

Supplementary Material to
Silicon stable isotope distribution traces Southern Ocean export of Si to the eastern South Pacific thermocline

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A. Monte Carlo t -test

A Monte Carlo method was adopted to compare deepwater $\delta^{30}\text{Si}$ values in the South Pacific, since variability is small compared to the analytical uncertainty of the data. All $\delta^{30}\text{Si}$ datapoints from two datasets being compared were perturbed 10^4 times by a normally-distributed random variable with a variance corresponding to the analytical uncertainty of the datapoints. After each perturbation, a two-sided unequal variance t -test (Welch's t -test) was performed on these dataset pairs and the p -value corresponding to the test statistic recorded. The probabilities reported in the main text refer to the relative proportion of p -values that were smaller than $\alpha = 0.05$.

B. Mixing calculations: endmember contribution

A simple mixing calculation was used to determine the proportion of Si in the high-latitude winter mixed layer (WML) contributed by the late summer surface waters. As Fig. 6 of the manuscript shows, the WML can be considered to be a mixture of the late summer surface and the deeper water column. Mathematically, this mass balance can be described by

$$\delta^{30}Si_{WML} = \delta^{30}Si_{SS} \cdot X_{SS} + \delta^{30}Si_{deep} \cdot (1 - X_{SS})$$

where WML refers to the winter mixed layer, SS to the late summer surface and $deep$ to the water column immediately below the WML, and X_{SS} is the proportion of Si in the WML provided by the late summer surface waters. This equation can be solved for X_{SS} :

$$X_{SS} = \frac{\delta^{30}Si_{WML} - \delta^{30}Si_{deep}}{\delta^{30}Si_{SS} - \delta^{30}Si_{deep}}$$

