

Supplementary Material

Surface ocean biogeochemistry and deep ocean circulation control relationships between nutrient-type trace metals (Cd, Ni, Cu, and Zn) and nutrients in the South Atlantic Ocean near the subtropical front

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Table S1. Average blanks, associated with the leach and leach-digestion of filters, and instrumental limit of detection (LOD) compiled from 7 days analysis. Blank data includes any contribution from the filter, reagents, and ICP-MS instrument background. All values in $\mu\text{g/L}$.

	Leach \pm 1SD ($n=20$)	Leach-Digestion \pm 1SD ($n=19$)	Instrumental LOD*
Al	1.78 ± 0.48	3.05 ± 1.21	0.36
Cd	0.004 ± 0.002	0.002 ± 0.001	0.002
Cu	0.06 ± 0.02	0.11 ± 0.03	0.02
P	15.0 ± 2.8	22.7 ± 5.7	12.1
Ni	0.06 ± 0.02	0.32 ± 0.18	0.02
Zn	0.93 ± 0.32	0.95 ± 0.29	0.08

* Calculated from 3 x SD of the calibration blank.

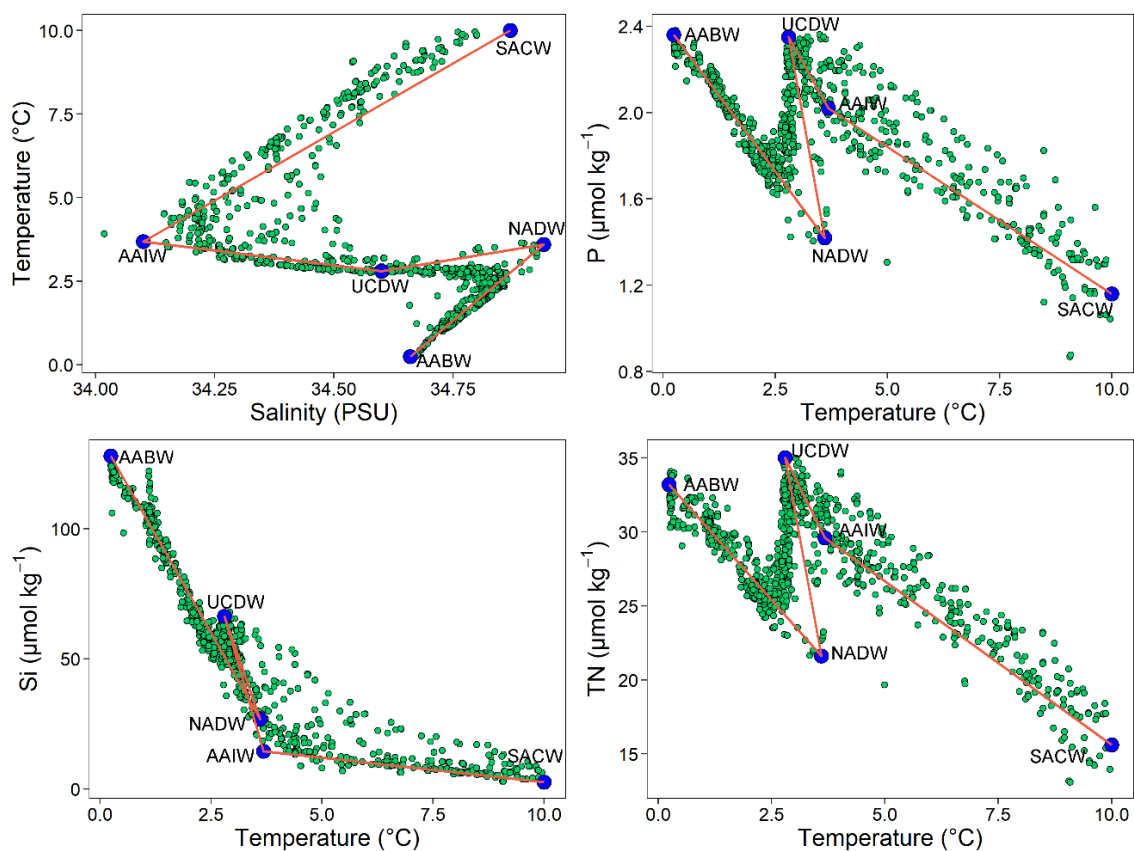


Figure S1. Property-property plots of water masses defined along the GA10 transect (South Atlantic Central Water [SACW], Antarctic Intermediate Water [AAIW], Upper Circumpolar Deep Water [UCDW], North Atlantic Deep Water [NADW], and Antarctic Bottom Water [AABW]).

