Supplementary Materials for:

Impact of the Kuroshio intrusion on the upper ocean nutrient inventory in the northern South China Sea: Insights from an isopycnal mixing model

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1 End-member sensitivity analysis

In order to quantify the error associated with different end-member values, two South China Sea (SCS) end-members (SCS1 with data collected from SEATS and its nearby stations in summer and SCS2 with data collected from SEATS and its nearby stations in winter) and three Kuroshio end-members (S4 with data collected from stations near the Luzon Strait in winter, Kuroshio with data collected from LU6 section in spring and western North Pacific (wNP) with data collected from The World Ocean Circulation Experiment (WOCE) data centre, Pacific PR20 section were selected to create four end-member combinations (SCS1-S4, SCS1-Kuroshio, SCS1-wNP and SCS2-Kuroshio; Fig. S1A). These combinations were applied to calculate the N_M of the same water parcels in the central northern SCS (NSCS) (equations 1 and 2 of the main text). As shown in Fig. S1B, differences of N_M for N+N ranging from 0-1 μmol L^{-1} among various end-member combinations were observed in the upper 100 m. By fixing the "SCS1" as the SCS end-member, the average uncertainties for N_M induced by changing Kuroshio end-members were -0.22±0.38, -0.002±0.030 and -0.28±0.59 μmol L^{-1} for N+N, SRP and $Si(OH)_4$, respectively. In contrast, given the fixed Kuroshio end-member, the uncertainties for the N_M estimation induced by changing SCS end-members were -0.09±0.28, 0.026±0.015 and 0.48±0.30 μmol L^{-1} for N+N, SRP and $Si(OH)_4$, respectively. Judging the end-member representation and the locations of the end-member, the SCS1-Kuroshio combination was selected for our model calculation.

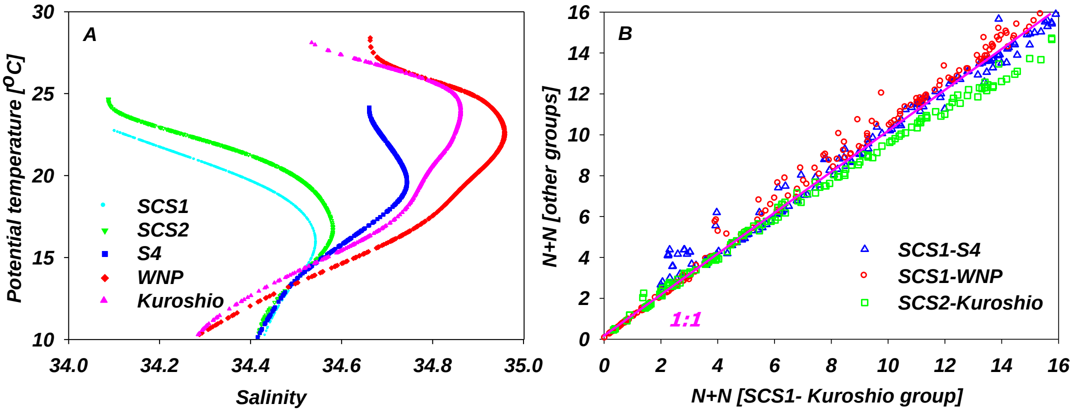

Figure S1. (A) Potential temperature versus salinity of the selected SCS and Kuroshio end-members for N_M sensitivity analysis; (B) The isopycnal mixing model predicted N+N (nitrate plus nitrite) concentrations resulting from various combinations of end-member values versus those derived using "SCS1" and "Kuroshio" as the end-members. The N+N concentration data of the wNP end-member are from the WOCE data centre, Pacific PR20 section (October 1990 and June 1991; http://cchdo.ucsd.edu/).