SUPPLEMENTARY FIGURES

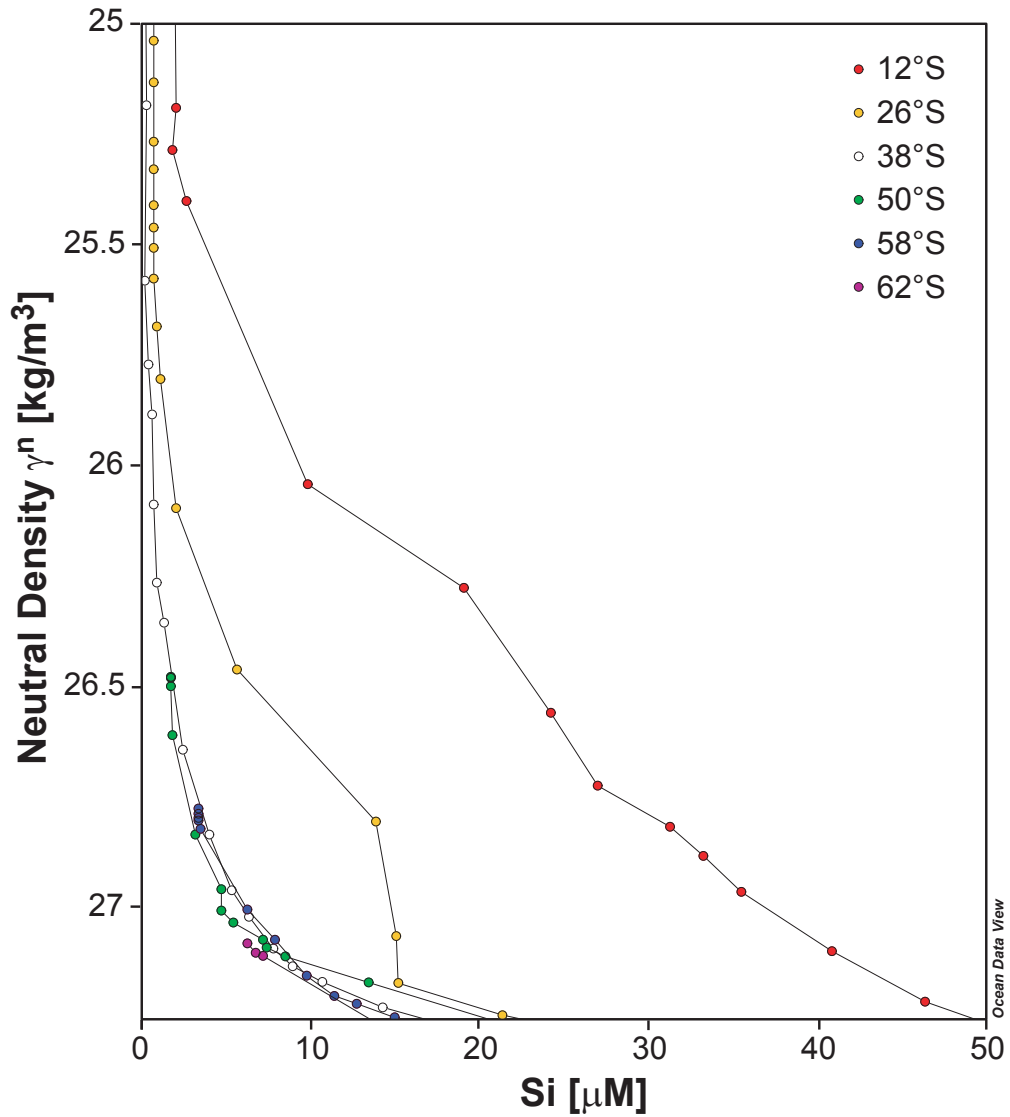


Figure S1: Silicon concentrations at thermocline to intermediate depths, plotted against neutral density γ^n . This is a more detailed view of concentration data presented in Fig. 5b of the manuscript, highlighting the constancy of [Si] along isopycnals in the eastern South Pacific. The elevated [Si] around $\gamma^n = 26.75 \text{ kg/m}^3$ at 26°S is also apparent. Data are from the CLIVAR & Carbon Hydrographic Data Office (<http://cchdo.ucsd.edu/>).