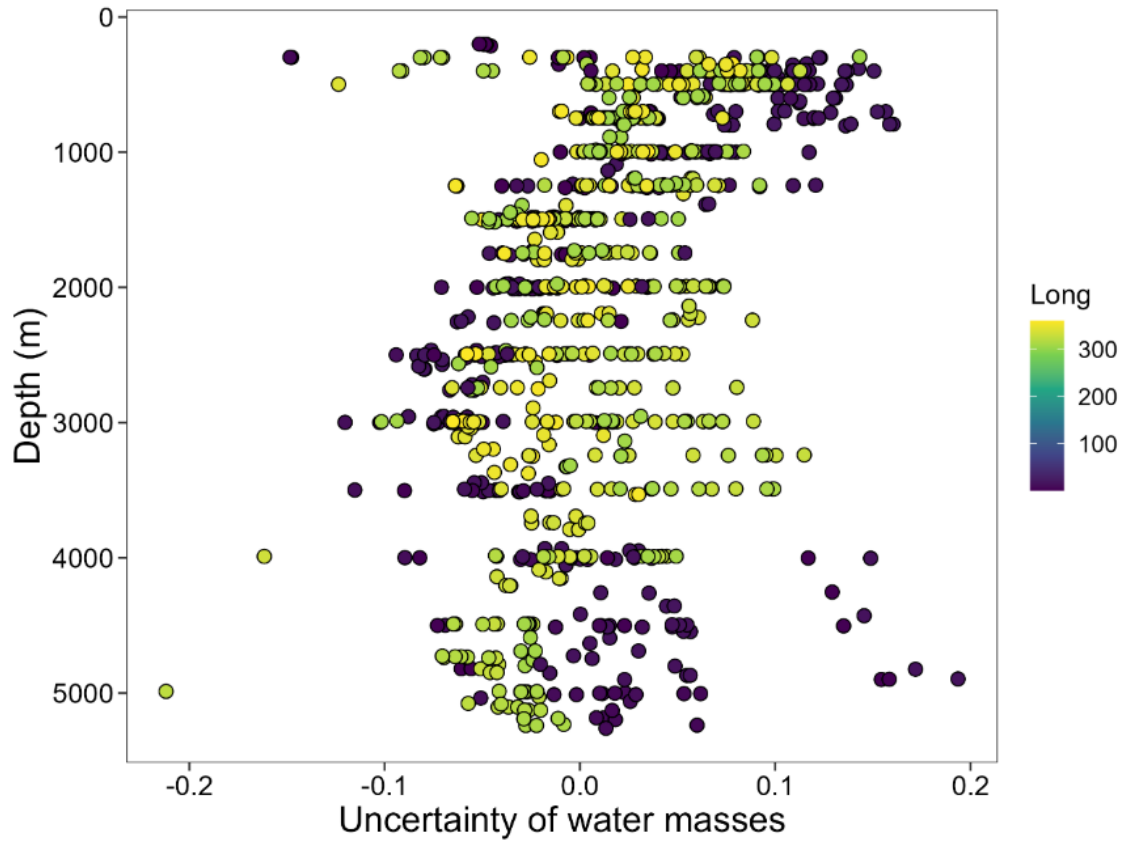


Figure S2. Uncertainties of water mass contribution from the OMP analyses. The uncertainties were calculated by summing residuals of each parameter scaled by its weighting, using methods as per (Evans et al., 2020). The colors indicate longitudes of the samples.

