Particle production and transformation in the eastern tropical North Pacific oxygen-deficient zone (ETNP-ODZ) revealed by $\delta^{15}N$-amino acids

Charlotte Lee (wlee4@islander.tamucc.edu)[1], Mark Altabet[2], Alanna Mnich[2], Lin Zhang (lin.zhang@tamucc.edu)[1]

1. Texas A&M University - Corpus Christi; 2. University of Massachusetts Dartmouth;

Introduction

The ETNP region offers a unique opportunity to study particle export due to its high productivity and the presence of an ODZ. It has been suggested that the efficiency of the biological pump in regions with ODZs may be higher as compared to oxic water columns. This may result from additional flux sources such as the primary producers at the secondary chlorophyll maximum (SCM) found in the upper ODZ. Reduced particle attenuation is another possible explanation as zooplankton abundance is very low within the ODZ. Additionally, a secondary zooplankton biomass maximum is present at the lower oxycline that could interact with particles below the ODZ.

In this study, we analyzed the $\delta^{15}N$ of nitrate, phenylalanine (Phe), and glutamic acid (Glu) in particles and zooplankton. The results were compared to those in oxic waters to investigate the sources of particles and the subsequent transformation processes in the ETNP-ODZ.

Sample Collection and Analysis

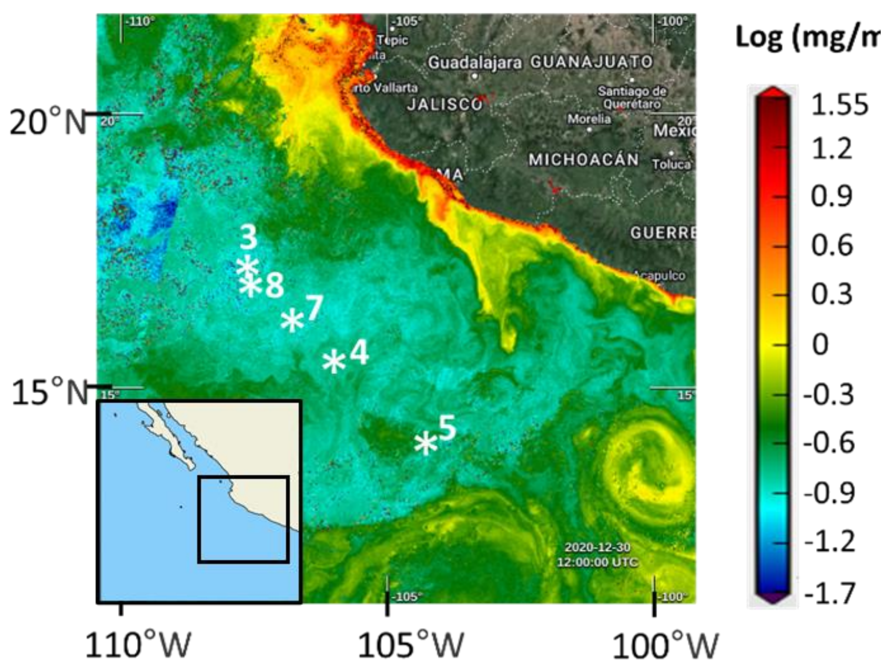

Fig 1. Sampling locations plotted over surface Chl-a retrieved from the Ocean Virtual Laboratory, ESA.