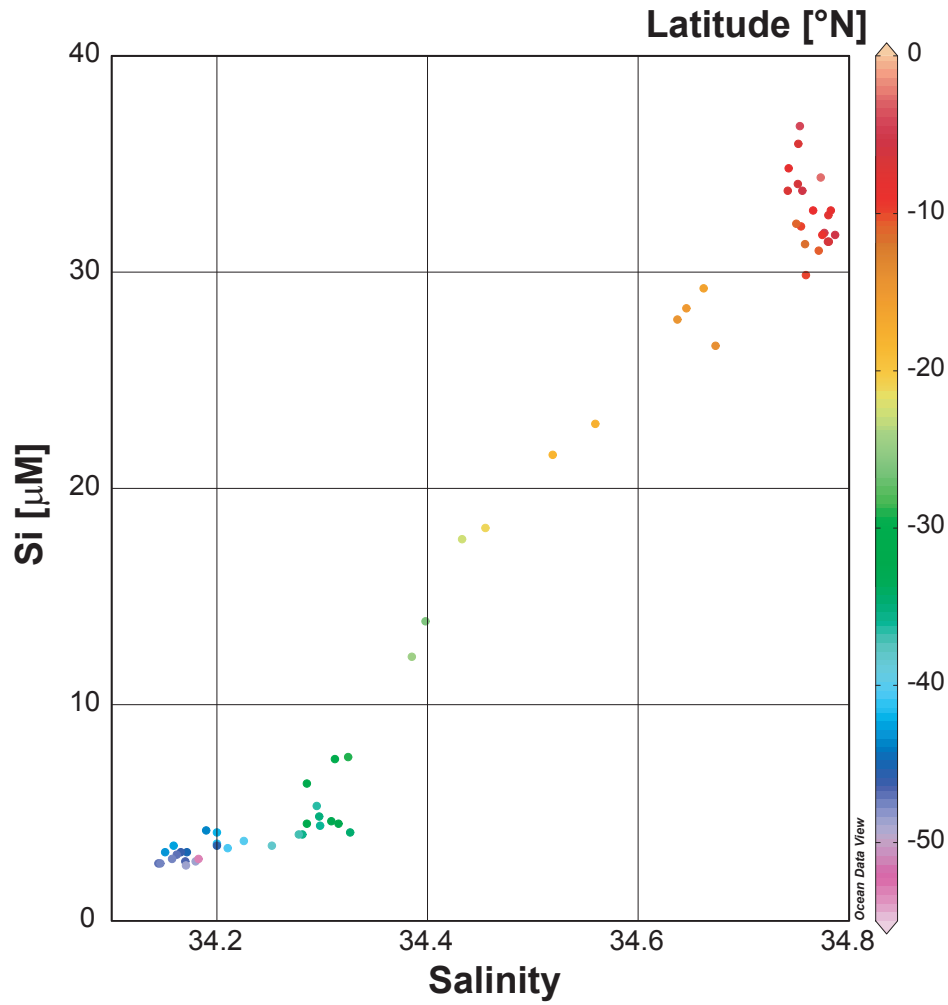


Figure S2: Isopycnal covariation of silicon concentration [Si] and seawater salinity for $26.75 \text{ kg/m}^3 \leq \gamma^n \leq 26.85 \text{ kg/m}^3$ below 100 dbar along line P18. Datapoint color denotes sampling latitude. Note the linear increase in [Si] with salinity centered around $\sim 30^{\circ}\text{S}$, documenting the mixing of saline and Si-rich equatorial waters into the subtropics. Data are from the CLIVAR & Carbon Hydrographic Data Office (<http://cchdo.ucsd.edu/>).

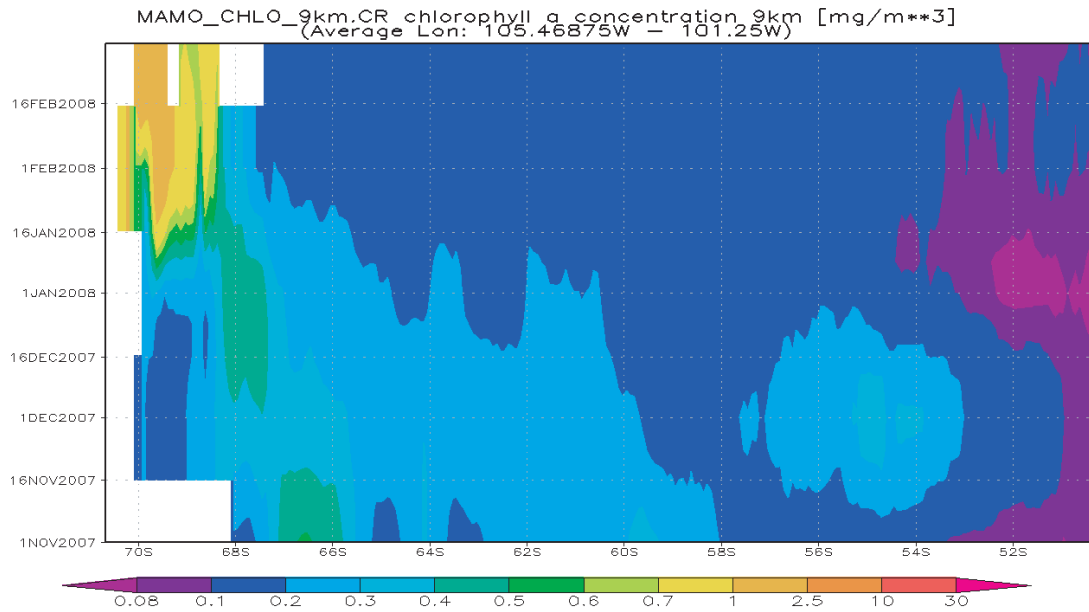


Figure S3: Hovmöller (latitude–time) plot of chlorophyll *a* concentrations (mg/m³; colorbar) in the Subantarctic and Antarctic Zones at ~103°W, from November 2007 to February 2008. The expedition 33RO20071215 of R/V *Ronald H. Brown* reached these high southern latitudes in February 2008. From satellite data (MODIS Aqua), accessed using the Giovanni online data system (<http://reason.gsfc.nasa.gov/Giovanni>), developed and maintained by the NASA Goddard Earth Sciences (GES) Data and Information Services Center (DISC).