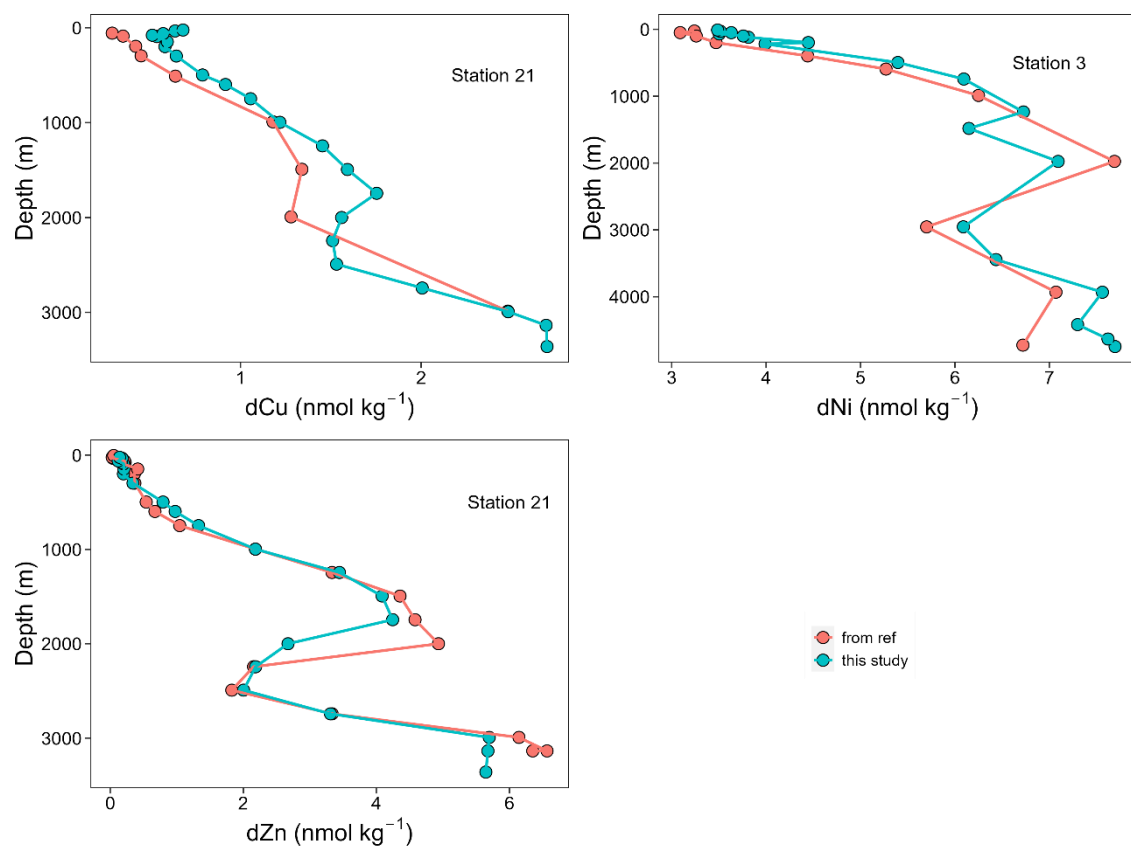


Figure S3. Comparisons in dissolved Cu (dCu), Ni (dNi), and Zn (dZn) concentrations between this study and reported values for samples collected on the same cruises. Blue dots: this study; red dots: reported values (dCu, (Little et al., 2018); dNi, (Archer et al., 2020); dZn, (Wyatt et al., 2014)).

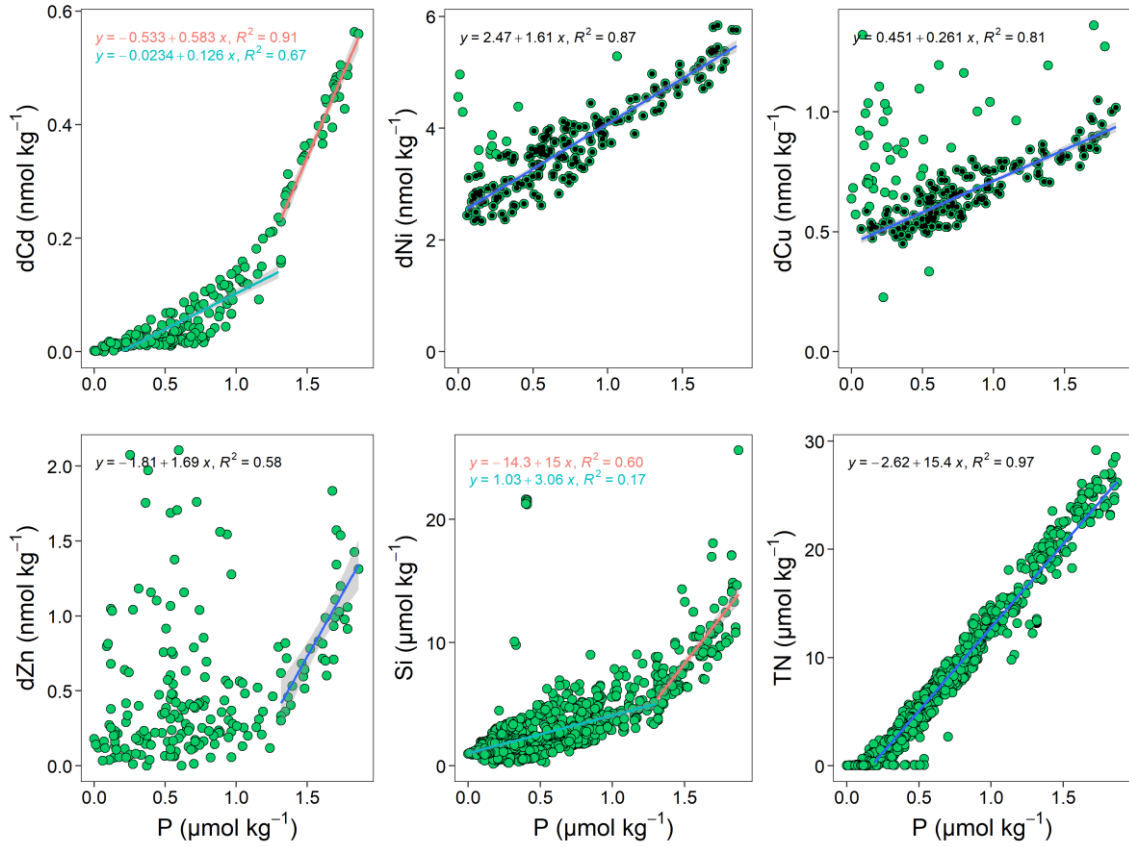


Figure S4. Correlations between phosphate (P) and dissolved trace metals (dCd, dCu, dNi, and dZn) and nutrients (silicic acid [Si] and nitrate+nitrite [TN]) for depth < 500 m along the GA10 transect in the South Atlantic Ocean. Linear regression models were applied to $P > 1.3 \mu\text{M}$ and $P < 1.3 \mu\text{M}$, respectively for the dCd-P and Si-P correlations. The linear equations of dCu-P and dNi-P relationships are calculated using the data points with black dots inside.

