Supplementary figures

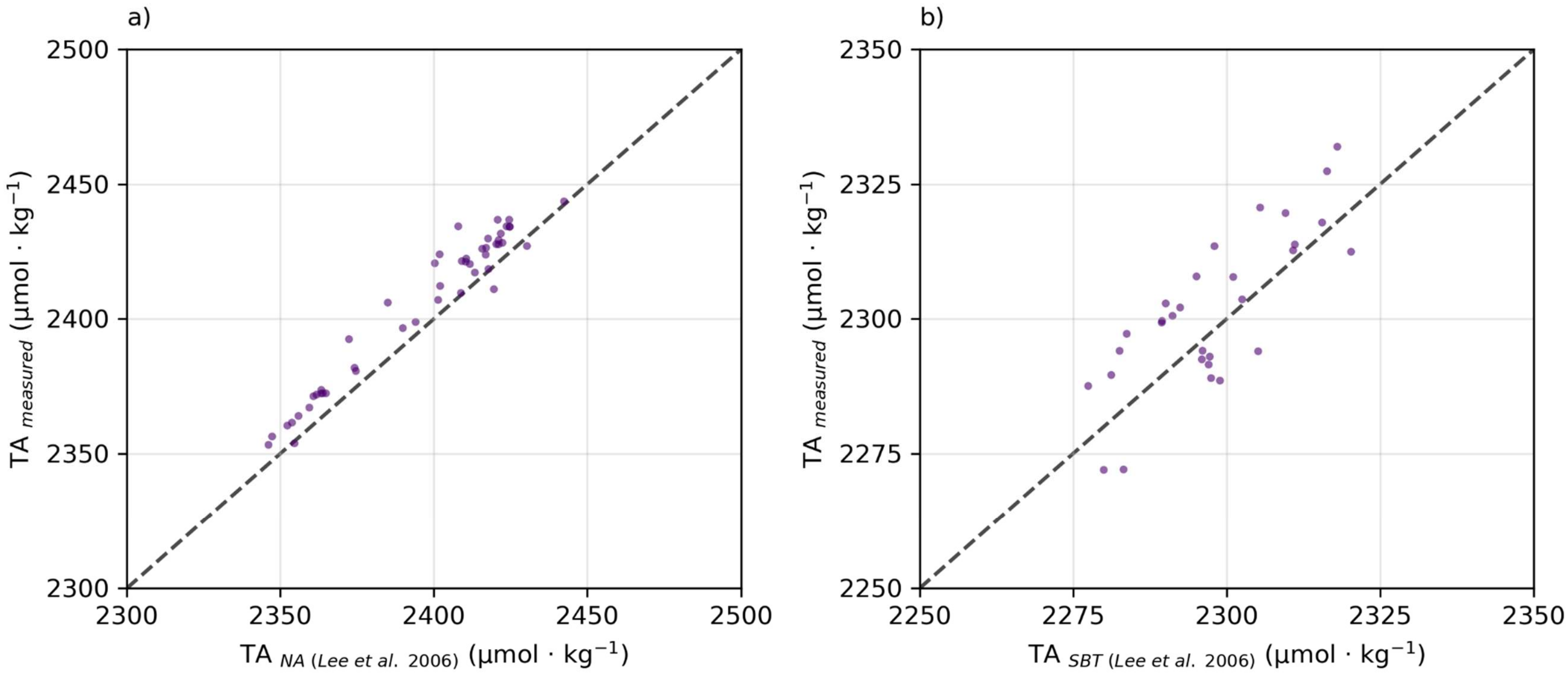

Figure S1. Measured and estimated total alkalinity (TA) using the relationships from Lee et al. (2006) for UWS subsamples for research expeditions a) SO279 (North Atlantic) and b) SO289 (South Pacific).

