Response to RC1

Title: "Biogeochemical Layering and Transformation of Particulate Organic Carbon in the Tropical Northwestern Pacific Ocean Inferred from $\delta^{13}C$"

In this document, we present the response to Referee's comments repeated in blue.

Thank you very much for taking the time to review our manuscript and providing insightful and constructive comments. Your feedback has been invaluable in helping us identify areas for improvement and enhancing the overall quality of our work. We have carefully considered each of your suggestions and made the necessary revisions. Below, we provide detailed responses to each of your comments:

1. While this paper represents new data on POM elemental and stable isotope composition (which is always welcome) and the interpretation given appears fairly senseful, though largely speculative. But because the data set is limited to 'classical' parameters of POM and does not provide more specific data about POM composition (e.g. isotopic composition of specific components) the paper falls short in substantially improving our insights in the fate of POM in the oceanic water column with regard to existing literature.

Thank you for highlighting both the strengths and limitations of our study. To address your concern regarding the speculative nature of our interpretation, we have incorporated additional references in the discussion section to provide a more robust context. Specifically, we have included studies on the carbon isotopic fractionation of amino sugar monomers and lipid monomers during POC degradation (revised manuscript L224-230).

"Previous studies have reported that during the degradation of POC, the carbon isotope fractionation characteristics of amino sugar monomers closely align with changes in $\delta^{13}C$-POC (Guo et al., 2023b). Moreover, several studies have highlighted that the carbon isotopic composition of lipid monomers does not exhibit significant depletion during POC degradation; in fact, it may even show a trend of enrichment (Close et al., 2014; Häggi et al., 2021). These observations further indicate the preferential degradation of amino acids and carbohydrates in POC."

We have also emphasized in the conclusion section the need for future studies to focus on the carbon isotopic composition of specific POC components (e.g., lipids and amino acids) to deepen our understanding of POC transformation processes (revised manuscript L324-326).

References:

Guo, J., et al. (2023b). Stable carbon isotopic composition of amino sugars in heterotrophic bacteria and phytoplankton: Implications for assessment of marine organic matter degradation. Limnology and Oceanography, 68, 2814–2825. http://doi.org/10.1002/lno.12468

Close, H. G., et al. (2014). Lipid and ^{13}C signatures of submicron and suspended particulate organic matter in the Eastern Tropical North Pacific: Implications for the contribution of Bacteria. Deep Sea Research Part I, 85, 15–34. http://doi.org/10.1016/j.dsr.2013.11.005

Häggi, C., et al. (2021). Impact of selective degradation on molecular isotope compositions in oxic and anoxic marine sediments. Organic Geochemistry, 153. http://doi.org/10.1016/j.orggeochem.2021.104192

2. A further major shortcoming of this paper is the one-dimensional (surface to deep) approach used when interpreting the data, despite the apparent complexity of ocean currents and counter currents in the studied area. No use is made of T-S, nutrient data to inform on mixed layer depth, DCM position and to identify major water masses and possible impacts of advection processes on observed profiles.

We appreciate your comments regarding the oversimplified approach in our interpretation. To address this issue, we have added a potential temperature-salinity (T-S) diagram (Figure 1, revised manuscript Figure 2) and detailed the identification of water masses in the study area (revised manuscript L150–170).