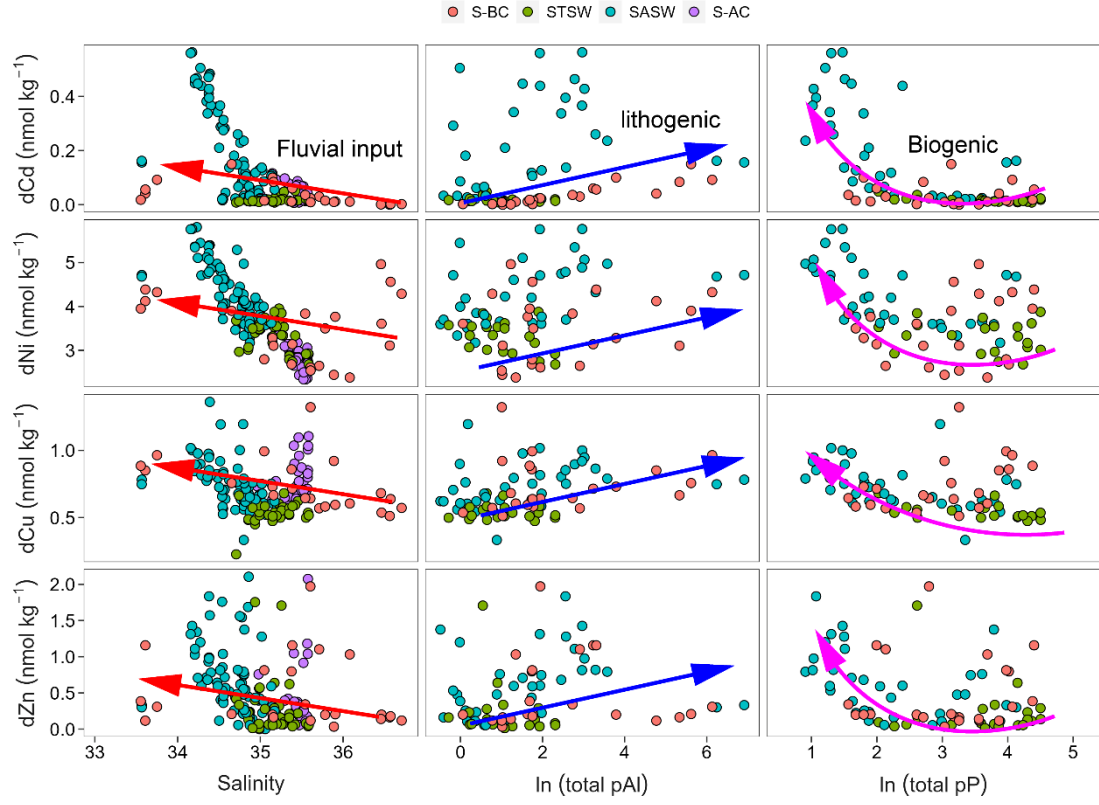


Figure S5 Correlations between dissolved trace metals (dCd, dCu, dNi, and dZn), and salinity, ln (total pAl), and ln (total pP) in the upper 500 m. STSW: water influenced by Subtropical Surface Water [STSW]; SASW: Sub-Antarctic Surface Water [SASW]; S-AC: STSW influenced by the Agulhas current [AC]; S-BC: STSW influenced by the Brazil current [BC]. Arrows with annotations indicate potential contributions of fluvial input, lithogenic particles, and biogenic particles.

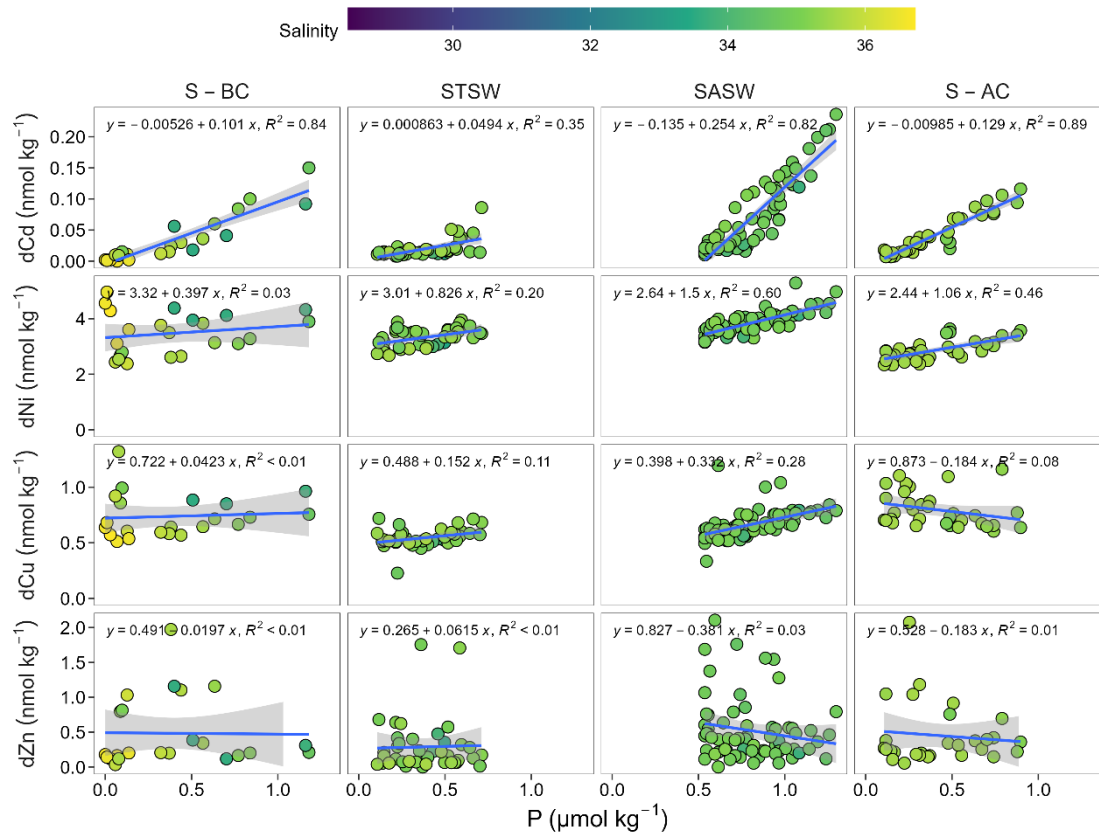


Figure S6. Correlations between dissolved trace metals (dCd, dCu, dNi, and dZn) and phosphate (P) in the upper 500 m waters with $P < 1.3 \mu\text{M}$. For abbreviations of water masses see Figure S5.

