Hokkaido University
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Response to the Comments from Reviewer #2 (Dr. Kiefer Forsch):

General comments

In this manuscript, Deng et al. take advantage of existing datasets: discrete bottle measurements and vertical microscale velocity fluxuations, to derive diffusive flux of the essential nutrients, iron, nitrate, phosphate, and silicate across an oceanographic transect which extends from the subarctic gyre to the subtropical gyre. The authors relate the derived diffusive fluxes with phytoplankton abundance, separated by taxa using pigment HPLC and CHEMTAX analysis. This work stands to contribute to our understanding of how nutrients and water mass mixing select for specific taxa during the productive summer season. It is important to relate rates of nutrient supply and their ratios to phytoplankton as this would be expected to relate directly to biological metrics, such as growth.

Thank you very much for your positive and constructive feedback on our manuscript. We appreciate your recognition of the relevance of our study to the field.

The manuscript is well-written and constructed in a manner that is easy to follow. I especially like all the figures, they do look almost publication-ready, though could be made slightly larger. I found that while the correlations are the most important contribution (along with derivation of fluxes for this region), the interpretation could be elaborated upon (see listed comments below). I do not think the focus was on phytoplankton responses, but rather relating distributions of specific taxa with vertical fluxes, and the title should reflect this.

Again, thanks very much for the reviewer's comments. We are pleased that you found the manuscript well-written and appreciated the clarity and quality of the figures. As suggested by the reviewer, the title has been changed as follows:

"Distribution patterns of phytoplankton groups controlling by the iron and macronutrient fluxes from subsurface waters in the western North Pacific during summer".

Specific comments

Reviewer#2-1
Line 28: rephrase. I think the main goal is to understand how the environment selects for specific phytoplankton groups.

Thank you for the reviewer's suggestion. We have modified the sentence in the revised manuscript as follows:

"*To understand the factors controlling the supply of Fe and macronutrients, and how the supply would influence the phytoplankton communities, along with the abundance and composition of phytoplankton groups, need to be studied simultaneously.*"

Reviewer#2-2
Line 30: "need to be studied, simultaneously."

Thank you for the suggestion. Accordingly, we have added the word "simultaneously" to the revised manuscript.

Reviewer#2-3
Line 32: I think you could add a sentence of why it is important to understand Fe supply in this region. For example, distribution of zooplankton, fisheries, higher trophic organisms?

Thank you for the suggestion. The following sentences have been added to the revised manuscript:

"*The availability of Fe and macronutrients can influence the higher trophic organisms through primary producers (i.e., phytoplankton). According to FAO (2020), the western North Pacific accounts for 25% of the global fishery production. Therefore, it is essential to know the mechanisms of Fe and macronutrient supply with the response of phytoplankton communities.*"

Reviewer#2-4

Line 38: “A more complete view of Fe biogeochemistry requires oceanic sources also be considered…” I think in this paragraph, it would be good to elaborate a little about why dust deposition doesn’t stimulate blooms. Timescale for biological response versus episodic dust deposition events? Bioavailability of this Fe? Not Fe/P limited (N-limited?).

Thank you for the suggestions. We have added the following sentences to the revised manuscript:

“*Although a few reports indicated that the dust supply stimulates phytoplankton growth in the subarctic Pacific (e.g., Bishop et al., 2002; Hamme et al., 2010), and the anthropogenic source of Fe has high bioavailability (Kurisu et al., 2024), dust-mediated biological production enhancement is still rare to be observed in the ocean because of sporadic aerosol Fe supply and scarce sampling opportunities (Boyd et al., 2010). Therefore, oceanic Fe sources must be considered for the major biological production in the North Pacific (Nagashima et al., 2023).*”

Reviewer#2-5
Line 42: I think for non-trace metal chemists, you might want to indicate that sedimentary Fe is derived from the continental shelves. (see also line 45)

Thank you for the suggestion. We have modified the sentences in the revised manuscript as follows:

In line 42,
“*sedimentary Fe derived from the continental shelves to the western subarctic Pacific…*”.

In line 45:
“*which indicates that sedimentary Fe derived from the continental shelves could be distributed widely*”.

Reviewer#2-6
Line 49: “winter surface mixing” do you mean deep convective mixing?

Yes, you are right. We have changed *"winter surface mixing"* to *"winter deep convective mixing"* in the revised manuscript to avoid confusion.

Reviewer#2-7
Line 53: please put the equation for Si* or be more specific about how silicate and nitrate concentrations are treated.

Thank you for the suggestion. We have modified the sentence in the revised manuscript as follows:

"*Sarmiento et al. (2004) utilized a tracer named Si* (Si* = $Si(OH)_4 - NO_3^-$), which was defined by combining silicate with nitrate…*"

Reviewer#2-8
Line 57: I am not a physicist. By internal tides, do you mean internal tide breaking or isopycnal deformation for the mechanism of mixing?

Yes, it means the breaking of internal tidal waves and isopycnal deformation occurred.

Reviewer#2-9
Line 62: "…North Pacific varies seasonally…"

Thank you for pointing out the mistake. We have corrected it according to the reviewer's suggestion.

Reviewer#2-10
Line 64: "…processes control the seasonal…" What do you mean by variability of the biology? Variability occurs through changing abundance and taxonomy.

Thank you for the comment. We have modified the sentence in the revised manuscript as follows:

"*the seasonal variation of phytoplankton abundance and taxonomy.*"

Reviewer#2-11
Line 66: What do phytoplankton pigment data indicate? A short explanation could help here.

Thank you for the comment. We have modified the sentence in the revised manuscript as follows:

"*phytoplankton community composition as estimated from the pigment data*".

