

Supplementary Materials for:

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

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1 Endmember sensitivity analysis

In order to quantify the error associated with different endmember values, two South China Sea (SCS) endmembers (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 endmembers (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 endmember combinations (SCS1-S4, SCS1-Kuroshio, SCS1-wNP and SCS2-Kuroshio; Fig. S1A). These combinations were applied to calculate the R_K and N_m of the same water parcels in the central northern SCS (NSCS). As shown in Fig. S1B, differences in N_m for N+N ranging from 0-1 $\mu\text{mol L}^{-1}$ among various endmember combinations were observed in the upper 100 m. By fixing the “SCS1” as the SCS endmember, the average uncertainties for N_m induced by changing Kuroshio endmembers were -0.22 ± 0.38 , -0.002 ± 0.030 and $-0.28 \pm 0.59 \mu\text{mol L}^{-1}$ for N+N, SRP and $\text{Si}(\text{OH})_4$, respectively. In contrast, given the fixed Kuroshio endmember, the uncertainties for the N_m estimation induced by changing SCS endmembers were -0.09 ± 0.28 , 0.026 ± 0.015 and $0.48 \pm 0.30 \mu\text{mol L}^{-1}$ for N+N, SRP and $\text{Si}(\text{OH})_4$, respectively. By judging the endmember representation and the locations of the endmember, the SCS1-Kuroshio combination was selected for our model calculation.

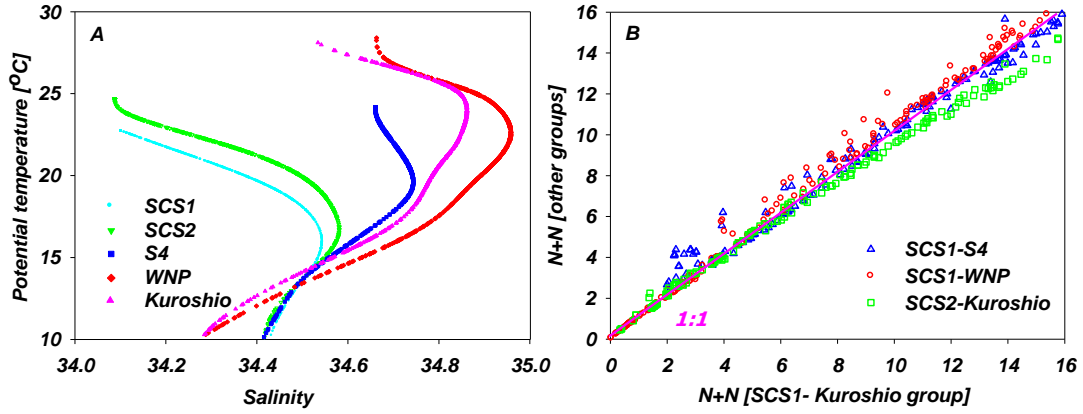


Figure S1. (A) Potential temperature versus salinity of the selected SCS and Kuroshio endmembers for N_m sensitivity analysis; (B) Isopycnal mixing model predicted N+N (nitrate plus nitrite) concentrations resulting from various combinations of endmember values versus those derived from using “SCS1” and “Kuroshio” as the endmembers. The N+N concentration data of the wNP endmember were collected at the Pacific PR20 section in October 1990 and June 1991 (WOCE (The World Ocean Circulation Experiment) Data Centre, <http://cchdo.ucsd.edu/>).

2 Error propagation for model-predicted nutrients

Considering all of the errors sources in our model prediction, the final error associated with the isopycnal approximation for nutrients (N_m) can be estimated according to:

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

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

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 (see main text for details). X_{NK} and S_{NK} indicate the system and random errors of the endmember nutrient concentrations 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 usually showed less system error but tended to show larger random error. In the upper 100 m of the central NSCS, the final errors associated with the isopycnal mixing model were on average $-0.16 \pm 0.65 \mu\text{mol L}^{-1}$ for N+N, $0.1 \pm 0.73 \mu\text{mol L}^{-1}$ for $\text{Si}(\text{OH})_4$ and $-0.002 \pm 0.043 \mu\text{mol L}^{-1}$ for SRP (Fig. S2).

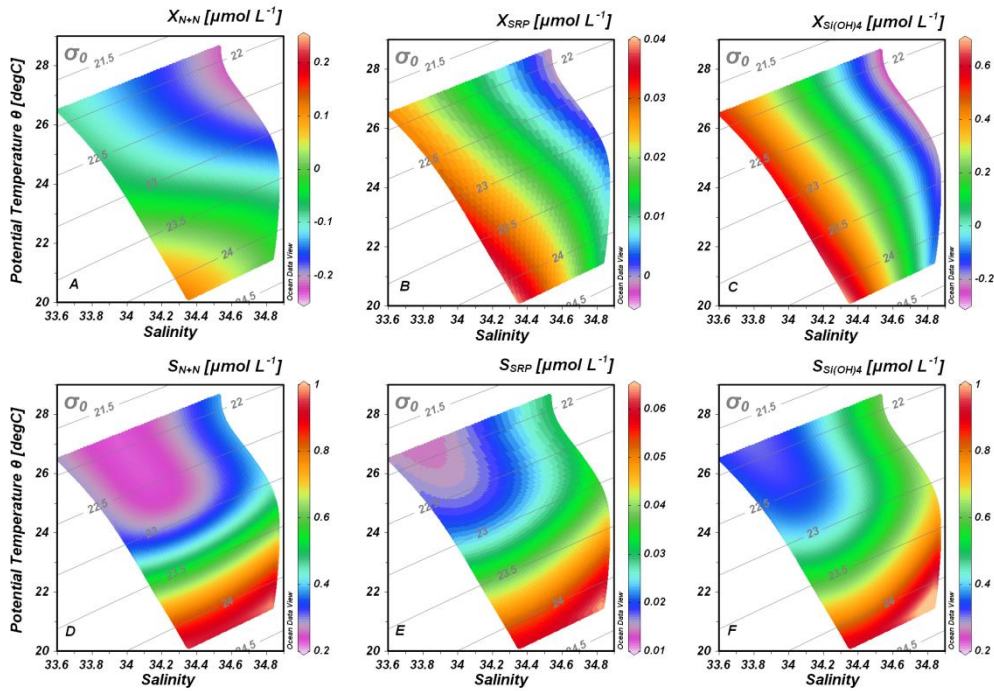


Figure S2. The system errors of the model prediction for (A) N+N (nitrate plus nitrite), X_{N+N} , (B) SRP (soluble reactive phosphate), X_{SRP} and (C) $\text{Si}(\text{OH})_4$ (silicic acid), $X_{\text{Si}(\text{OH})_4}$ in the upper 100 m of the central NSCS. Also shown are the corresponding random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