2 Error propagation for model-predicted nutrients

Considering errors for each term used in our model calculation, the final error derived from the isopycnal approximation for nutrients (N_M) can be estimated according to:

$$X_N = (N_K - N_S) \times X_{RK} + R_K \times X_{NK} + (1 - R_K) \times X_{NS} \quad \text{(S1)}$$

$$S_N = \sqrt{(N_K - N_S)^2 \times (S_{RK})^2 + (R_K \times S_{NK})^2 + ((1 - R_K) \times S_{NS})^2} \quad \text{(S2)}$$

Here, X_N denotes the system error after the error propagation for N_m, and S_N denotes the random error which results from the propagation of errors' standard deviation for N_m. The final error for N_m can thus be illustrated as $X_N \pm S_N$. X_{RK} and S_{RK} denote the system and random errors of the Kuroshio water fraction (R_K) evaluated from the Ca^{2+}

data. X_{NK} and S_{NK} indicate the system and random errors of the end-member concentrations of nutrients in the Kuroshio water, while X_{NS} and the S_{NS} represent those in the SCS proper water. As shown in Fig. S2, both X_N and S_N generally increased with increasing potential density but behaved differently with the R_K: the larger R_K values usually show less system error but tend to show larger random error. In the upper 100 m of the central NSCS, the final errors derived from the isopycnal mixing model were on average -0.16±0.65 μmol L^{-1} for N+N, 0.1±0.73 μmol L^{-1} for $Si(OH)_4$ and -0.002±0.043 μmol L^{-1} for SRP (Fig. S2).

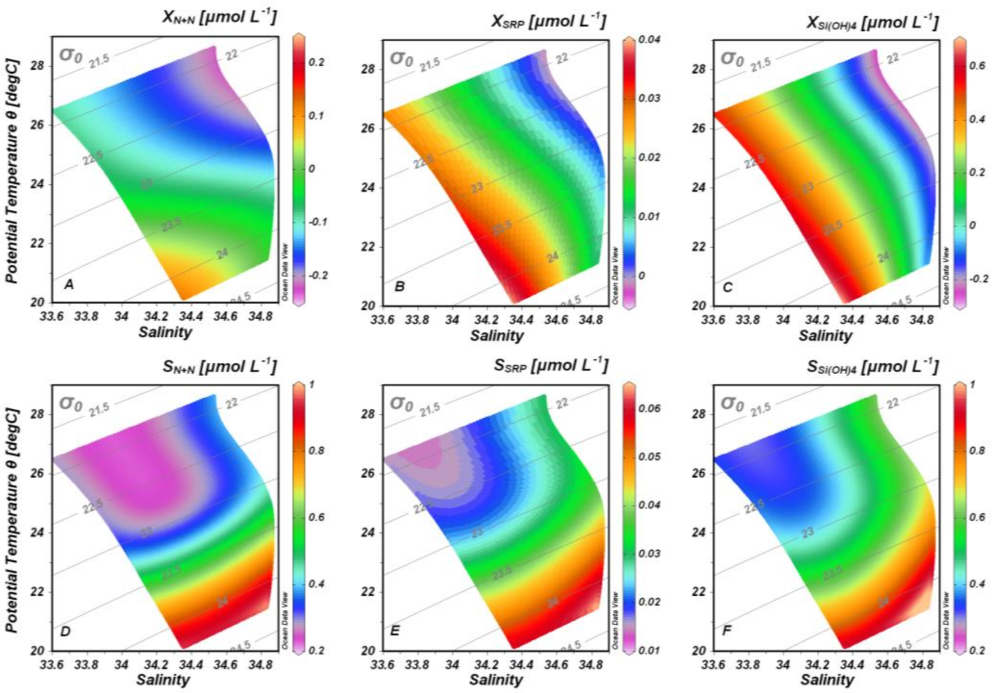

Figure S2. The system error of the model prediction for (A) N+N (nitrate plus nitrite), X_{N+N}, (B) SRP (soluble reactive phosphate), X_{SRP} and (C) $Si(OH)_4$ (silicic acid), $X_{Si(OH)4}$ in the upper 100 m of the central NSCS. Also shown are the corresponding random errors for (D) N+N, S_{N+N}, (E) SRP, S_{SRP} and (F) $Si(OH)_4$, $S_{Si(OH)4}$.