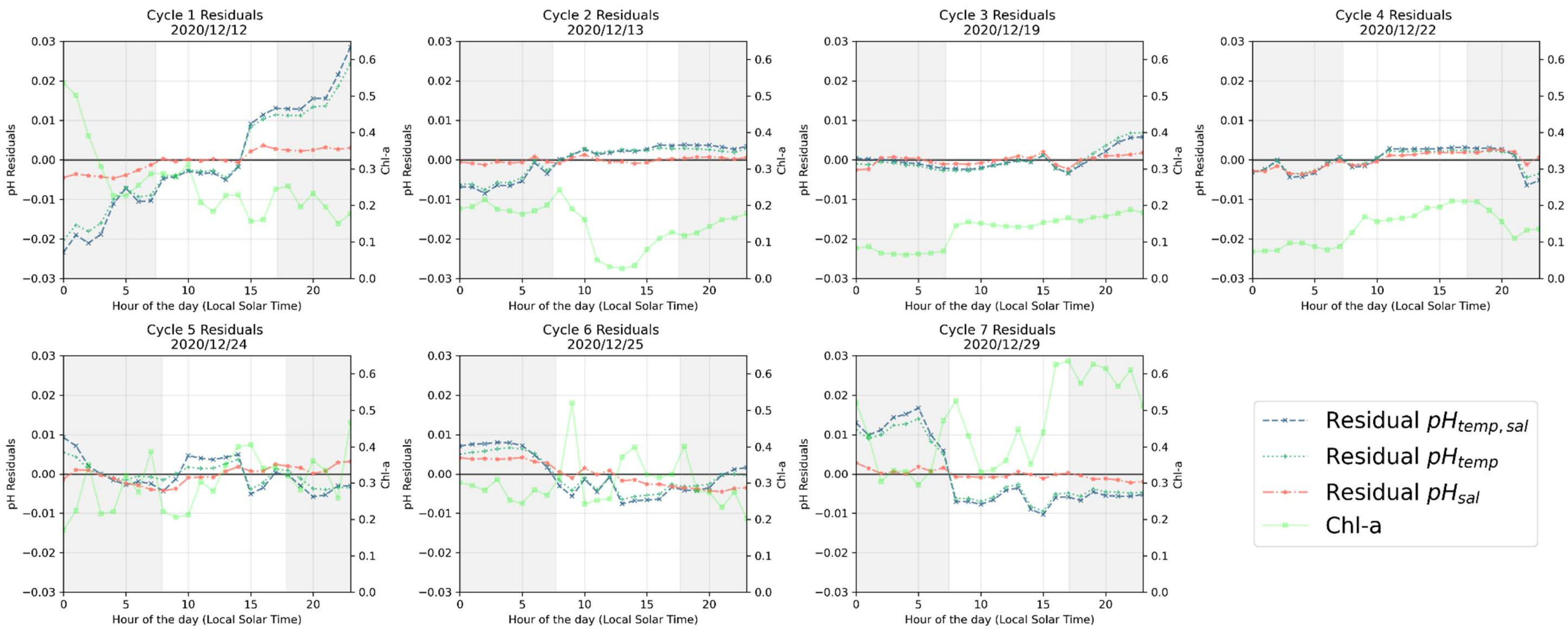

Figure S2. Residual plots for diurnal cycles in the North Atlantic, illustrating the discrepancies between observed pH via optode (pH_{obs}) and pH calculated from temperature and salinity combined ($pH_{temp,sal}$), temperature only (pH_{temp}), and salinity only (pH_{sal}). Horizontal dashed lines at y=0 indicate no deviation between observed and calculated pH values, serving as reference points for assessing overestimations or underestimations. Chl-a has its own y-axis.