"Based on the relationship between potential temperature and salinity (θ-S) (Fig. 2), eight water masses in the study area were identified: North Pacific Tropical Surface Water (NPTSW), North Pacific Subsurface Water (NPSSW), North Pacific Subtropical Mode Water (NPSTMW), North Pacific Intermediate Water (NPIW), North Pacific Deep Water (NPDW), as well as Equatorial Surface Water (ESW), South Pacific Subsurface Water (SPSSW) and South Pacific Intermediate Water (SPIW). In the upper ocean (0-300 m), we found that both NPTSSW and SPSSW exhibited high salinity characteristics. The salinity of NPTSSW was distributed between 34.66 and 35.01, while the salinity of SPSSW was distributed between 35.15 and 35.65. In addition, as the water depth increased, the temperature of NPTSSW and SPSSW decreased significantly, with NPTSSW dropping from 27.18 ℃ to 16.21 ℃ and SPSSW dropping from 29.23 ℃ to 14.81 ℃. The representative water mass in the middle ocean (300-1000 m) is NPIW, which is characterized by a rapid decrease in temperature (11.44-5.57 ℃) and a slight increase in salinity (~0.3) with increasing water depth. The representative water mass in the deep ocean (1000-2000 m) is NPDW, which has stable properties and slight changes in salinity and temperature. Notably, the water mass distribution at station E142-19 is quite special. Ranging from the subsurface to the deep layer, the water mass properties of this station are relatively stable, showing low-salinity and low-temperature characteristics. This is attributed to the intrusion of both North Pacific Intermediate Water (NPIW) and South Pacific Intermediate Water (SPIW) into the station in the mid-ocean region. Additionally, the station is situated within the MD upwelling area, where strong upwelling transports low-temperature, low-salinity North Pacific Deep Water (NPDW) from the bottom to the upper layer, enhancing seawater

exchange. Consequently, the water at station E142-19 comprises a mixture of diverse water masses."

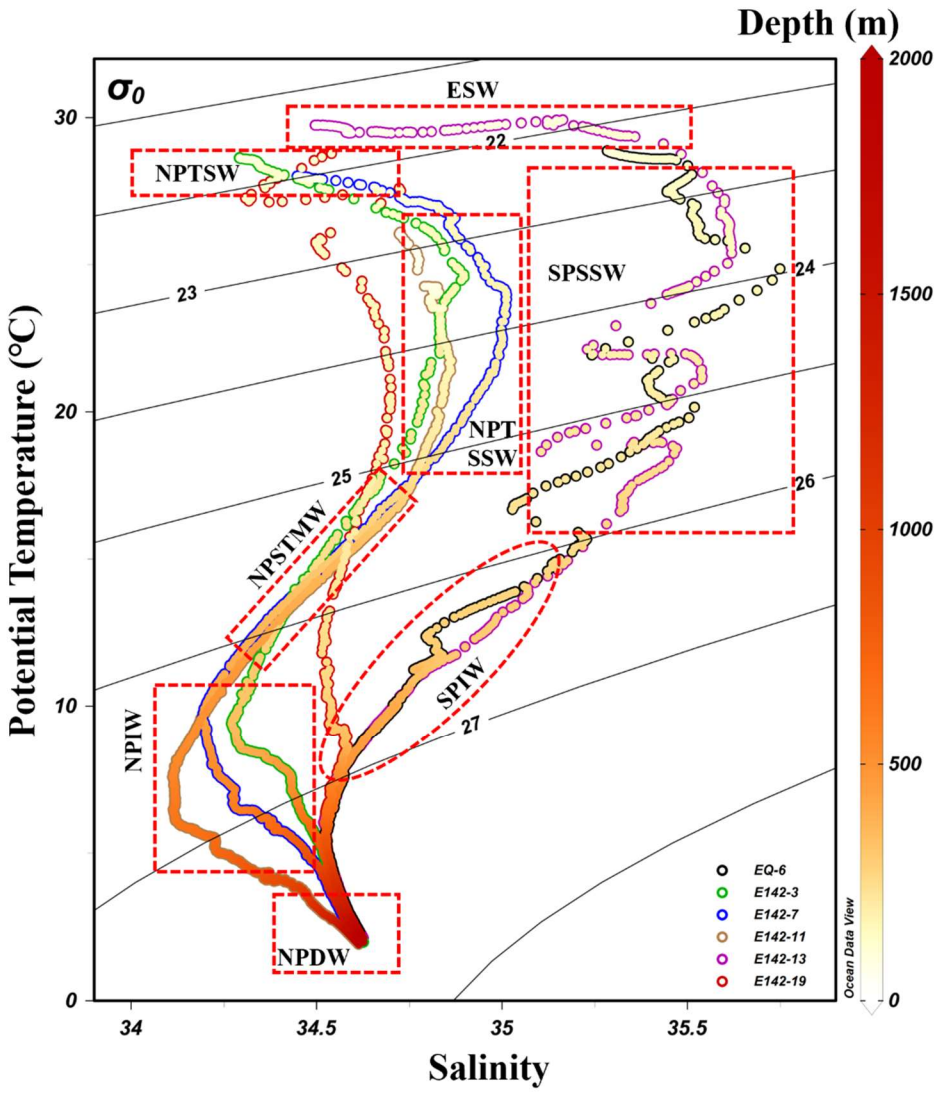

Figure 1. Relationship between potential temperature (θ) and salinity (S) at each sampling station. The data points at each station are marked with hollow circles of different colors. (Source: Tian et al. (2025), manuscript under review)