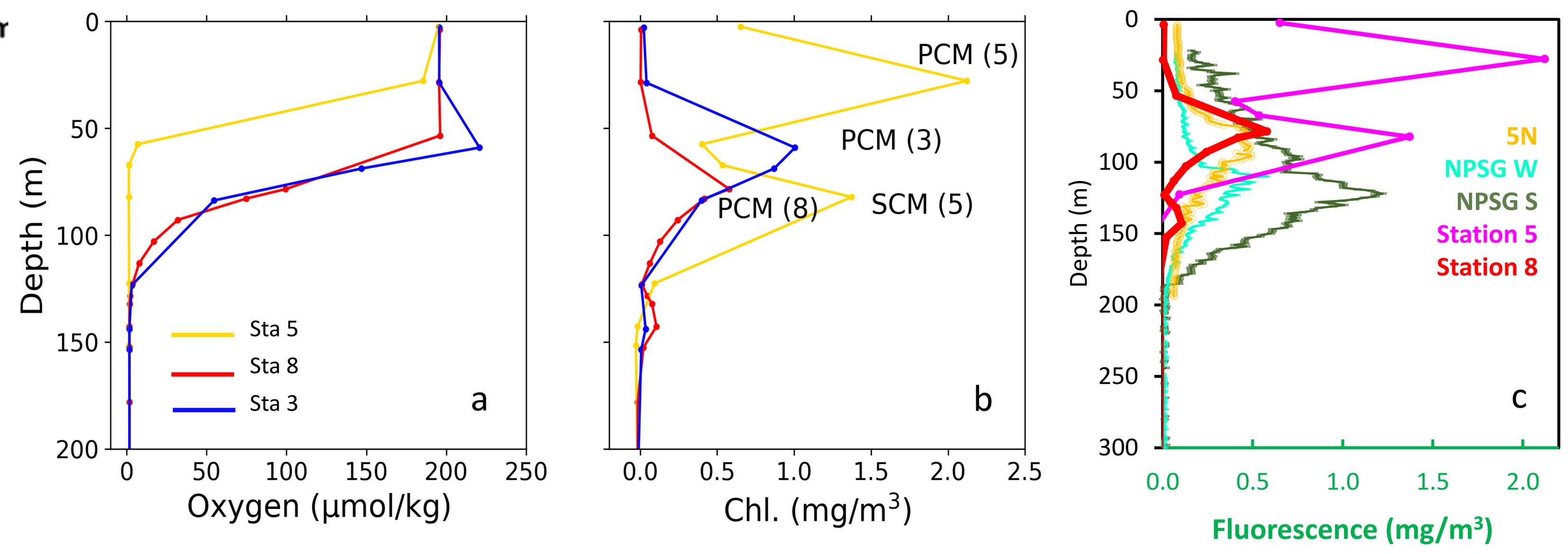

Fig 2. Depth profiles of (a) oxygen and (b) chlorophyll concentrations from 0 – 200 m. Primary and secondary chlorophyll maxima are labelled (PCM and SCM). The numbers in the bracket denote the station number. (c) Fluorescence at Equatorial Pacific (5N and 8N, 155W) stations and NPSG in winter (W) and summer (S) are plotted for comparison[1].

- 200 - 800L of water was filtered in situ using McLane Pump:
  - GF75 Filter: 0.3 - 53 µm → **Suspended particles**
  - Nitex mesh: > 53 µm → **Sinking particles**
- All samples were freeze-dried, homogenized, and analyzed for $\delta^{15}N_{Phe}$ and $\delta^{15}N_{Glu}$ with Ion-exchange chromatography (IC) and purge-and-trap IRMS[2].

$\delta^{15}N_{Phe}$ → $\delta^{15}N$ Baseline of food web, tracking the N source
$TP_{Glu\text{-}Phe}$ → Integrated trophic levels in natural biogenic materials, calculated from the empirical formula[3]:
$TP_{Glu\text{-}Phe} = (\delta^{15}N_{Glu} - \delta^{15}N_{Phe} - 3.4)/7.6 + 1$

$\delta^{15}N_{Phe}$, $\delta^{15}N_{Glu}$, and $TP_{Glu\text{-}Phe}$ of Particles