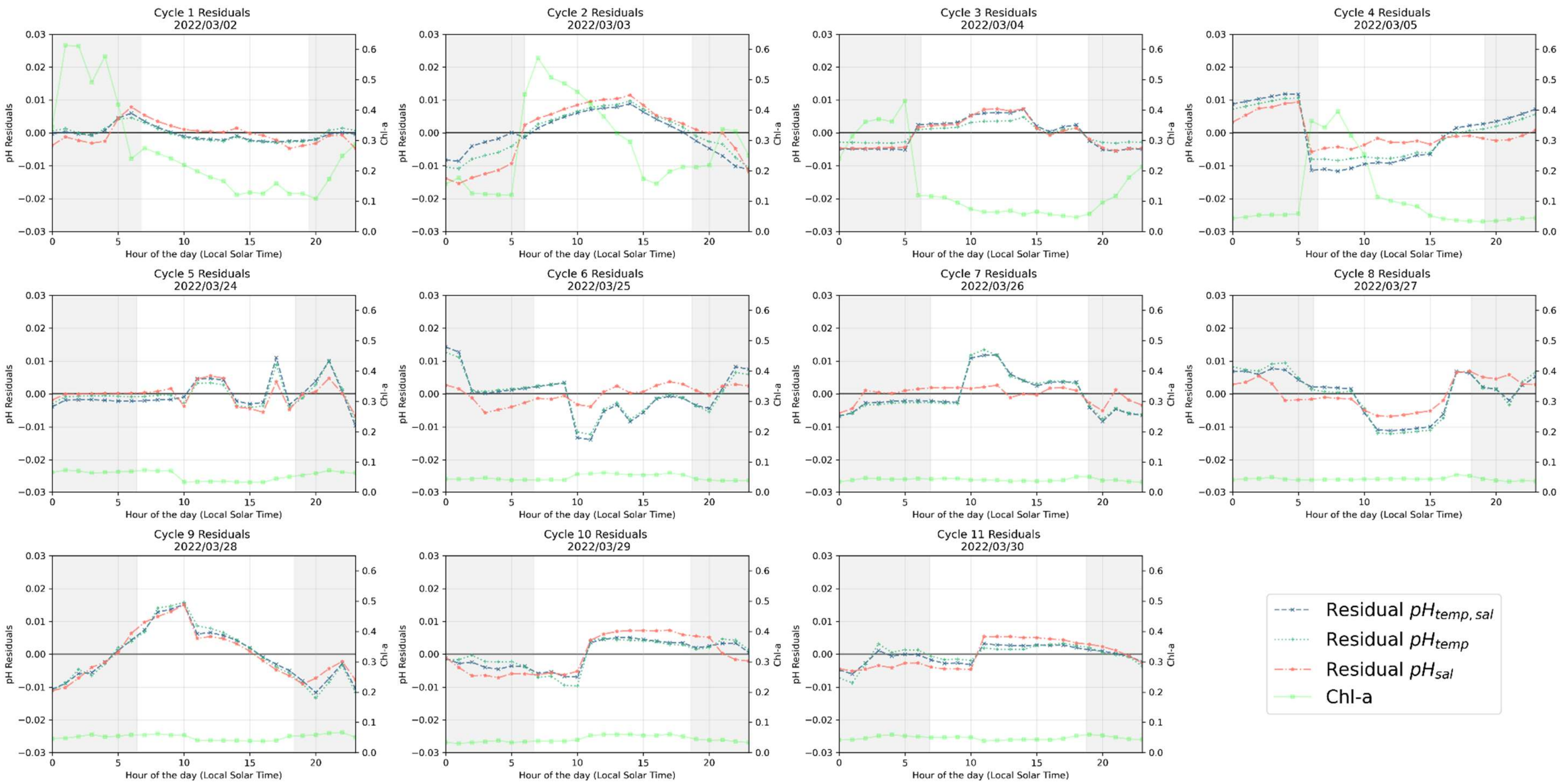

Figure S3. Residual plots for diurnal cycles in the North Atlantic, illustrating the discrepancies between observed pH via optode (pH_{obs}) and pH calculated from temperature and salinity combined ($pH_{temp,sal}$), temperature only (pH_{temp}), and salinity only (pH_{sal}). Horizontal dashed lines at y=0 indicate no deviation between observed and calculated pH values, serving as reference points for assessing overestimations or underestimations. Chl-a has its own y-axis

