Downstream Evolution of the Kuroshio Velocity Structure and Transport

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The Kuroshio flows along the North Pacific western boundary carrying heat, mass and momentum poleward. Along this route, the Kuroshio’ s strength and vertical structure undergo significant temporal and spatial variability. Recent observational studies have examined the Kuroshio between Luzon and Taiwan, just before the Kuroshio flows into the East China Sea and upstream of the beginning of the Ryukyu Current (a subsurface-intensified current that carries part of the total poleward western boundary current flow). These observations were part of the recent US Origins of the Kuroshio and Mindanao Currents (OKMC) and Taiwan Observations of Kuroshio Transport Variability (OKTV) and Study of the Kuroshio II (SK-II) observational programs. These studies, together with previous observational efforts, build a comprehensive picture of the Kuroshio on its route from its origins near Luzon to southeastern Japan, where the current finally transitions from a western boundary current into the Kuroshio Extension, a vigorously meandering free jet. Through the joint OKMC/OKTV efforts, Kuroshio strength and velocity structure were measured between June 2012 and November 2014 with pressure-sensor equipped inverted echo sounders (PIESs) and upward- looking acoustic Doppler current profilers (ADCPs) deployed across the current northeast of Luzon, Philippines, and east of Taiwan with an 8 month overlap in the two arrays’ deployment periods. The time-mean net (i.e., integrated from the surface to the bottom) absolute transport increases downstream and the observed downstream increase is consistent with the return flow predicted by the simple Sverdrup relation and the mean wind stress curl field over the North Pacific (despite the complicated bathymetry and gaps along the North Pacific western boundary). Northeast of Luzon, the Kuroshio is shallower than 750 dbar, while east of Taiwan areas of positive flow reach to the seafloor (3000 m). A similar deepening of the subtropical western boundary current is observed in the North Atlantic in the region where the Gulf Stream leaves Cape Hatteras. In addition, there is a deep counterflow beneath the poleward-flowing Kuroshio. Time-varying transports and velocities indicate the strong influence at both sections of westward propagating eddies from the ocean interior. Topography associated with the ridges east of Taiwan also influences the mean and time-varying velocity structure there. By comparison, in the North Atlantic there is also a deep counterflow beneath the Gulf Stream at Cape Hatteras, however, this is likely due to different processes than those at play in the North Pacific, due to the presence of the Deep Western Boundary Current there which carries equatorward flow in the Atlantic Meridional Overturning Circulation (AMOC) cold limb flow.

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