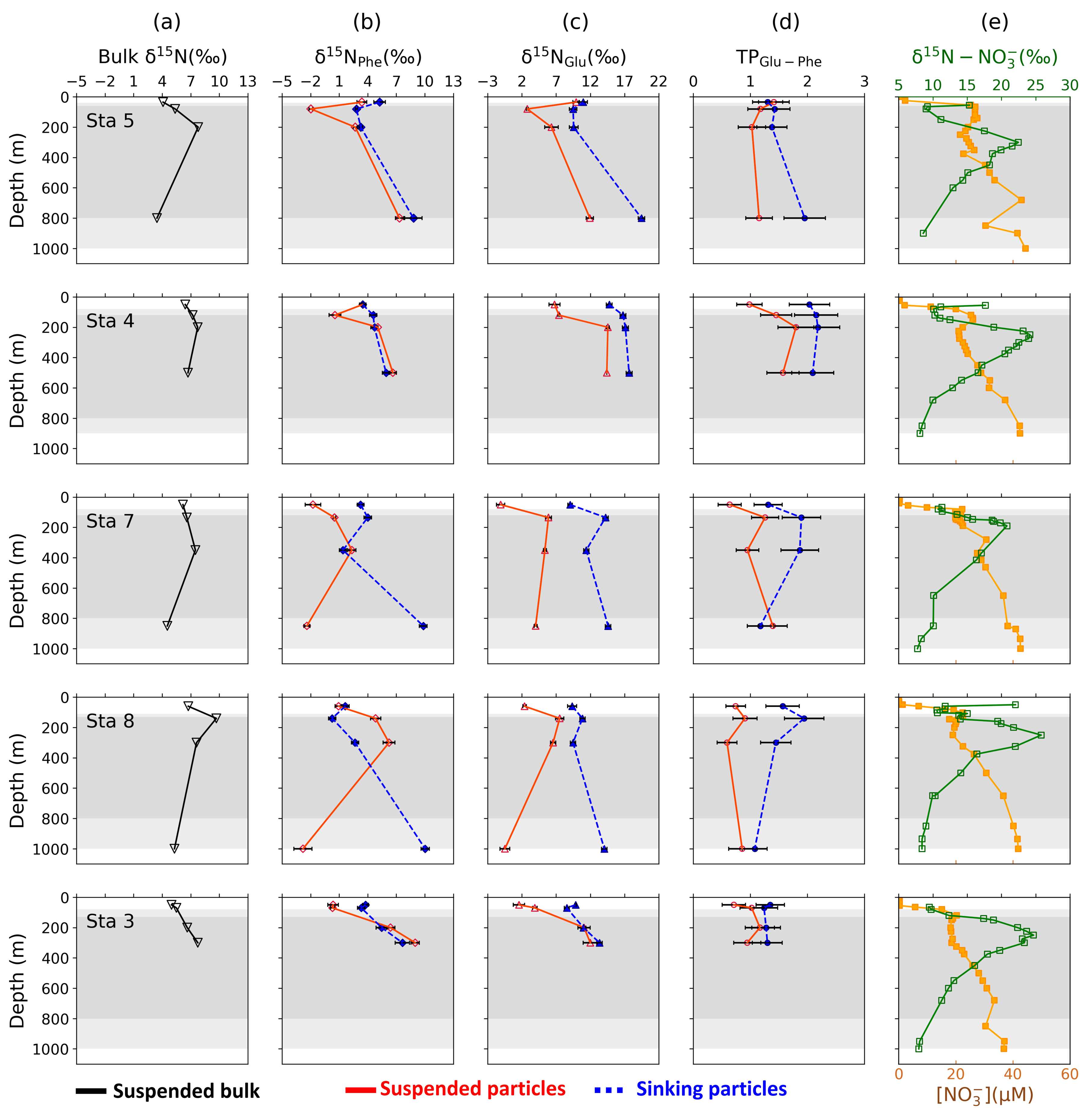

Fig 3. Depth profiles of (a) bulk $\delta^{15}N$ of suspended particles; (b) $\delta^{15}N_{Phe}$, (c) $\delta^{15}N_{Glu}$, (d) $TP_{Glu\text{-}Phe}$ of suspended and sinking particles; and (e) $\delta^{15}N$ and concentration of NO_3^- at the ETNP-ODZ. The dark shaded area denote the ODZ. The upper and lower oxyclines are lightly shaded.