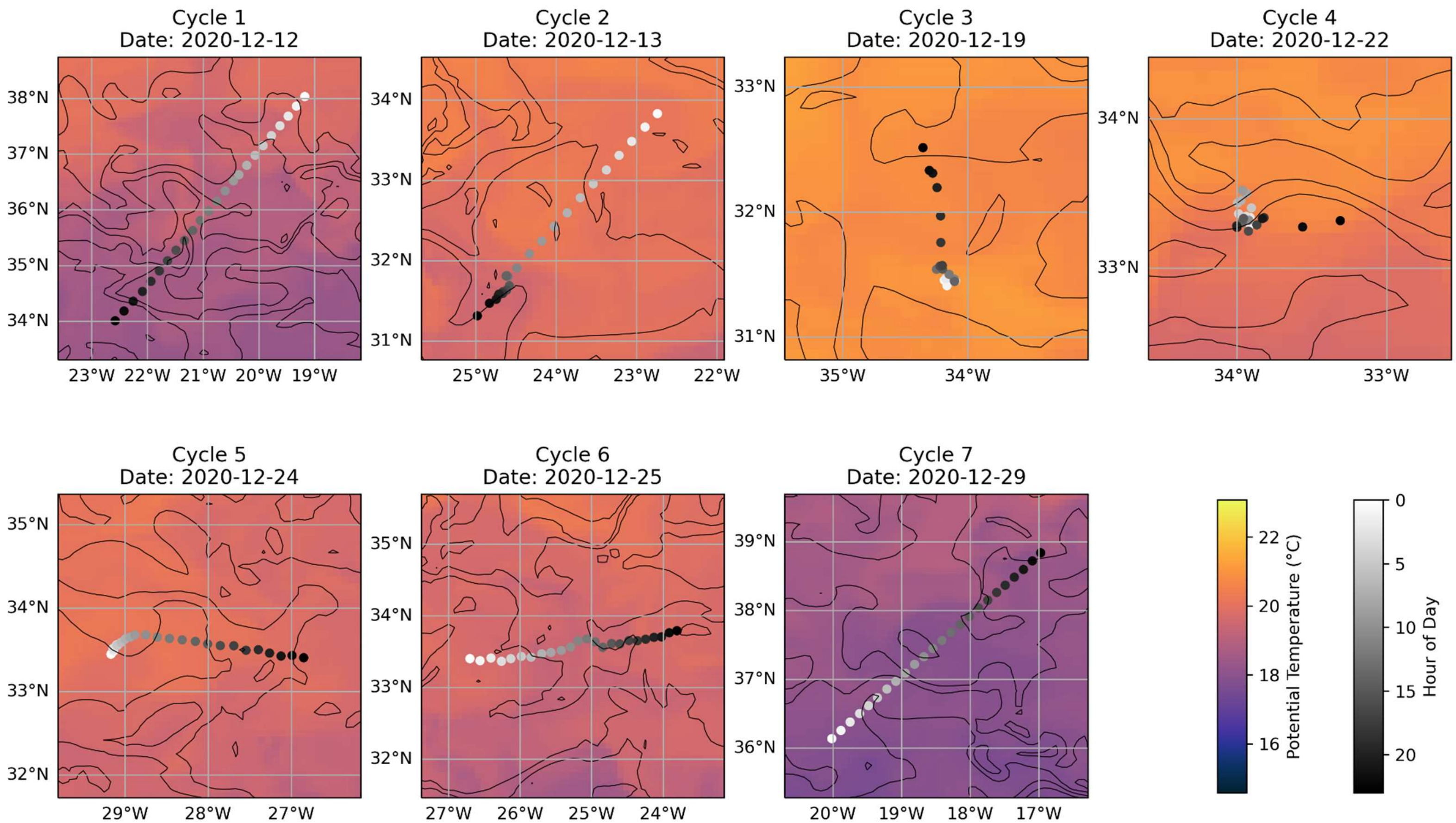

Figure S4. Trajectory for each identified individual diurnal cycles for cruise SO279 in the North Atlantic Ocean. Dot color represents hour of the day. Contour lines are drawn every 0.5°C. Background map shows potential temperature from E.U. Copernicus Marine Service Information; https://doi.org/10.48670/moi-00016.

