

Response to RC3

Title: “Stoichiometric deviation and regulatory mechanisms of AOU-nutrient ratio in the oligotrophic Northwest Pacific Ocean”

In this document, we present the response to Referee’s comments repeated in [blue](#).

The authors have carefully considered my comments and have made substantial and generally appropriate revisions to the manuscript. In particular, the revised manuscript now distinguishes the mechanisms operating in the upper, intermediate, and deep waters, clarifies the diagnostic rather than independent evidential role of residual preformed nutrients, and provides additional methodological information and literature comparisons for TEP. These revisions have substantially improved the clarity and balance of the manuscript.

I consider the manuscript suitable for publication after the following minor revisions.

1. the f_{DOM} and f_{POM} issue

f_{DOM} f_{POM} are defined as the fractions of total oxygen consumption attributable to DOM and POM remineralization, respectively. Therefore, I think these two fractions should satisfy the mass-balance constraint: $f_{\text{DOM}} + f_{\text{POM}} = 1$.

If this is the case and I am right, then the current sensitivity analysis varies f_{DOM} and f_{POM} independently among 0.4, 0.5, and 0.6, producing 27 parameter combinations. Some of these combinations assign less or more than 100% of the total oxygen consumption to DOM and POM together and are therefore not physically consistent.

I recommend recalculating $r\text{PreNO}_3$ and $r\text{PrePO}_4$ under the above constraint. The corresponding means, ranges, and standard deviations should be updated in the manuscript, supplementary material, figures, and public dataset as necessary. The authors should also confirm whether the principal vertical patterns and interpretations remain unchanged after this recalculation.

Response: We thank the reviewer for pointing out this important issue. Following the reviewer's suggestion, we recalculated r_{PreNO_3} and r_{PrePO_4} using nine physically constrained parameter combinations, including three DOM – POM partitioning scenarios ($f_{\text{DOM}}/f_{\text{POM}} = 0.4/0.6$, $0.5/0.5$, and $0.6/0.4$) combined with three r_{POM} values (6.9, 8.75, and 10.6). The constraint of $f_{\text{DOM}} + f_{\text{POM}} = 1$ has now been explicitly stated in the calculation method.

“ r_{DOM} and r_{POM} denote the moles of O_2 consumed per mole of nitrogen regenerated during DOM and POM remineralization. To ensure mass balance of oxygen consumption partitioning, f_{DOM} and f_{POM} were constrained as: $f_{\text{DOM}} + f_{\text{POM}} = 1$. Accordingly, three partitioning scenarios were considered ($f_{\text{DOM}}/f_{\text{POM}} = 0.4/0.6$, $0.5/0.5$, and $0.6/0.4$), and r_{POM} was assigned three values (6.9, 8.75, and 10.6), representing the minimum, Redfield, and maximum estimates reported in the literature (Table S2) (Letscher and Villareal, 2018; Smyth and Letscher, 2023). These combinations produced 9 calculations for each observation. These calculations were used to represent the uncertainty associated with applying empirical parameters to the broader Pacific Ocean. For each observation, the 9 calculations were summarized as minimum–maximum (arithmetic average $\pm$ standard deviation). The arithmetic average was used as the central diagnostic value in the manuscript, whereas the minimum, maximum, and standard deviation describe sensitivity to the prescribed parameter combinations. The complete summaries are available in the public data set (Tian, 2026).”

The recalculated ensemble mean values of r_{PreNO_3} and r_{PrePO_4} showed no differences from the previous calculations. This is because the original parameter space was centered around $f_{\text{DOM}} = 0.5$ and $f_{\text{POM}} = 0.5$, and thus the mean remineralization coefficients remained unchanged after applying the mass balance constraint. However, the standard deviations and ranges were reduced because the revised calculation excluded parameter combinations that did not satisfy the mass balance constraint (See the attached *Table. 1* for details).

We also revised the definition of the measured nitrate term in the calculation. Specifically, $\text{NO}_{3\text{meas}}$ has been changed to NO_{xmeas} , representing the sum of nitrate and nitrite concentration, because the calculation considers the total inorganic nitrogen regenerated during remineralization. Nitrite concentrations were very low and therefore had negligible effects on

the calculated $r\text{PreNO}_x$ values (Fig. 1).