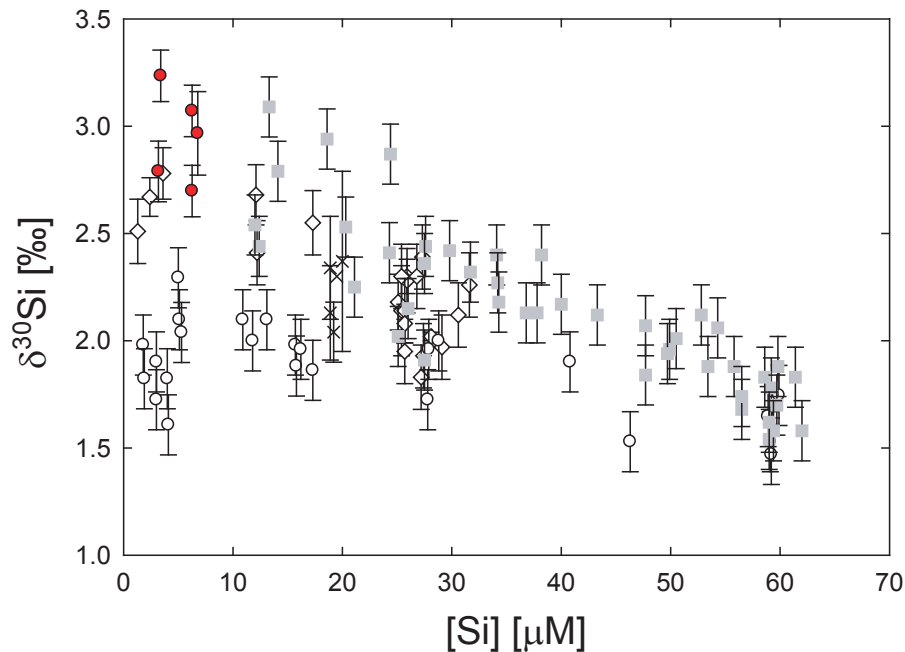


Figure S4: A comparison of surface Southern Ocean $\delta^{30}\text{Si}$ data from 62°S–50°S at 103°W (this study; red circles) with published data (gray squares: *Varela et al.* [2004], open circles: *Cardinal et al.* [2005], crosses: *Cavagna et al.* [2011], open diamonds: *Fripiat et al.* [2011a]). Our data are consistent with the high values seen by most authors; the reason for the comparatively low values observed by *Cardinal et al.* [2005] is not known.