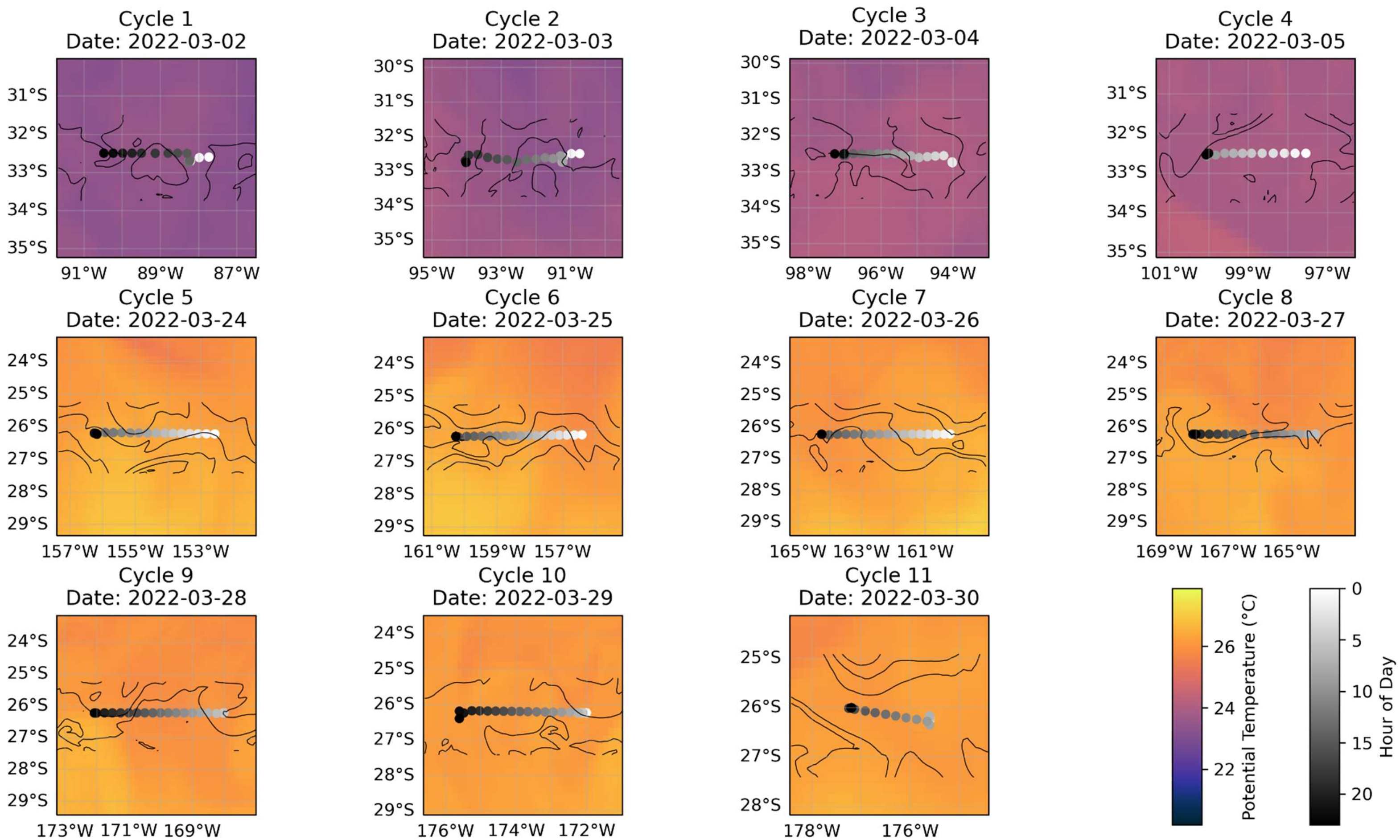

Figure S5. Trajectory for each identified individual diurnal cycles for cruise SO289 in the South Pacific Ocean. Dot color represents hour of the day. Contour lines are drawn every 0.5°C. Background map shows potential temperature from E.U. Copernicus Marine Service Information; https://doi.org/10.48670/moi-00016.