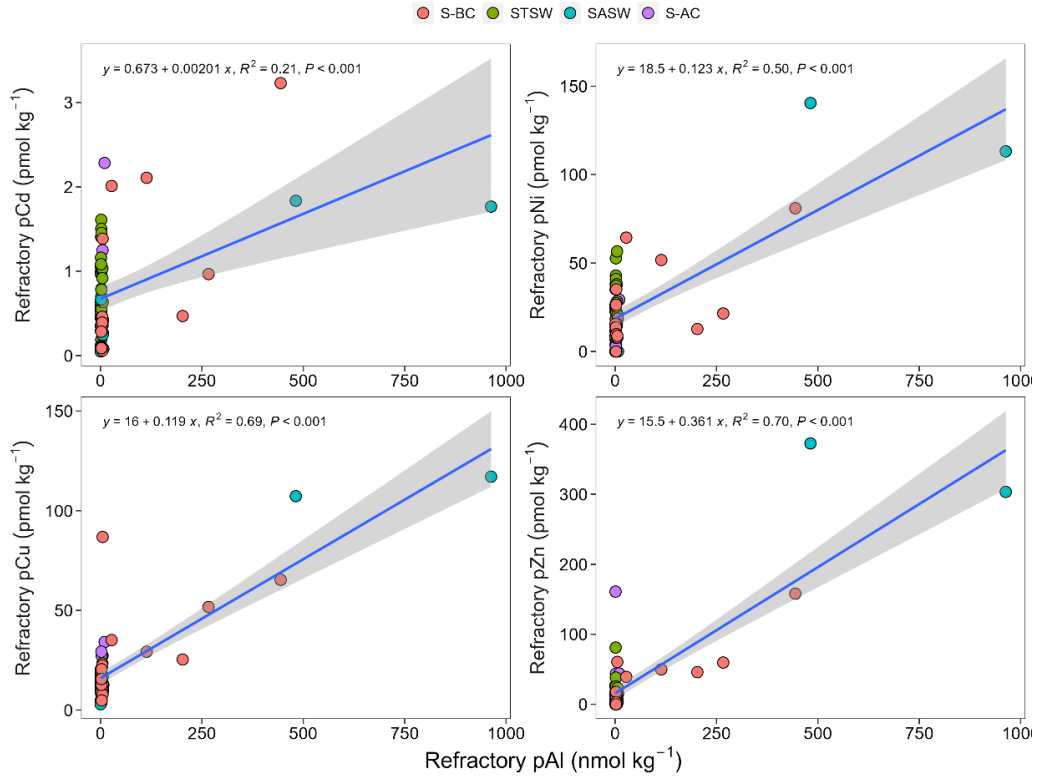


Figure S7. Correlations between refractory particulate Cd (RpCd), Ni (RpNi), Cu (RpCu), Zn (RpZn) and Al (RpAl) in the upper 200 m water. For abbreviations of water masses see Figure S5.

