# Tightly packed isotherms constrain temporal turnover in marine biodiversity

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The persistence of marine ecosystems under climate warming depends critically on the capacity of communities to reorganize. Climate warming is expected to increase community turnover as marine organisms track poleward-shifting isotherms. However, whether turnover differs systematically between regions with tightly packed and sparsely spaced isotherms remains largely unexplored. Using data from 23,283 marine assemblages worldwide, we show that isotherm flatness conditions how warming translates into community turnover, generating pronounced regional heterogeneity in biodiversity change. At a given rate of ocean warming, a tenfold decrease in isotherm flatness is associated with an approximately 6% lower temporal turnover per decade. At a finer spatial scale, analyses of 1,617 environmental DNA (eDNA) samples from the Japanese coast reveal similarly suppressed turnover in fish assemblages occupying regions with low isotherm flatness, particularly in confluence zones of cold and warm currents. In these confluence zones, constrained turnover coincides with an emergent shift in dominant thermal constraints, from historical cold limitation toward increasing heat exposure of the assemblage. Together, our results identify isotherm flatness as a previously underappreciated geometric constraint that modulates community turnover under climate warming. Such turnover suppression may mask growing risk, as adaptation mechanisms shaped by chronic cold limitation may be slow to adjust to emerging heat exposure.

Keywords: Community turnover, Isotherm flatness, Ocean warming, Confluence zones, Shift in thermal constraints

 