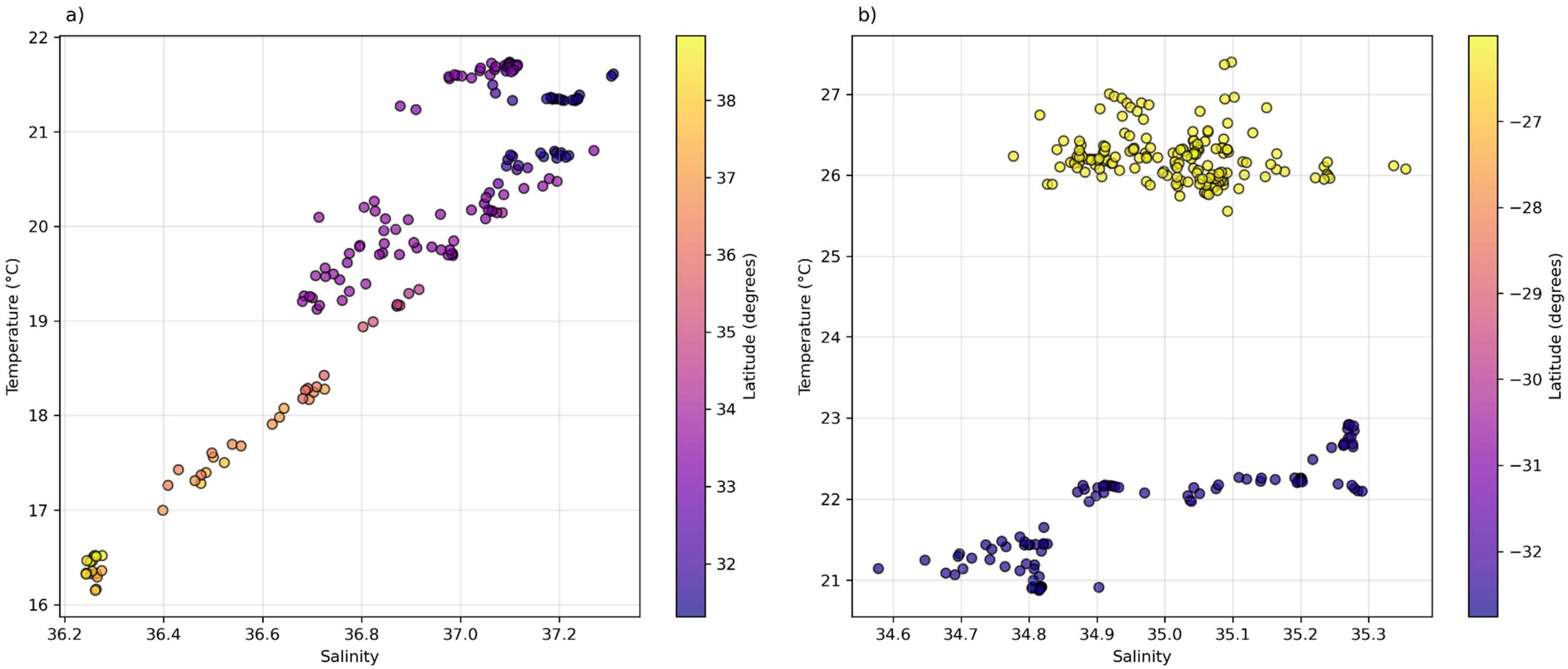

Figure S6. T/S diagram for the a) North Atlantic and b) South Pacific regions, color-coded by observed latitude.

Text S7. Quantifying changes in DIC required for targeted pH

In this study, we explored the alterations in dissolved inorganic carbon (DIC) required to induce a specific pH change in seawater. The initial conditions of the experiment were set with a Total Alkalinity (TA) of 2300 µmol/kg, an initial DIC concentration of 2000 µmol/kg, salinity at 35 practical salinity units, and temperature maintained at 25°C under atmospheric pressure (0 dbar). These conditions mimic typical oceanic conditions in temperate regions.

We employed the PyCO2Sys package to calculate the carbonate system parameters (parameters describe in Section 2.6; (Humphreys et al., 2022). Initially, we determined the system's pH under the given conditions (TA and initial DIC), with no contributions from phosphate or silicate. The initial pH was calculated on the total scale.

To achieve a decrease in pH by 0.1 units from the initial value, we applied a numerical solver (fsolve from SciPy) to find the DIC level necessary to reach the target pH under the same conditions of salinity, temperature, and pressure. This iterative approach refined the DIC estimate until the desired pH was achieved.

Following the determination of the required DIC to reach the target pH, we calculated the change in DIC needed and converted this value from µmol/kg to mg C/L using the molecular weight of carbon (12.01 g/mol) and the density of seawater (1.025 kg/L). Subsequently, this concentration was converted to mg C/m^3 for practical applications and monitoring purposes.

The daily change in pH of 0.1 corresponds to 687 mg C/m^3/day.

References

Humphreys, M. P., Lewis, E. R., Sharp, J. D., & Pierrot, D. (2022). PyCO2SYS v1.8: marine carbonate system calculations in Python. *Geosci. Model Dev.*, *15*(1), 15-43. https://doi.org/10.5194/gmd-15-15-2022

Lee, K., Tong, L. T., Millero, F. J., Sabine, C. L., Dickson, A. G., Goyet, C., Park, G. H., Wanninkhof, R., Feely, R. A., & Key, R. M. (2006). Global relationships of total alkalinity with salinity and temperature in surface waters of the world's oceans. *Geophysical Research Letters*, *33*(19).