**Supplementary Materials**

**Pelagic coccolithophore production and dissolution and their impacts on particulate inorganic carbon cycling in the western North Pacific**

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**Supplementary Methods**

**Measurement of environmental factors**

Chlorophyll *a* (Chl *a*) concentrations were measured after being extracted with 90 % acetone for 14 h at −20°C using a Trilogy Laboratory Fluorometer with non-acidification (NA) module (Turner Designs, USA) (Welschmeyer, 1994). Nutrient samples were collected in acid-washed Nalgene high-density polyethylene (HDPE) bottles and determined onboard the vessel using a Four-channel Continuous-Flow Technicon AA3 Autoanalyzer (Bran+Luebbe GmbH). The detection limits were 0.1 μmol $L^{-1}$, 0.08 μmol $L^{-1}$ and 0.16 μmol $L^{-1}$ for dissolved inorganic nitrogen (DIN, nitrate plus nitrite), soluble reactive phosphate (SRP) and dissolved silicate (DSi), respectively. For measurement of DIN and SRP concentrations in surface samples below the detection limit of the AA3 Auto-Analyzer, duplicate samples were collected and frozen separately at −20°C until analysis. Nanomolar DIN concentrations were determined using a continuous-flow analysis system combined with a liquid waveguide capillary flow cell as described by (Zhang, 2000). Nanomolar SRP concentrations were measured using an automated analyzer including a syringe pump and multiposition selection valve combined with a solid-phase extraction cartridge (Deng et al., 2020). Ammonium ($NH_4^+$) was measured onboard using solid-phase extraction combined with fluorescence detection (SPE-Flu) (Zhu et al., 2013; Zhu et al., 2018).

Samples for analysis of dissolved inorganic carbon (DIC) and total alkalinity (TA) were collected in 250 mL PYREX® borosilicate glass bottles, and poisoned with 250 μL of a $HgCl_2$-saturated solution upon sample collection. DIC was measured using an infrared carbon dioxide ($CO_2$) detector (Apollo ASC-3) (Cai et al., 2004). TA was determined for 25 mL samples using an open-cell setting based on the Gran titration technique (Cai et al., 2010) with a Kloehn digital syringe pump. Dissolved oxygen (DO) concentrations were measured onboard using the spectrophotometric Winkler method (Dai et al., 2006).

**Dissolution rate estimates using Alk\*-TTD&$^{14}$C age**

We calculated Alk\* using the Global Ocean Data Analysis Project (GLODAP) v2 database across the 30°N to 45°N transect in the North Pacific basin (Carter et al., 2014). The age of seawater was obtained following established methods by combining the chlorofluorocarbon (CFC)-12 transit time distribution (TTD) ages from the GLODAPv2.2016 database and GLODAP $^{14}$C data (Key et al., 2004; Gebbie and Huybers, 2012; Sulpis et al., 2021; Jeansson et al., 2021).We binned all data in this region at 0.05 kg $m^{-3}$ potential density intervals. Regressions were discarded if they contained less than 15 points and if the p-value of the regression was > 0.05 (Subhas et al., 2022).
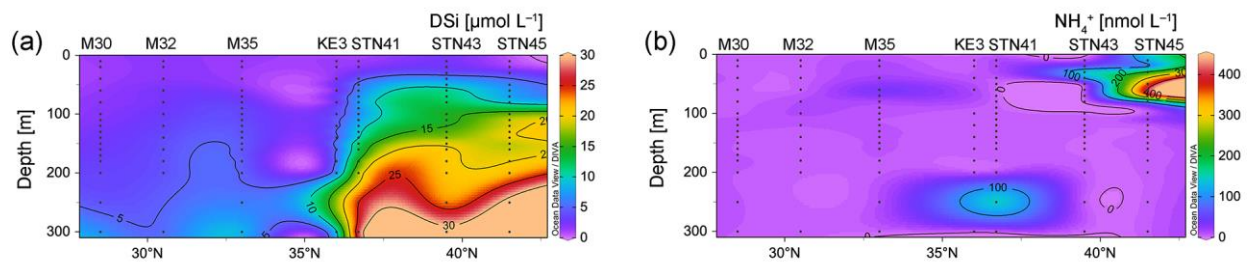
**Supplementary Figures**