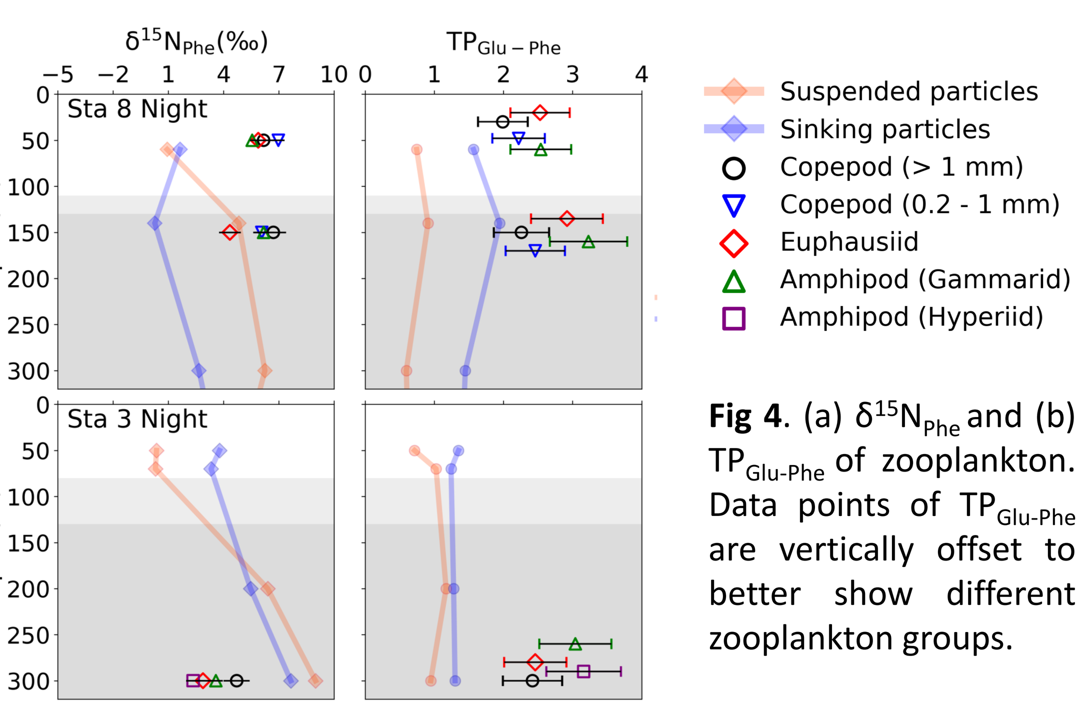

Fig 4. (a) $\delta^{15}N_{Phe}$ and (b) $TP_{Glu\text{-}Phe}$ of zooplankton. Data points of $TP_{Glu\text{-}Phe}$ are vertically offset to better show different zooplankton groups.

- **Zooplankton likely avoids feeding in the ODZ core at Stat 3**
- **Potential feeding at the upper oxycline (UO)/ODZ interface at Sta 8**

Digital version of the poster:

Particle production at PCM and SCM

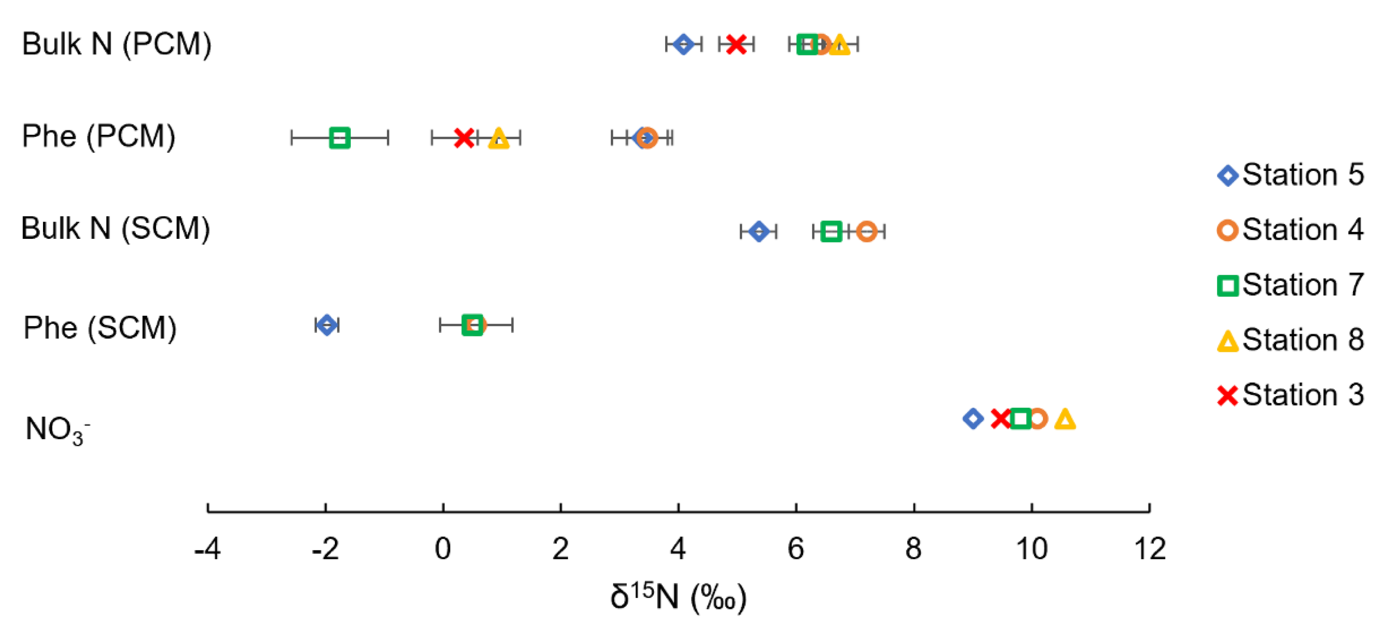

Fig 5. $\delta^{15}N$ of bulk and Phe in suspended particles at the PCM and SCM (Station 5, 4, and 7 only) compared to $\delta^{15}N$ of subsurface NO_3^- below the nitracline.