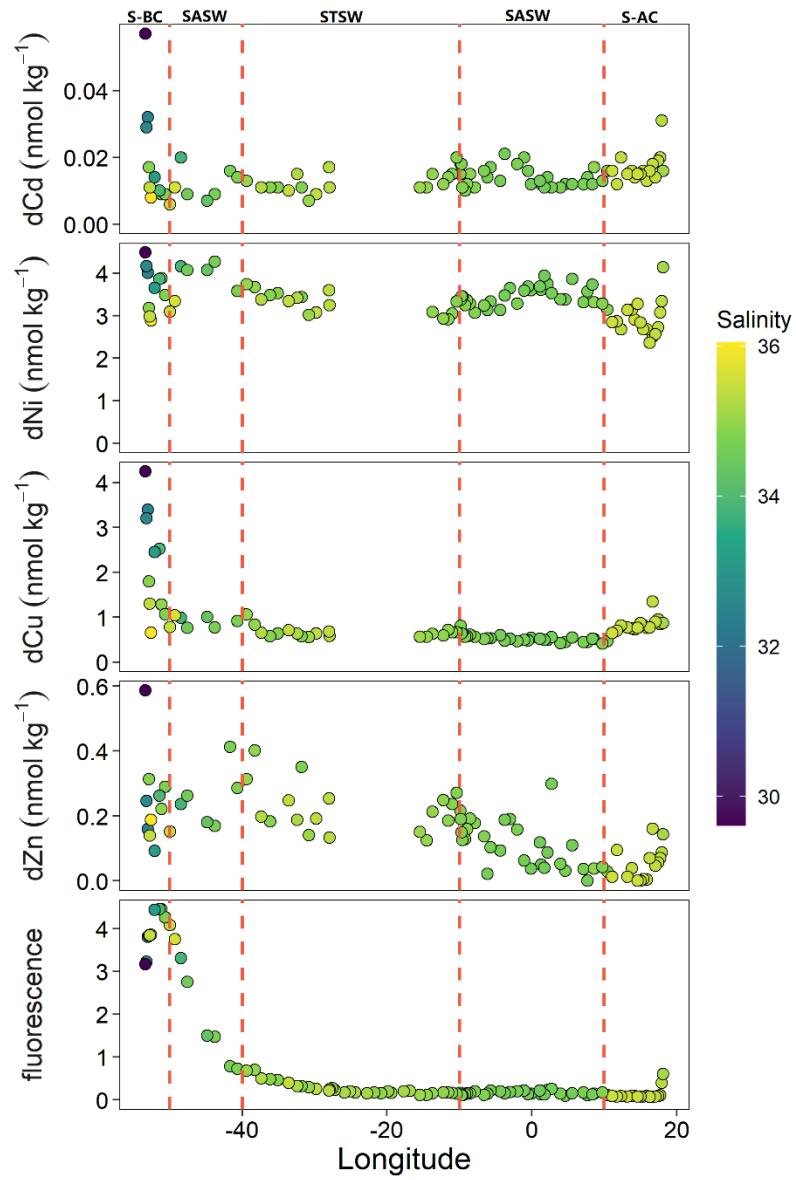


Figure S8. Distributions of dissolved Cd, Cu, Ni, and Zn, and fluorescence along the GA10 transect that collected from a towed “fish” that deployed at 2 – 3 m. For abbreviations of water masses see Figure S5.

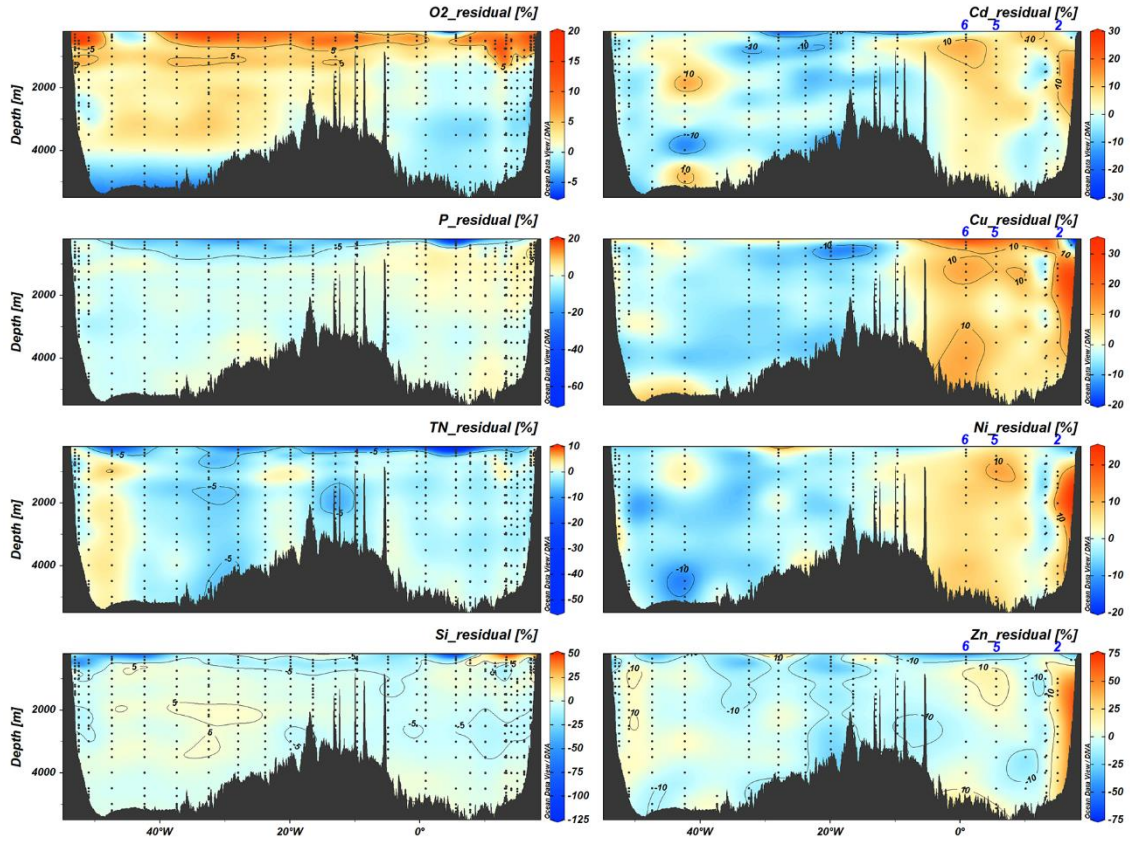


Figure S9. Relative residuals ((measured – reconstructed)/measured × 100%) of oxygen (O_2), nutrients (phosphate [P], nitrate+nitrite [TN], and silicic acid [Si]), and dissolved trace metals (Cd, Cu, Ni, and Zn) along transect GA10. Stations #2, #5, and #6 with positive residuals of dTMs are labeled in blue.

