

Communication

# Injection of High Chlorophyll-a Waters by a Branch of Kuroshio Current into the Nutrient-Poor North Pacific Subtropical Gyre

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**Abstract:** An unusual eastward flow was observed branching out from the Kuroshio Current near the island of Taiwan in the western North Pacific in during the period June–July 2010. The branch meandered eastward approximately 21°N, carrying high chlorophyll-a (Chla) waters for over 1000 km from 125°E into the nutrient-poor North Pacific subtropical gyre (NPSG). The branch was warmer and fresher than the surrounding waters, with temperature–salinity properties resembling those of Kuroshio Current. Thus, we called it the eastward cross-shore Kuroshio branch (ECKB). Injecting fresher waters far into the central NPSG, the ECKB flowed at a mean surface speed of 0.5 m per second, as shown in satellite altimeters, a Lagrangian drifter, and the Japan-Meteorological-Agency (JMA) 137°E-meridian cruise transect. The mechanism of the ECKB was linked to a surface cyclonic wind anomaly to the north at approximately 22–24°N. The cyclonic wind anomaly cooled the ocean surface beneath it via Ekman suction and then enhanced the subtropical front to its south at approximately 21°N near the Kuroshio Current. The strengthened subtropical front subsequently induced an eastward flow that bifurcated from the main stream of the northward-flowing Kuroshio Current.



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## 1. Introduction

In the subtropical North Pacific, surface ocean circulation is dominated by a wind-driven, clockwise-circulating North Pacific Subtropical Gyre (NPSG). At the western boundary of the NPSG, a fast-flowing western boundary current called the Kuroshio Current (KC) [1] connects the North Pacific Current in the north and the North Equatorial Current (NEC) in the south near the equator (Figure 1a). The KC, meaning “black stream” in Japanese, obtained its name due to the black color or precisely the deep blue color of its waters. The deep blue color of the KC is mostly due to a lack of phytoplankton as a result of nutrient depletion especially in waters off the east of Taiwan [2].

Against the westward-flowing NEC, a slow surface countercurrent flows eastward at speeds of approximately 2–10 cm s<sup>-1</sup> [3–5]. This slow current is the North Pacific Subtropical Countercurrent (STCC) (Figure 1a), which was first reported by Uda and Hasunuma [6] from in situ observations. The STCC is strong in late winter to spring (March–June) with a peak in June, however, it is weak in fall [7]. The STCC is much slower than the KC, and its footprint cannot be clearly observed in the climatology geostrophic flow in July (Figure 1b). Between the main stream of the northward-flowing KC and the eastward-flowing STCC, the Kuroshio recirculation (KR; Figure 1a) generally occurs east of the Taiwan Island during the interaction between the KC and the mesoscale eddies that propagate from the east [4,8–12]. Based on computer simulations, Chu et al. [4] concluded that the STCC originates from the east of the Luzon Strait at approximately 122.5°E on the