- **Bulk $\delta^{15}N$ and $\delta^{15}N_{Phe}$ of suspended particles reflect that phytoplankton communities at PCM were supported by both NO_3^- and recycled N**
- **SCM materials contributed to sinking particles at Station 5**

Particle alteration by microbes and zooplankton

- **Heterotrophic microbial remineralization may exert a smaller N fractionation effect on suspended particles in the ODZ compared to oxic water column over the upper 300 m (Fig. 6)**

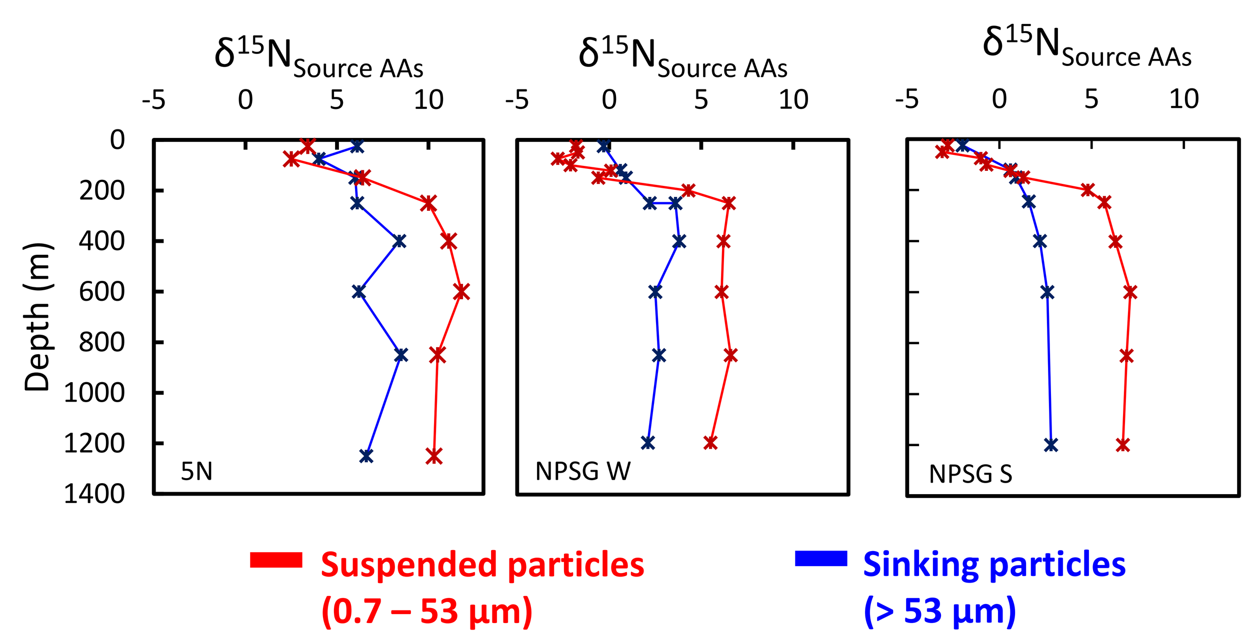

Fig 6. Vertical profiles of $\delta^{15}N$ of a weighted average of source AAs (Gly, Lys, Phe, Ser) in suspended and sinking particles from oxic waters in Equatorial Pacific (5N, 155W)[4] and NPSG: winter (W) and summer (S)[4].

- **Chemoautotrophic production at the lower oxycline (LO) may produce low $\delta^{15}N_{Phe}$ signals in suspended particles**
- **Increase in zooplankton activities and microbial remineralization at the LO elevates $\delta^{15}N_{Phe}$ and $TP_{Glu\text{-}Phe}$ of sinking particles**

References:
1. Popp, B. et al. (2017) *BCO-DMO*. Version Date 2017-02-17.
2. Zhang et al. (2021). *Rapid Communications In Mass Spectrometry*. 35(e9085).
3. Chikaraishi et al. (2009). *Limnology and Oceanography: methods. 7*(11), 740-750.
4. Popp, B. et al. (2018) *BCO-DMO*. (Version 1) Version Date 2018-12-05

Acknowledgements:
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