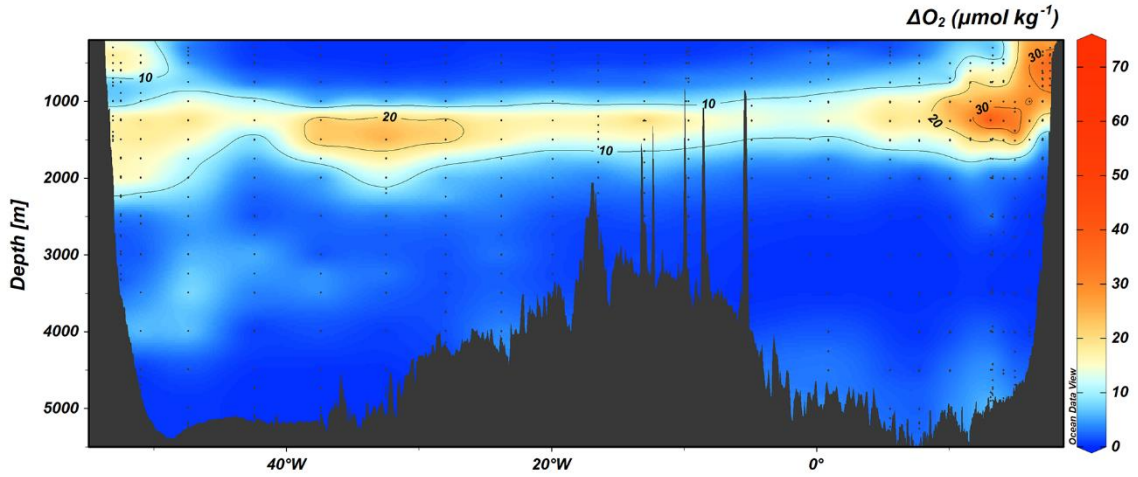


Figure S10. O_2 deficit (ΔO_2) calculated from the extended OMP using a Redfield ratio $\Delta P:\Delta N:\Delta Si:\Delta O_2$ of 1:16:40:-170. Contours show ΔO_2 of 10, 20, and 30 $\mu\text{mol kg}^{-1}$, respectively.

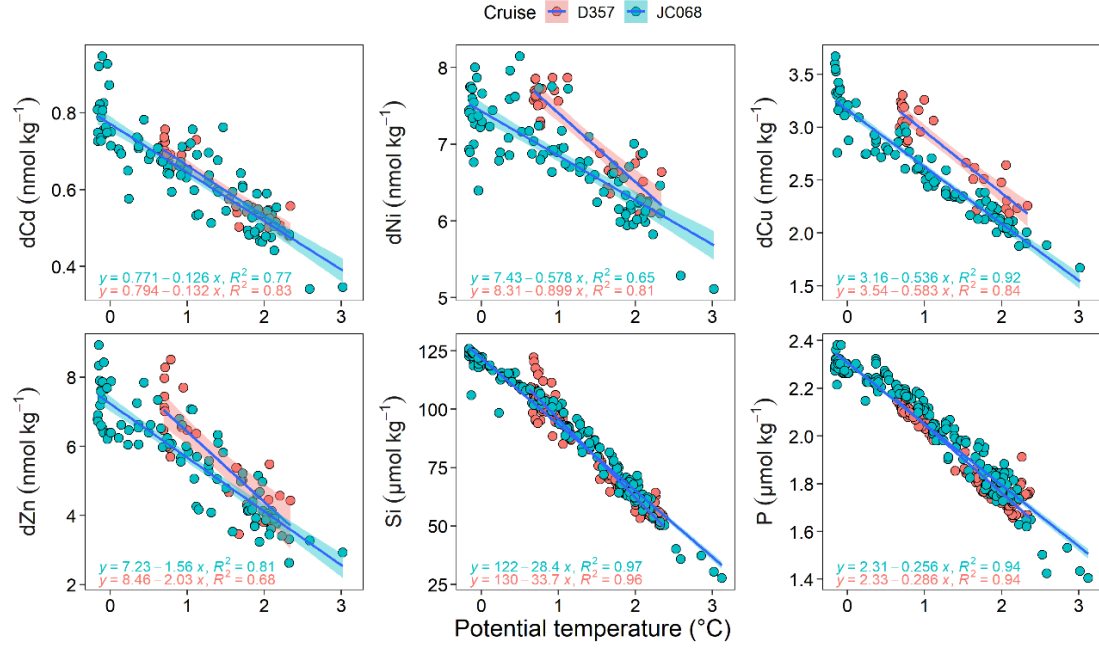


Figure S11. Correlations between nutrients (phosphate [P] and silicic acid [Si]) and dissolved trace metals (dCd, dCu, dNi, dZn) and potential temperature in deep waters (depth > 2500 m). Linear regression models are separately applied to D357 cruise samples (red) and JC068 samples (blue).

