

A New Dynamic Regime in the North Pacific Climate System after 2018: Physical Drivers and Biogeochemical Impacts

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Over the four decades following the 1976/77 climate regime shift, the Kuroshio Extension (KE) in the North Pacific subtropical gyre exhibited quasi-decadal oscillations between stable and unstable dynamic states. These oscillations were facilitated by a delayed negative feedback loop involving wind-forced interior ocean adjustment, its modulation on the KE dynamic state, and the KE's feedback onto atmospheric storm tracks and the wind stress field. After 2018, this feedback loop ceased to function, giving rise to a new dynamic regime, in which the Kuroshio south of Japan assumes a persistent offshore meandering path, while the stabilized KE jet migrates poleward. We identified three key processes responsible for the emergence of this regime: (1) a shift in the external forcing field, characterized by intensified wind forcing over the northern subtropical gyre and weakened forcing over the southern gyre; (2) nonlinear reinforcement between the meandering Kuroshio and the poleward-migrated KE jet; and (3) altered storm track and wind stress responses to the KE's newly established state. The establishment of this regime has significant implications not only regional mode water properties but also for marine biogeochemical conditions across the broader North Pacific basin. Our analysis suggests that the recent decline in dissolved oxygen observed at Station ALOHA off Hawaii can be quantitatively attributed to changes in wind-forced ventilated thermocline circulation.

Keywords: Climate regime shift, Kuroshio/Kuroshio Extension, deoxygenation trend, ventilated thermocline change