**Fig. S1.** Vertical depth distributions of (a) dissolved silicate (DSi) and (b) ammonium (NH$_4^+$) concentrations in the upper 300 m of the water column.
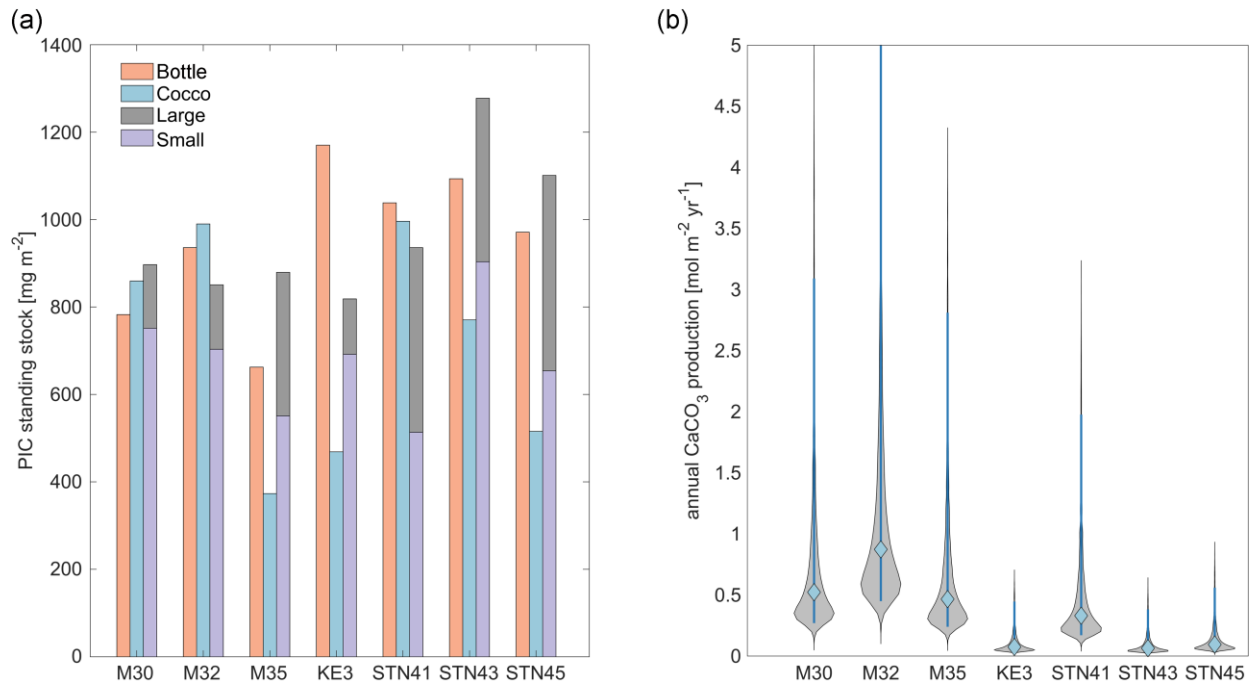
**Fig. S2.** Standing stock and production of particulate inorganic carbon (PIC) above 150 m-depth at each sampling station (see Fig. 1 for their location). (a) Vertically integrated calcium carbonate ($CaCO_3$) standing stock estimated from Niskin bottle-sampled PIC, total calcite concentrations (Cocco) and size-fractionated (large and small indicates > 51 µm and 1–51 µm size fractions, respectively) PIC concentrations; (b) annual $CaCO_3$ production corrected for seasonal bias using satellite-derived PIC concentrations.
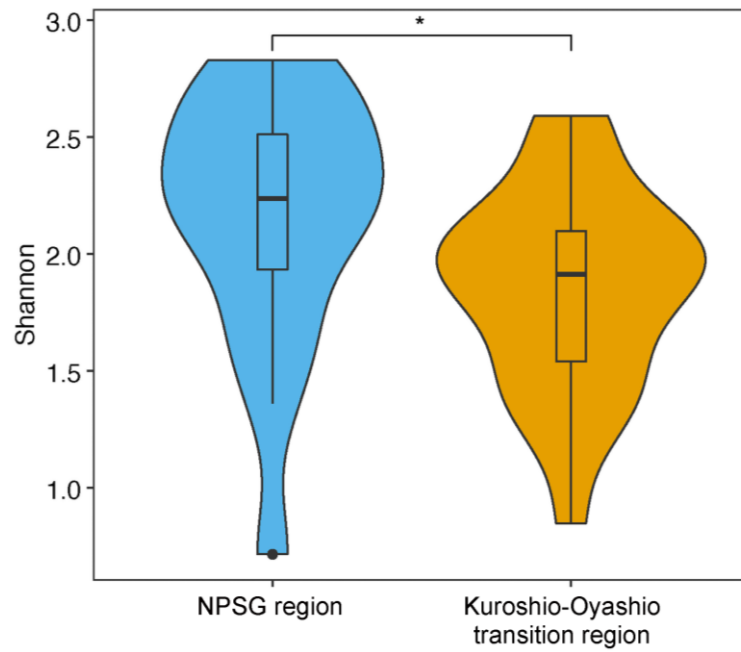
**Fig. S3.** Comparison of the Shannon diversity index of the coccolithophore phytoplankton community between the North Pacific Subtropical Gyre (NPSG) region and the Kuroshio-Oyashio transition region. * represents a statistical significance of $p < 