The 100 km wide 100-1000 fold enhancement in turbulent mixing caused by the Kuroshio induced mesoscale hydraulic jump in the lee of Tokara Strait

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The Kuroshio, a western boundary current of the North Pacific, transports tremendous amounts of heat and salt to the northern downstream, the Kuroshio Extension. The temperature decrease and primary production along the flow affect the biogeochemistry and CO_2 uptake, which make these western boundary current regions as the Carbon Hotspots. The previous studies suggested that the oligotrophic Kuroshio carries relatively nutrient rich water in its subsurface as the Kuroshio nutrient stream, similar to the Gulf Stream. These relatively high nutrient concentrations than the ambient water of the same density in the Kuroshio subsurface could promote primary production and CO_2 uptake in these regions. However, mechanisms of how the relatively higher nutrient concentrations along the Kuroshio is formed are not well understood. One of the likely hypotheses is that the strong turbulent mixing in the regions where the Kuroshio flows over rough topography. Because the Kuroshio path is largely arrested by the half pipe like topography along its upstream path in the Okinawa trough, the Kuroshio inevitably takes the hairpin like curved path, when it approaches to the southwest of Kyushu and changes its flow direction to south, before it turns to flow toward northeast again off east of Kyushu. During the Kuroshio undergoes its forced meandering, it flows through the Tokara Strait.
Recent microstructure surveys in the Tokara Strait suggested that very strong turbulent mixing occurs near seamounts and islands, and that the Kuroshio catalyzes the mixing due to diurnal and/or near-inertial internal waves by trapping these internal waves on its anticyclonic side. However, because these observations are made only at a few points using a vertical microstructure profiler, or using a tow-yo microstructure profiler only in the upstream side, it is still unclear how the Kuroshio induces turbulence when it flows through Tokara Strait. In this study, more intensive tow-yo microstructure surveys were conducted to uncover the detailed turbulence quantities through the entire path of the Kuroshio across the Tokara Strait. The five tow-yo microstructure transects reveal that the Kuroshio induces the 100 km wide vigorous turbulence of O(10^{-7}-10^{-6} W kg^{-1}) turbulent kinetic energy dissipation rates in the lee of Tokara Strait. The dissipation rates found in this region are 100-1000 times stronger than that found typically in the open ocean thermocline. More importantly, the lateral and vertical scales of the turbulent layers are found to be 100 km and a few 100 m, respectively, suggesting that the turbulence magnitude and its impacts are enormously large. In the presentation, we will show results of analyses to understand the mechanisms in more detail, which induce this strong turbulence.

キーワード：黒潮、乱流混合、トカラ海峡
Keywords: Kuroshio, Microscale Turbulent Mixing, Tokara Strait