We also revised the discussion section to highlight the influence of water mass nutrient conditions on POC concentrations (revised manuscript L193-194):

"Since the nutrient concentration in ESW and SPSSW is higher than that in NPTSW and NPTSSW, the surface POC concentrations at stations E142-13 and EQ-6 were slightly higher than those at other stations."

Additionally, we updated the Vertical distribution of DO, δ^{13}C-POC, and POC (Figure 2, revised manuscript Figure 3) and marked the positions of the DCM on the diagrams for clarity.

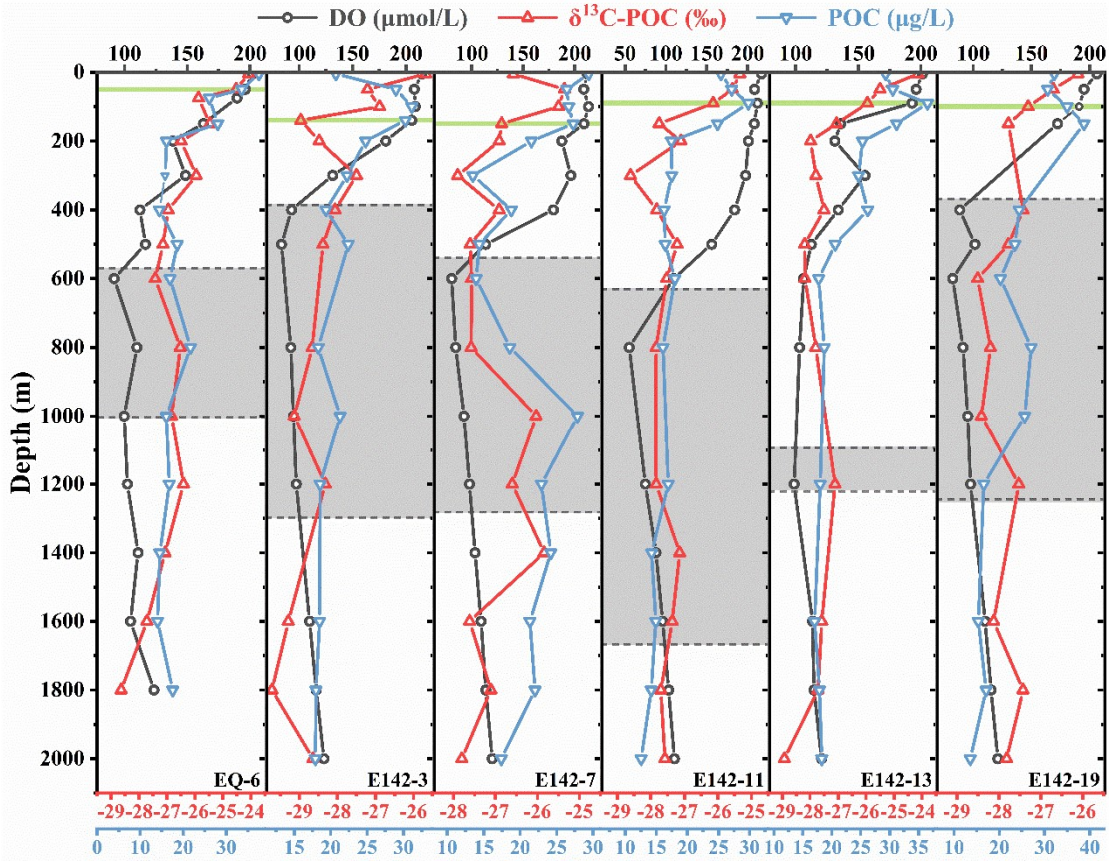

Figure 2. Vertical distribution of DO, δ^{13}C-POC, and POC concentration at each sampling station. The gray area marks the hypoxic zone with DO = 100 μmol/L as the boundary. The green line represents the DCM depth.