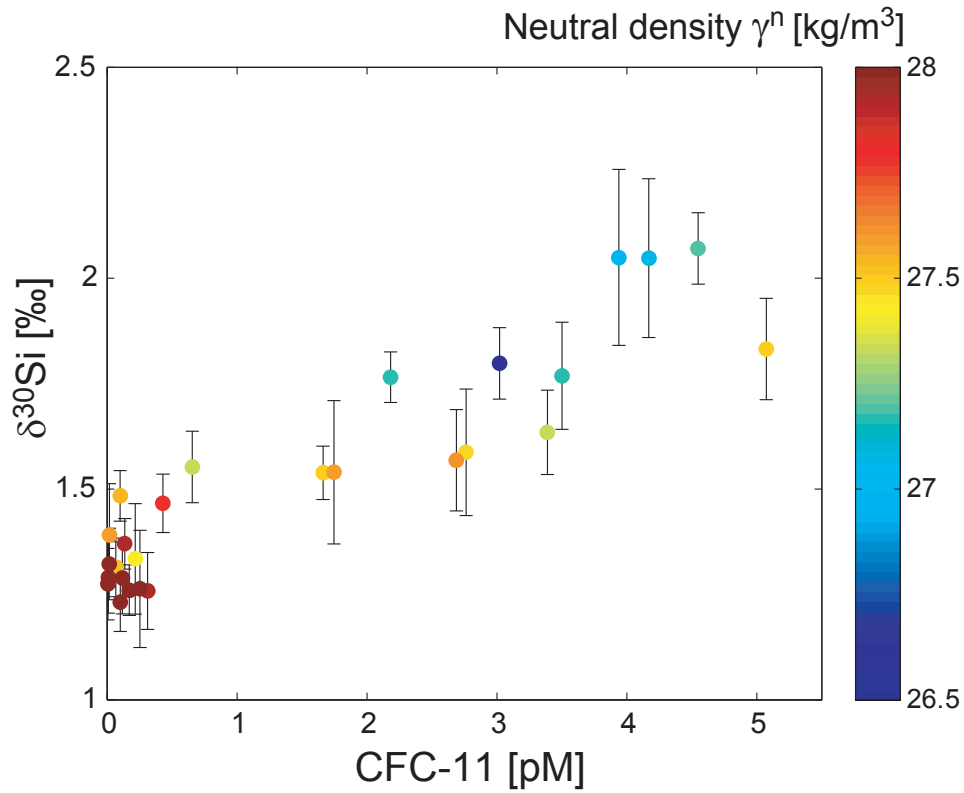


Figure S5: CFC-11 concentrations plotted against $\delta^{30}\text{Si}$ values for samples below the depth of the mixed layer. The poorly-ventilated equatorial Pacific station (12°S) is excluded. Datapoint color corresponds to neutral density. CFC-11 and density data are from the CLIVAR & Carbon Hydrographic Data Office (<http://cchdo.ucsd.edu/>).

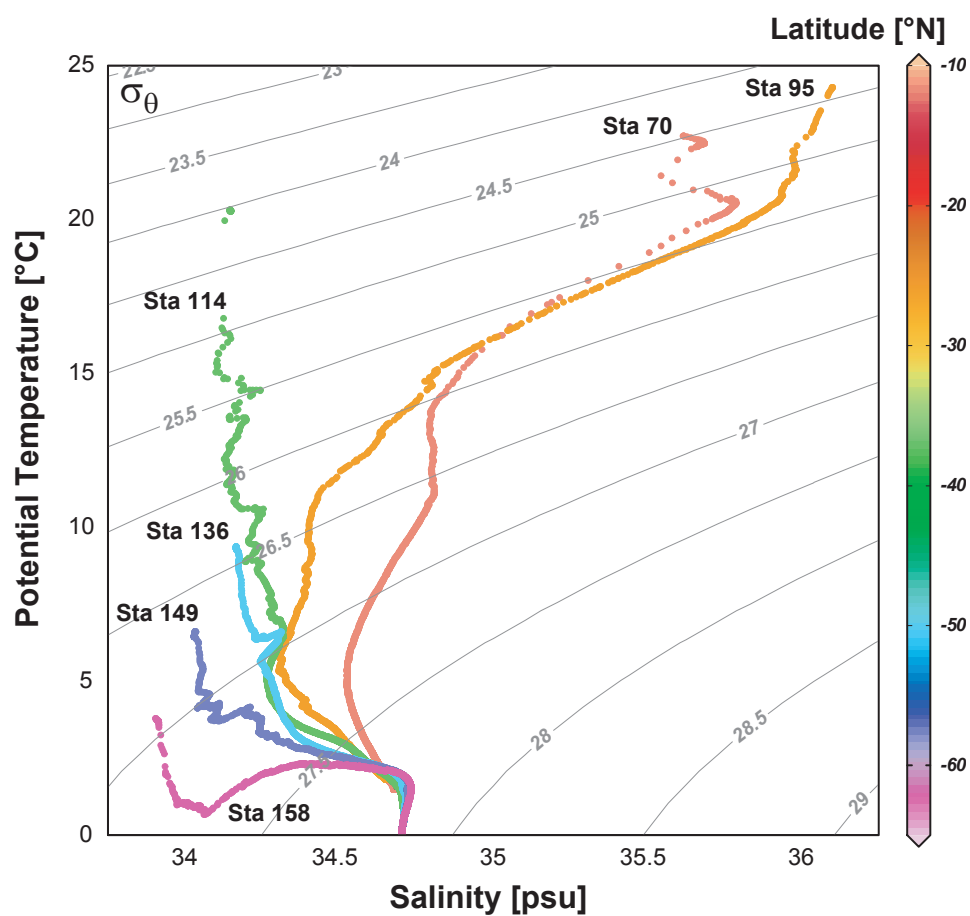


Figure S6: Potential temperature–salinity diagram for 33RO20071215 stations from which samples were analysed for $\delta^{30}\text{Si}$ (see Fig. 1 of the main text for station locations). Data are from the CLIVAR & Carbon Hydrographic Data Office (<http://cchdo.ucsd.edu/>).