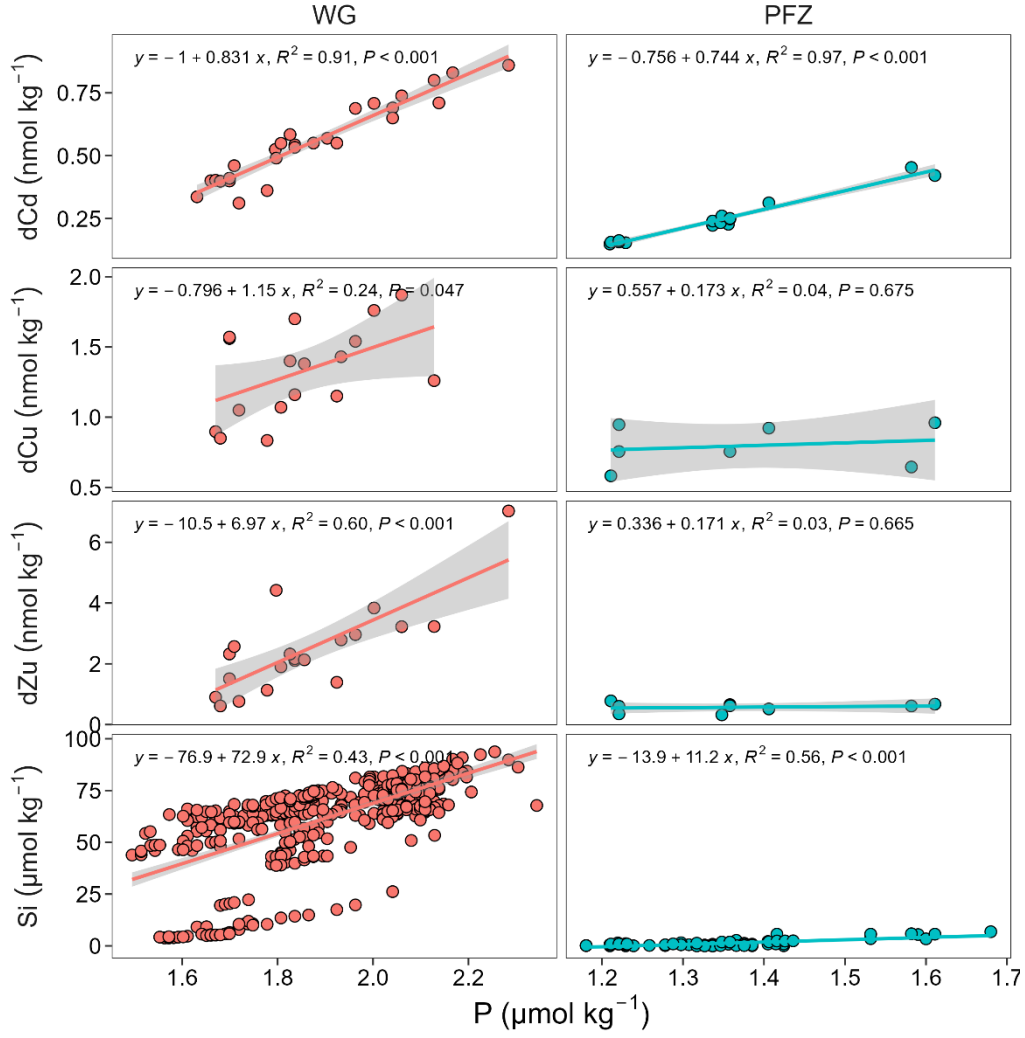


Figure S12. Relationships between dissolved Cd (dCd), Cu (dCu), Ni (dNi), silicic acid (Si) and phosphate (P) in the Weddell Gyre (WG) and Polar Front Zone (PFZ) of the Southern Ocean. Data from (Cloete et al., 2019; Croot et al., 2011; GEOTRACES IDP 2021).

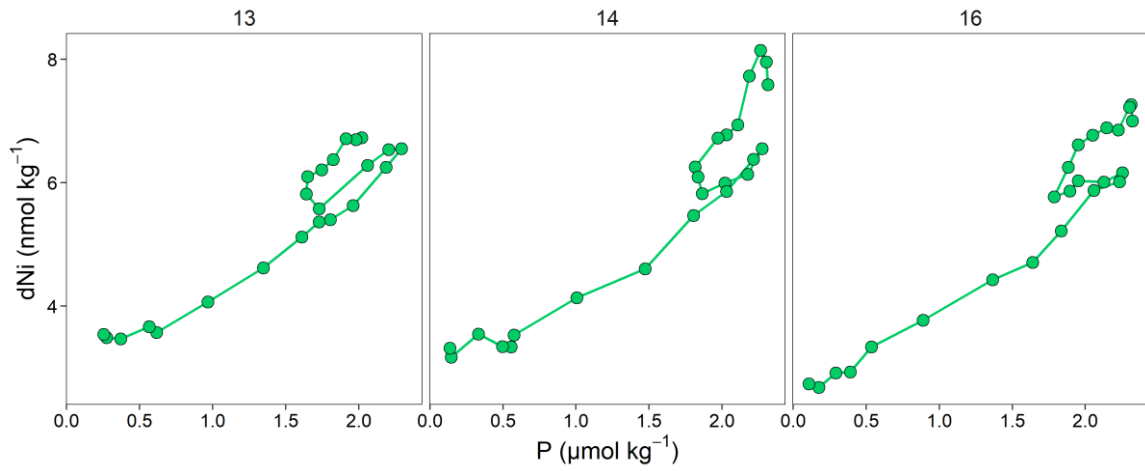


Figure S13. Relationships between dissolved nickel (dNi) and phosphate (P) at stations 13, 14, and 16. The data points are connected by the depth sequence of sampling.

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