Nutrient supply to the euphotic layer in the Kuroshio and Kuroshio Extension

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As one of the western boundary currents in the North Pacific, Kuroshio is known as a strong current with high speed, narrow width and great depth. It provides a poleward heat transport as flowing from east of Luzon to south of Japan and diminishing in Kuroshio Extension region. Meanwhile it brings a large amount of nutrient from its upstream to downstream with a maximum nutrient flux core between 400 m and 500 m approximately. However, only the nutrients transported into euphotic zone can be used by primary production. As a general idea, the vertical processes such as wind-driven upwelling, diapycnal diffusion, wintertime convection and eddy heaving are considered to be the important mechanisms supplying nutrient to the euphotic zone. However, recent researches pointed out that the lateral transport cannot be ignored for nutrient input to several basin scale gyres such as North Atlantic subtropical gyre, as well as the other subtropical ocean gyres. With a “Kuroshio nutrient stream” underlying the Kuroshio, nutrient supply to euphotic layers in the Kuroshio region needs more study.

In this study, we use results of an eddy-resolving coupled physical-biological ocean model to investigate (1) lateral and vertical transport of nutrient into the euphotic layer (0-100 m) in the Kuroshio and Kuroshio Extension, (2) the contribution of different sources of nutrient (coastal, deep layer and open ocean) to the variation of downstream nutrient transport along the Kuroshio and Kuroshio Extension. Our analysis shows that around the Luzon Strait, the horizontal transport of nutrient (water) along the Kuroshio direction in the euphotic layer increases from 2.8 kmol/s (5.4 Sv) to 7.9 kmol/s (7.5 Sv). As a mean state in this area, vertical transport provides 1.1 Sv of net water transport and 3.8 kmol/s of net nutrient transport to the euphotic layer. Along the shelf break in the East China Sea, the horizontal transport provides 8.9 kmol/s (6.7 Sv) of nutrient (water) to the area south of Kyushu. As the Kuroshio flows to south of Japan from the Tokara Strait, its nutrient (water) transport increases to 21.5 kmol/s (10.2 Sv) near the Izu-Ogasawara Ridge. The main input for the Kuroshio south of Japan is the horizontal transport from onshore side of the Kuroshio that provides 1.6 Sv of net water transport but 14.3 kmol/s of net nutrient transport. The large amount of nutrient input from onshore side of the Kuroshio to the Kuroshio south of Japan can be explained by upwelling along the coast of Japan. The high concentration of nutrient is upwelled to the surface layer along the coast of Japan with a value of 16.4 kmol/s and then transported horizontally to the Kuroshio region. In the Kuroshio Extension region, the transport in the direction along the Kuroshio flow decreases to 19.6 kmol/s (6.0 Sv), the transport in the direction across the Kuroshio brings 4.0 kmol/s of nutrient transport from subpolar gyre into the Kuroshio Extension region and 5.7 kmol/s of nutrient transport from the Kuroshio Extension region to subtropical gyre. Vertical transport in the Kuroshio Extension region shows an interesting staggered upward and downward distributions with the path meandering and have a total transport of 5.2 kmol/s (0.7 Sv) nutrient (water) into the euphotic layer.

Keywords: Nutrient transport, euphotic layer, Kuroshio

