Fine-scale structure and mixing across the front between the Tsugaru Warm and Oyashio Currents in summer along the Sanriku Coast, east of Japan

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High-resolution shipboard observations were made across the front between the Tsugaru Warm Current (TWC) and the Oyashio in July 2013. Fine structure in the frontal zones were successfully captured with an Underway Conductivity–Temperature–Depth (UCTD) profiler deployed with a typical horizontal interval of 2–3 nautical miles. The front characterized by marked horizontal gradients in temperature and salinity extended from the subsurface onto the shelf. Along this frontal layer, the minimum frequency for internal waves became substantially lower than the local inertial frequency, mainly due to the strong vertical shear of the geostrophic velocity. Turbulent energy dissipation rates ε (vertical diffusivity K_ρ) were frequently elevated along the front and its offshore side up to 3×10^{-8} W kg^{-1} (10^{-4} m^2 s^{-1}), which may have been caused by an “internal tide chimney”, trapping low-frequency internal waves within the band of strong shear. At the onshore side of the TWC on the shelf, strong mixing with ε (K_ρ) exceeding 10^{-6} W kg^{-1} (10^{-3} m^2 s^{-1}) was also observed. A large portion of the water columns in the frontal area provided suitable conditions for double diffusion; in some layers with moderate turbulence, temperature microstructures indicative of double diffusion were observed. The vigorous mixing processes around the front are likely to modify the properties of the TWC downstream, which could then produce a latitudinal gradient in environments along the coast.

Keywords: Tsugaru Warm Current, Oyashio, Front, Vertical mixing, Internal tide chimney

