

Water temperature increases and changes in fish distribution off the Pacific coast of northeastern Japan

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Climate change is now an undeniable and accelerating force reshaping the world's oceans (IPCC, 2021). Rising sea temperatures are transforming marine habitats at unprecedented rates. Fishes and other organisms shift their geographic and depth ranges to remain within suitable thermal and environmental conditions. These movements are typically poleward in latitude and deeper in the water column. The area off the Pacific coast of northeastern Japan, one of the world's most productive fishing grounds, is known as the areas in the world where sea temperatures are rising significantly. The Japan Meteorological Agency reported that the temperature at the sea surface in the region has had a strong, significant warming trend ($p < 0.01$) of 1.20°C per 100 years. Kakehi et al. (2021) documented bottom temperature increases of $0.08\text{--}0.11^{\circ}\text{C yr}^{-1}$ (150–300 m depth) during 2003–2019 in this region. Owing to this bottom temperature warming, demersal fish communities such as bighead grenadier *Abyssicola macrochir* and darkfin sculpin *Malacocottus zonurus* are exhibiting clear northward distributional shifts and density change (Kakehi et al., 2021). From 2022 to 2025, unprecedented northward shift of the Kuroshio Extension occurred. The northward movement of warm currents has a strong ability to transport southern organisms, and the northern limits of southern fish species have been updated.

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