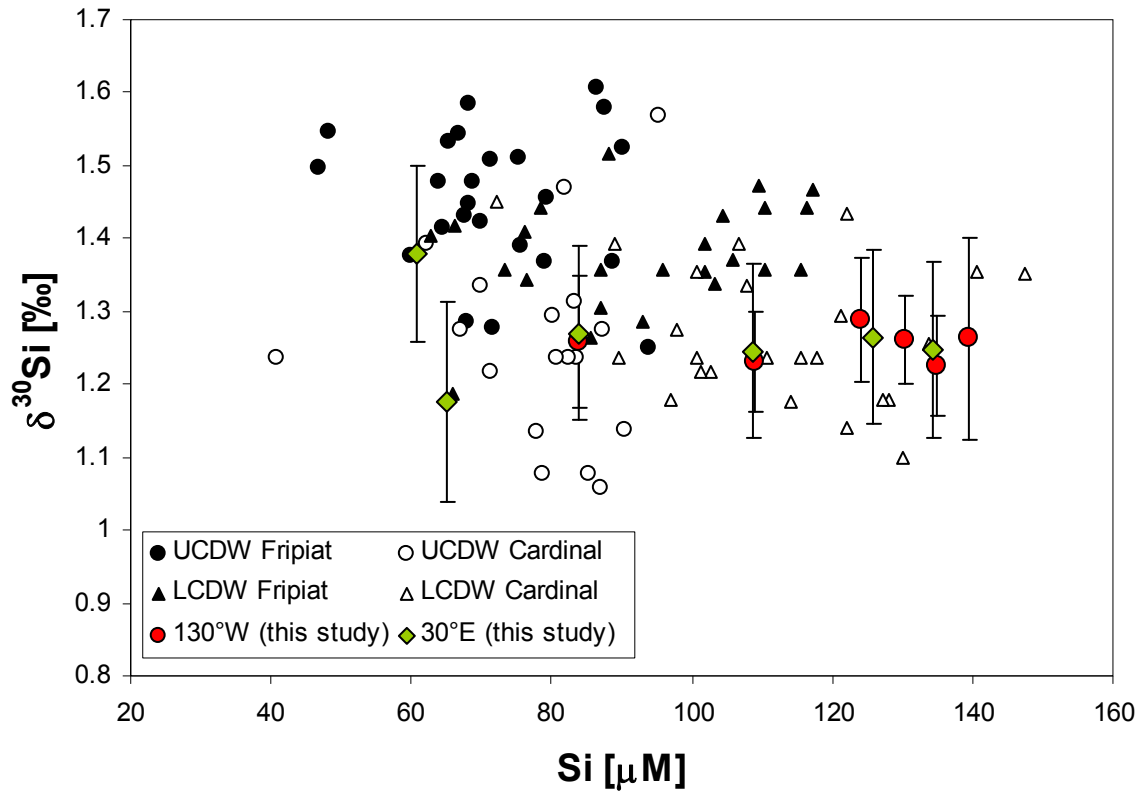


Figure S7: A comparison of deep Southern Ocean $\delta^{30}\text{Si}$ data from this study ($\gamma^n \geq 27.93 \text{ kg/m}^3$) with that from *Fripiat et al.* [2011b] and *Cardinal et al.* [2005] (their data as plotted in Fig. 8b of *Fripiat et al.* [2011b]). Our data show no variability in deep Southern Ocean $\delta^{30}\text{Si}$ values from the Indo-Atlantic to the eastern Pacific sectors, whilst *Fripiat et al.* [2011b] inferred a 0.2‰ decrease in deepwater $\delta^{30}\text{Si}$ values from the Atlantic to the Australian sectors based on their and *Cardinal et al.*'s [2005] data plotted above. Error bars on our data are external $2\sigma_{\text{SEM}}$ or $2\sigma_{\text{SD}}$ as given in Supplementary Table 1. The external reproducibility of *Cardinal et al.*'s [2005] analytical protocol is $\pm 0.14\text{‰}$ ($2\sigma_{\text{SD}}$); errors estimated by *Fripiat et al.* [2011b] from replicate analyses range from $\pm 0.02\text{‰}$ to $\pm 0.68\text{‰}$ ($2\sigma_{\text{SD}}$).

References

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