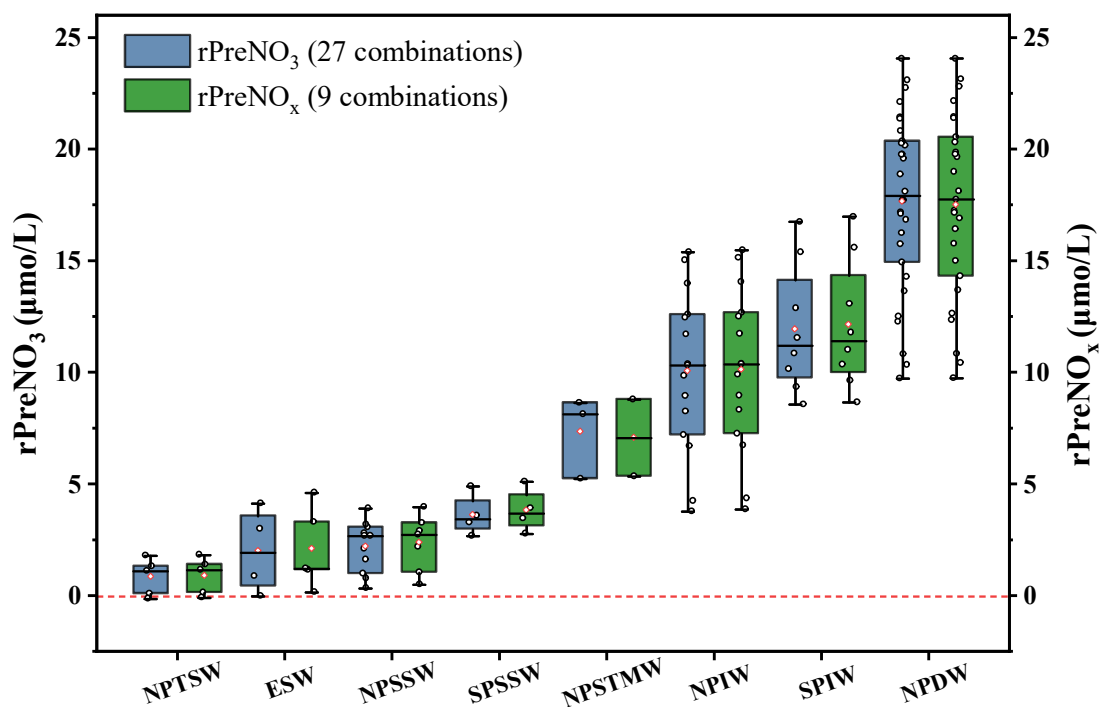


Figure 1. Comparison of $r\text{PreNO}_3$ and $r\text{PreNO}_x$ estimates across different water masses. $r\text{PreNO}_3$ was calculated using the original 27 combinations, whereas $r\text{PreNO}_x$ was recalculated using the 9 mass-balance constrained combinations and $\text{NO}_{x\text{meas}}$ (nitrate + nitrite).

Importantly, the recalculated results confirmed that the depth distributions, relationships with AOU and nutrients, and associated interpretations were consistent with the previous results, indicating that the main conclusions are robust to the revised mass balance constraint.

We have updated the manuscript, Supplementary Materials, figures, and public dataset accordingly to reflect the revised mass-balance constrained calculations.

2. Interpretation of TEP abundance

The authors have appropriately acknowledged that the absolute TEP concentrations observed in this study fall within the relatively low range reported for oceanic environments. The newly added TEP-C/POC comparison is useful because it shows that TEP-associated carbon represents a substantial fraction of the relatively small POC pool in the study region.

Nevertheless, Table S1 also shows that the TEP concentrations and TEP-C/POC ratios reported here are not among the highest values observed globally. In particular, comparable or

higher TEP-C/POC ratios have been reported from some other sites (Table S1). Therefore, statements such as the TEP-C/POC ratio being “generally higher than those observed in most productive coastal, shelf, and surface open-ocean environments” should be moderated.

I personally think a more accurate interpretation would be that the absolute TEP concentration is not exceptionally high on a global scale, but that TEP constitutes a substantial component of the local POC pool under the oligotrophic conditions of the study region. This relative importance makes TEP production a plausible contributor to the observed upper-ocean AOU/nutrient deviations, although it does not necessarily demonstrate that TEP is the sole or dominant driver. Eventually, further study is needed to reveal or confirm this point---particularly to check whether similar abnormal AOU/nutrient ratios are presence in those regions with similarly high TEP/POC ratios. This call for further study should also be included in the manuscript.

Response: We thank the reviewer for the careful suggestion regarding the interpretation of TEP abundance. Our original intention in the Results section was to convey that the observed TEP-C/POC ratios were higher than those reported for most eutrophic oceanic regions (i.e., sites without “*” in Table S1). However, we recognize that our original phrasing may overstated the global significance of the TEP-C/POC ratios. Therefore, we have revised the Results section to a more objective and precise statement (Revised manuscript, lines 298-304):

“Nevertheless, when TEP concentrations were converted to estimated carbon equivalents using a factor of 0.51 (Engel and Passow, 2001), the TEP-C/POC ratio ranged from 15.45% to 71.75%, with a mean of $43.81 \pm 14.62\%$. Thus, the TEP-associated carbon a substantial fraction of the local POC pool, accounting for nearly half on average, despite the modest absolute TEP concentrations. The mean ratio was commonly higher than those observed in eutrophic oceanic regions (Table S1).”

In the Discussion section, we have clarified that while absolute TEP concentrations are not globally exceptional, TEP-C/POC ratios indicate that TEP-associated carbon constitutes a substantial component of the local POC pool under oligotrophic conditions. We have also

acknowledged that the co-occurrence of elevated TEP and low AOU/nutrient ratios supports TEP production as a plausible contributor, but not necessarily the sole or dominant driver, and we have added the recommended call for future studies to examine whether similar AOU/nutrient anomalies occur in other regions with comparably high TEP-C/POC ratios (Revised manuscript, lines 376-389).

“The observed TEP-C/POC ratio in the upper waters (mean of $43.81 \pm 14.62\%$) indicate that estimated TEP-associated carbon constituted a substantial component of the local POC pool (Fig. 3i, Table S1). Positive ensemble average $r\text{PreNO}_3$ and $r\text{PrePO}_4$ residuals occurred together with elevated TEP concentrations in the upper water column (Figs. 3d, e, and i). This indicates that measured nutrient concentrations were higher than predicted from AOU under the prescribed DOM and POM remineralization parameters, resulting in a lower AOU/nutrient ratio in the upper waters. Although standing TEP concentrations do not directly quantify production, the substantial contribution of TEP-associated carbon to the local POC pool and its co-occurrence with low AOU/nutrient ratios support carbon allocation to TEP as one plausible contributor to the observed deviations. Future studies should examine whether similarly low AOU/nutrient ratios occur in other ocean regions with comparably high TEP-C/POC ratios to assess the spatial generality of this association.”