], while others suggest stronger ventilation [2] that possibly extended to local deepwater formation during Heinrich Stadial 1 [3].

Here we compile geochemical tracers for ocean ventilation, export productivity, salinity, and temperature, to examine the glacial circulation state of the North Pacific and its control on productivity and climate. These data suggest better ventilated intermediate waters, an increase in surface ocean salinity and temperature, and a decrease in productivity at the LGM compared to the Holocene. This is consistent with an increase in overturning circulation, which would act to bring in warm, salty, and nutrient-poor waters from the subtropics and transform these to intermediate waters, analogous to a shallower version of the modern North Atlantic. Our interpretation is supported by results from a simple box model, which highlight the importance of lateral exchange between subtropical and subpolar waters in controlling high latitude productivity and climate.

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