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Stoichiometric deviation and regulatory mechanisms of AOU–nutrient ratio in the oligotrophic Northwest Pacific Ocean

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S1. Supplementary Method 1. Preparation of the xanthan gum calibration curve

A fresh xanthan gum stock solution (75 mg L^{-1}) was diluted to obtain five standards. Aliquots of 0.125, 0.250, 0.500, 0.750, and 1.000 mL of the stock solution were pipetted into clean 5 mL polypropylene tubes, and the final volume of each standard was adjusted to 1 mL with ultrapure water. This produced standards containing 9.37, 18.75, 37.50, 56.25, and 75.00 µg xanthan gum, respectively, with three replicates at each level. Each standard was mixed with 0.5 mL of Alcian Blue solution (400 mg L^{-1}, pH 2.5) for 5−10 s and filtered through a 0.45 µm polycarbonate membrane (Whatman) under a vacuum below 175 mmHg. Procedural blanks were processed in parallel. The filters were extracted with 6 mL of 80% sulfuric acid for 10 h, and absorbance was measured at 787 nm. A linear regression of xanthan gum mass against absorbance after blank correction yielded:

$$M_{XG} = 100.15A_{787} + 1.67 \quad \text{(S1)}$$

where M_{XG} is the xanthan gum equivalent mass in µg and A_{787} is the absorbance at 787 nm (R^2=0.99; Fig. S1). TEP concentrations were calculated by dividing the xanthan gum equivalent mass by the filtered seawater volume and are reported as µg Xeq L^{-1}.

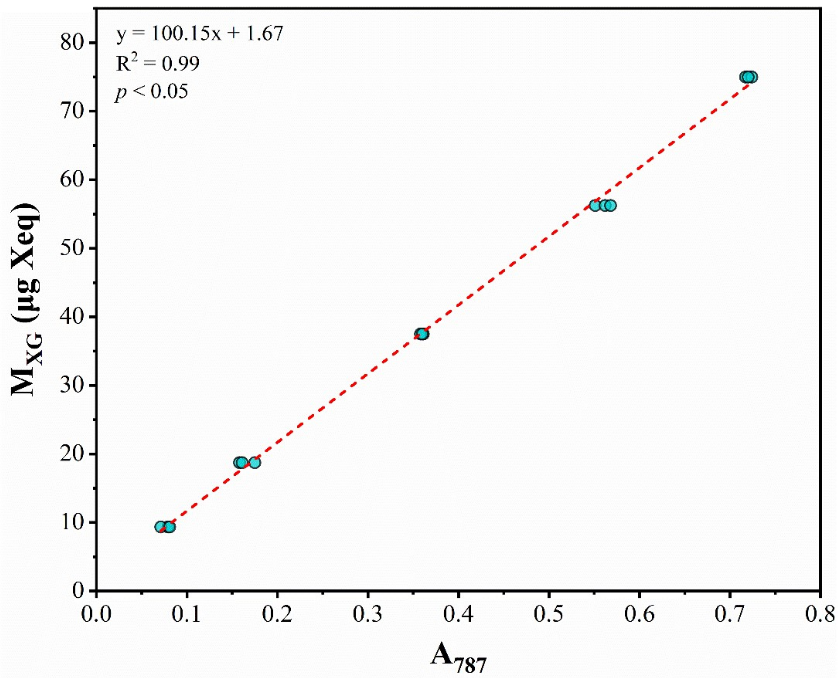

Figure S1. Xanthan gum calibration curve for TEP quantification.

S2. Supplementary Method 2. Calculation of $rPreNO_x$ and $rPrePO_4$

$rPreNO_x$ was computed as:

$$rPreNO_x = NO_{xmeas} - (f_{DOM} \bullet \frac{AOU}{r_{DOM}} + f_{POM} \bullet \frac{AOU}{r_{POM}}) \quad \text{(S2)},$$

where measured NO_x (NO_{xmeas}) is defined as the sum of the concentrations of NO_3-N and NO_2-N. AOU is given by:

$$AOU = DO_{sat} - DO_{meas} \quad \text{(S3)},$$

where DO_{sat} is the saturated DO concentration at a given temperature, salinity, and pressure (Garcia and Gordon, 1992), and DO_{meas} is the measured DO concentration. f_{DOM} and f_{POM} represent the fractions of total oxygen consumption attributed to DOM and POM, respectively. 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: $f_{DOM} + f_{POM} = 1$. Accordingly, three partitioning scenarios were considered (f_{DOM}/f_{POM} = 0.4/0.6, 0.5/0.5, and 0.6/0.4), and rPOM 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 ± 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).

