

THE POLAR OCEANS AND ATMOSPHERIC CO₂

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We argue for a pervasive link between cold climates and polar ocean stratification. In both the Subarctic North Pacific and the Antarctic Zone of the Southern Ocean, ice ages were marked by low productivity. The accumulated evidence from sediment cores points to an increase in density stratification that reduced the supply of nutrients from the ocean interior into the sunlit surface in both of these regions. The last ice age was associated with stratification of the Antarctic and the subarctic North Pacific. This link also applies to longer time scales, including the onset of extensive northern hemisphere glaciation 2.7 million years ago, which was concurrent with stratification of the Subarctic North Pacific and the Southern Ocean. A mechanism is provided by the non-linear relationship between the temperature of seawater and its density: cooling of the ocean will decrease the role that temperature plays in the density structure of the polar water column, allowing a freshwater cap to cause greater density stratification. Nutrient-rich polar ocean regions such as the Antarctic and the Subarctic Pacific represent a “leak” in the biological pump, allowing deeply sequestered carbon dioxide to escape back into the atmosphere, and stratification of these regions largely stops that leak. Thus, the link between climate cooling and the stratification of nutrient-rich polar regions represents a positive feedback in the climate system, raising atmospheric carbon dioxide during warm periods and reducing it during cold periods.