0.05$, which indicates that the coccolithophore assemblage diversity in the NPSG region was significantly higher than in the Kuroshio-Oyashio transition region.
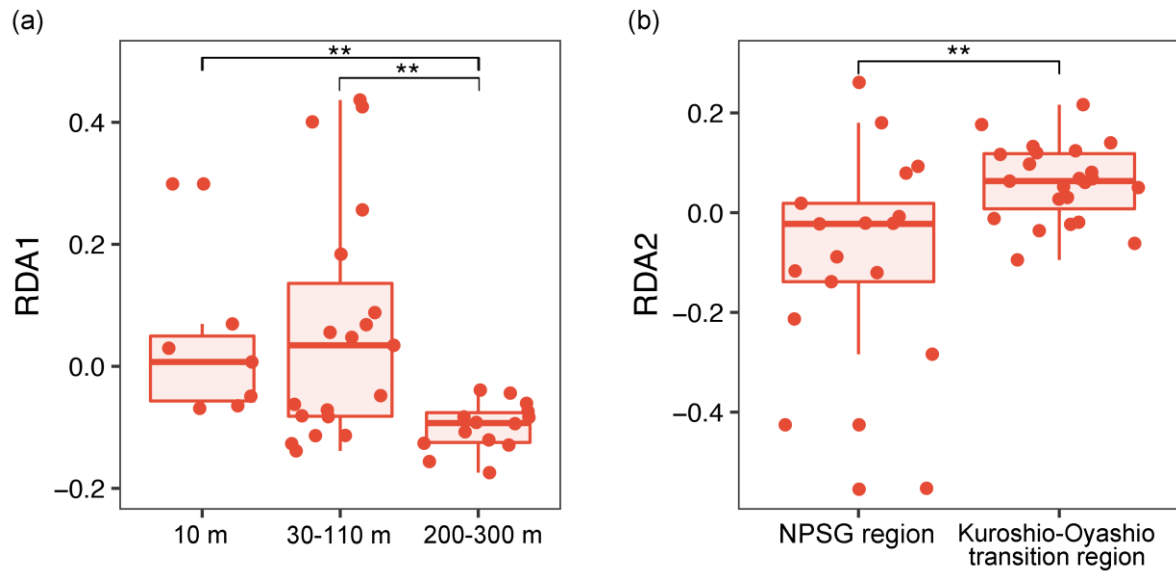
**Fig. S4.** Relationship (a) between the redundancy analysis (RDA)1 axis and different depths and (b) between the RDA2 axis and the two ocean regions targeted in this study. ** indicates a statistical significance of $p < 0.01$; NPSG represents the North Pacific Subtropical Gyre.
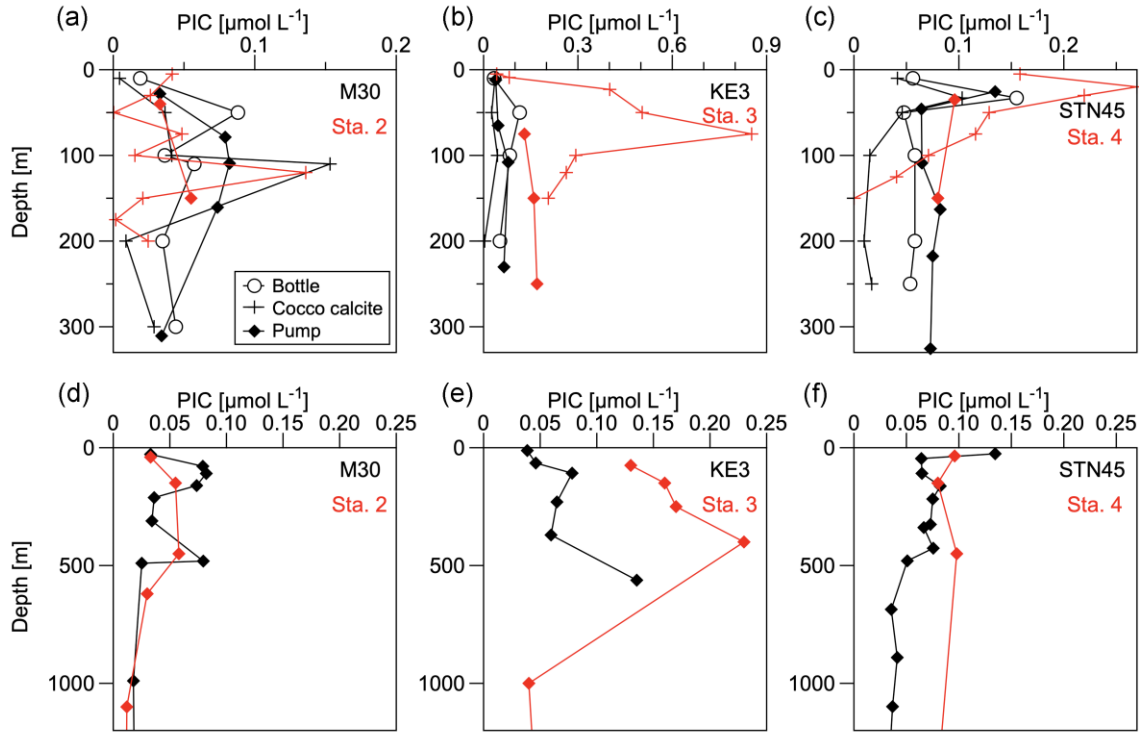
**Fig. S5.** Vertical depth profiles of particulate inorganic carbon (PIC) concentrations from Niskin bottle-sampling, coccolithophore (Cocco) calcite and PIC concentrations from in-situ pump-sampling at stations M30 (28.5°N, 155°E), KE3 (36°N, 155°E) and STN45 (41.5°N, 155°E) (see Fig. 1) in the (a–c) upper 350 m and (d–f) 1,200 m of the water-column, respectively. Red symbols are data from Sta.2 (27.73°N, 155.25°W), Sta.3 (35.26°N, 150.98°W) and Sta.4 (41.75°N, 148.25°W) investigated during the CDisK-IV cruise (Ziveri et al., 2023; Dong et al., 2019).
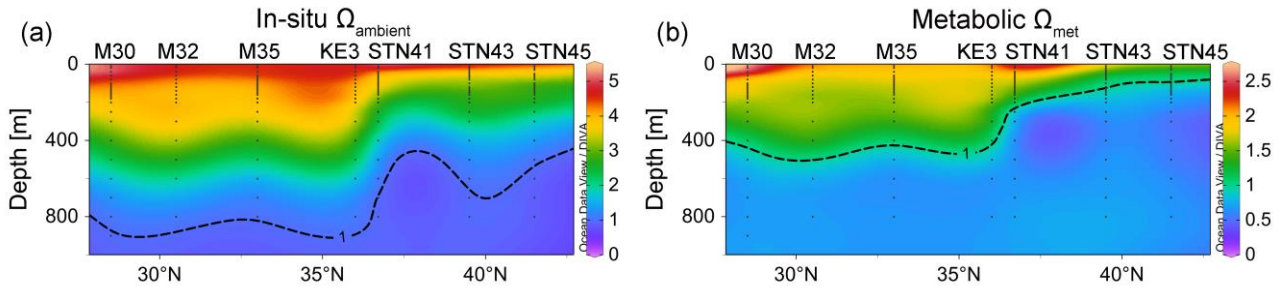
**Fig. S6.** Depth-profiles of (a) in-situ calcite saturation state ($\Omega_{ambient}$) calculated using ambient total alkalinity and dissolved inorganic carbon data and (b) metabolic $\Omega_{met}$ for calcite in the upper 1000 m of the water column at various study site stations. Black dashed lines denote the calcite saturation horizon where $\Omega = 1$.

**Supplementary Tables**

**Table S1.** Location of the seven sampling stations during the NORC2022-306 cruise. Stations M30, M32 and M35 were in the North Pacific Subtropical Gyre, and the remaining stations were in the Kuroshio-Oyashio transition region.

| Station | Latitude (°N) | Longitude (°E) |
|---------|---------------|----------------|
| M30 | 28.5 | 155 |
| M32 | 30.5 | 155 |
| M35 | 33.0 | 155 |
| KE3 | 36.0 | 155 |
| STN41 | 36.7 | 155 |
| STN43 | 39.5 | 155 |
| STN45 | 41.5 | 155 |

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