Similarly, $rPrePO_4$ was computed as:

$$rPrePO_4 = PO_{4meas} - \frac{1}{16}(f_{DOM} \bullet \frac{AOU}{r_{DOM}} + f_{POM} \bullet \frac{AOU}{r_{POM}}) \quad \text{(S4)}$$

Because the remineralization parameters specific to phosphorus could not be independently constrained, the nitrogen regeneration terms derived from DOM and POM were converted to phosphorus equivalents using an N:P ratio of 16:1 (Letscher and Villareal, 2018), solely as a common conversion reference.

Table S1. The review of the surface POC concentrations, TEP concentrations and TEP-C/POC ratios in the literature.

Region	**Depth**	**POC (μmol L^{-1})**	**TEP (μg Xeq L^{-1})**	**[b]TEP-C/POC (%)**	**Reference**
[a]Tropical Northwest Pacific	Upper Water	1.13–3.22 (2.27 ± 0.53)	7.53–34.22 (22.52 ± 8.54)	15.45–71.75 (43.81 ± 14.62)	This study
Fram Strait	5–150 m	[c]23.10	5–517 (75 ± 78)	13.8 ± 6.1	Engel et al. (2017)
Northern South China Sea	0–200 m	0.20–4.38	0.6–78.6	5.6–55.5 (27.4 ± 1.3)	Ge et al. (2022)
[a]South China Sea	0–220 m	[c]1.70	14–47 (30 ± 8)	32.0–173 (75.0 ± 37.0)	Guo et al. (2022)
[a]Western tropical North Pacific	0–220 m	[c]2.37	12–54 (34 ± 10)	45.0–114 (61.0 ± 40.0)	Guo et al. (2022)
Jaran Bay	Subsurface	9.15–100.07 (33.23 ± 15.53)	26.5–1695.4 (215.9 ± 172.2)	2.4–67.3 (21.7 ± 11.4)	Lee et al. (2020)
East China Sea coast	Surface	6.99–76.08 (30.20)	11.25–509.58 (214.90)	30.2	Wen et al. (2022)
North of the South Orkney Islands	Surface	13.8 ± 2.6	144.4 ± 21.7	45.9 ± 5.1	Zamanillo et al. (2019a)
South of the South Orkney Islands	Surface	5.5 ± 1.2	48.1 ± 6.5	40.8 ± 10.2	Zamanillo et al. (2019a)
Northwest of South Georgia	Surface	18.0 ± 4.4	125.5 ± 21.1	30.6 ± 5.1	Zamanillo et al. (2019a)
West of Anvers Island	Surface	19.3 ± 3.5	111.6 ± 13.0	25.5 ± 5.1	Zamanillo et al. (2019a)
[a]Open Atlantic Ocean	Surface	1.7–7.1 (4.2 ± 1.9)	18.3–131.7 (59.8 ± 27.4)	34.0–103 (66.0 ± 19.0)	Zamanillo et al. (2019b)
Southwestern Atlantic Shelf	Surface	6.8–44.3 (16.6 ± 15.8)	98.6–427.2 (255.7 ± 130.4)	28.0–110 (73.0 ± 36.0)	Zamanillo et al. (2019b)

[a]Oligotrophic ocean

[b]A factor of 0.51 was used to convert TEP (μg Xeq L^{-1}) to TEP-C (μg C L^{-1})

[c]Calculated from the reported mean TEP concentration and TEP-C/POC ratio

Table S2. Parameters for the calculation of residual $PreNO_X/PrePO_4$ in the Pacific Ocean

Depth (m)/neutral density (γ_n)	f_{DOM}	f_{POM}	r_{POM}	r_{DOM}
0−100 m/γ_n: 24.2−24.7	0.4, 0.5, 0.6	0.4, 0.5, 0.6	6.9, 8.75, 10.6	18.1
γ_n> 24.7	0.4, 0.5, 0.6	0.4, 0.5, 0.6	6.9, 8.75, 10.6	18.9

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