3. The method section should be more detailed, since no information on sample preservation, standards, references used, corrections applied .. is given.

We appreciate your suggestion to provide more detailed information in the methods section. In response, we have extensively revised this section to include details on sample preservation, the use of standard reference materials, and the applied corrections (revised manuscript L105–135):

"DO: Water samples were collected, fixed, and titrated according to the classic Winkler method, the precision of which was 2.2×10-3 μmol/L (Bryan et al., 1976; Zuo et al., 2018). The discrete DO samples were used to calibrate the DO concentration data obtained by the CTD sensor.

POC, δ^{13}C-POC, and PN: Particle samples were obtained by filtering 2-5 L of seawater onto a GF/F glass filter (0.7 μm, Whatman) that had been combusted in a muffle furnace (450°C, 4 h) and acid-soaked (0.5 M hydrochloric acid (HCl), 24 h). The filter was treated with HCl to remove inorganic carbonates and oven-dried at 60°C. After collection, samples were stored below -20 °C until laboratory analysis. Afterward, POC, PN concentration, and δ^{13}C-POC were analyzed using an elemental analyzer and an isotope mass spectrometer (Thermo Fisher Scientific Flash EA 1112 HT-Delta V Advantages, United States) with an accuracy of ± 0.8‰ and ± 0.2‰, respectively. Standard reference materials were used to calibrate δ13C and POC, PN measurements, including USGS64 (δ^{13}C = -40.8 ± 0.04‰, C% = 31.97%, N% = 18.65%,

Indiana University), USGS40 ($\delta^{13}C$ = -26.39 ± 0.04‰, C% = 40.8%, N% = 9.52%, Geological Survey, United States), and Urea #2a ($\delta^{13}C$ = -9.14 ± 0.02‰, C% = 220%, N% = 46.67%, Indiana University) (Ma et al., 2021).

DIC and $\delta^{13}C$-DIC: Sampling was performed using a 50 ml glass bottle. After the water sample overflowed, 1 ml of the sample was taken out with a pipette and then fixed with saturated mercuric chloride solution to remove the influence of biological activity. After collection, samples were stored in refrigerator at 4°C for later laboratory measurement of DIC concentration using a total DIC analyzer (Apollo SciTech AS-C3, United States) with an accuracy of ± 0.1% (Ma et al., 2020). For calibration, certified reference material (Batch 144, 2031.53 ± 0.62 μmol/kg) provided by the Scripps Institution of Oceanography (University of California, San Diego) was used. $\delta^{13}C$-DIC automatic analysis was performed using a Thermo Delta-V isotope ratio mass spectrometer (ThermoFisher Scientific MAT 253Plus, United States). For calibration, certified reference materials for dissolved inorganic carbon ($\delta^{13}C$-DIC) were used, including GBW04498 ($\delta^{13}C$ = -27.28 ± 0.10‰), GBW04499 ($\delta^{13}C$ = -19.58 ± 0.10‰), and GBW04500 ($\delta^{13}C$ = -4.58 ± 0.12‰), all provided by the Institute of Geophysical and Geochemical Exploration (Chinese Academy of Geological Sciences).

Chl -a: 2 L of water sample after zooplankton removal was filtered onto pre-combusted (450°C for 5 h) GF/F filters (0.7 μm, Whatman) and placed in the refrigerator at −20°C before measurement. In the laboratory, the filters were extracted with 90% propanol for 12-24 h, and the concentration was measured using a fluorescence photometer (Turner Designs, United States) (Ma et al., 2020).”

We believe these revisions provide a clearer and more comprehensive description of our methods, addressing both your concerns and the needs of readers.

Once again, we thank you for your valuable feedback and constructive suggestions, which have significantly improved the quality of our manuscript. We hope the revisions we have made address your concerns and enhance the scientific rigor of the study.