Reviewer#2-12
Line 135: some typos exist in the supplement (line 41)

Thank you for the comment. In the revised version of the supplement, we have modified the sentence in the revised manuscript as follows:

"*The nutrient contents in the depth range Z_1 to Z_2 shrink because the input is smaller than the output.*"

Reviewer#2-13
Line 167: instead of "are mainly contributed by" you could write "the main components derive from"

Thank you for the suggestion. We have modified the sentence in the revised manuscript as follows:

"*the upper NPIW (U-NPIW) and the lower NPIW (L-NPIW), whose main components are derived from the Okhotsk Sea water (OSW) and the Western Subarctic Gyre (WSAG) water, respectively.*"

Reviewer#2-14
Figure 2: I think it would be great if you indicated on these hydrographic sections where the main water masses are located with depth.

Thank you for the suggestion. We consider that the salinity minimum feature shown in Figure 2b indicates the presence of NPIW, and that is written in line 171. However, the

depth of NPIW is variable between areas, so we cannot indicate the water masses by depth.

According to the reviewer's comment, we have also added the following sentence to the caption of Figure 2 in the revised manuscript:

"In Figure 2b, the salinity minimum between the 26.5 - 27.0 σ_θ indicates the presence of U-NPIW. These figures were drawn using the ODV."

Reviewer#2-15
Line 187: How is the "surface layer" defined?

Thank you for the comment. The "surface layer" was defined by the isopycnal surface 22.0 σ_θ, as indicated in Figure 3.

Reviewer#2-16
Line 209: Is this a known behavior for nitrate? Nitrate will act conservatively along a subsurface flow-path only if there are no biological processes occurring, or regeneration is balanced by uptake.

Thank you for the comments. The formation and distribution of nutrient-rich NPIW strongly affect the intermediate water in the North Pacific Ocean (Nishioka et al., 2020). Based on the distribution of NPIW, physical nutrient supply and biological nutrient uptake/regeneration processes are also crucial for determining nutrient concentrations in the study area.

Reviewer#2-17
Line 210: What is a "high concentration"? I would include specific values for these concentrations, or concentration ranges. Similarly, how are the high cores defined as both nutrients have red colors in Figure 4 extending to STG at sigma 27.0. Only station 18 looks exceptionally high.

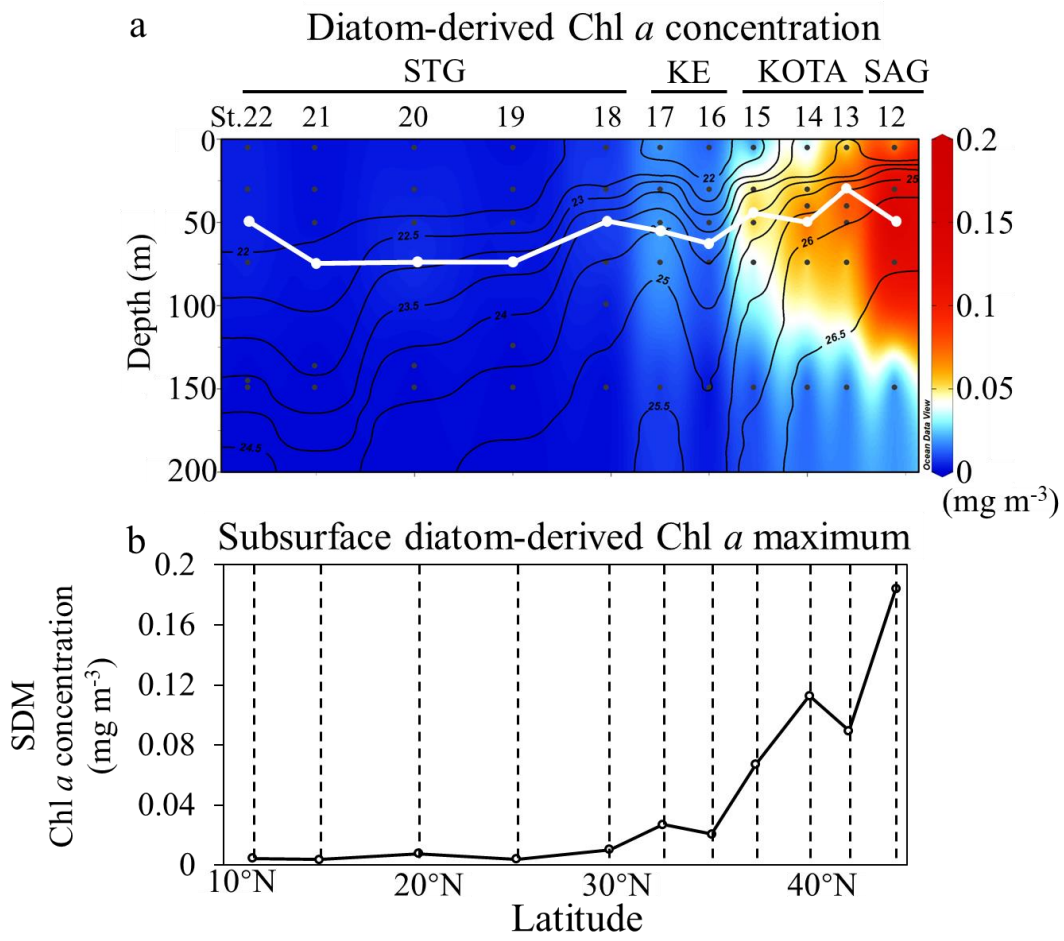
Thank you for the comments. We have defined the high concentration core as nitrate concentration with > 20 μM; therefore, we have modified the sentence in the revised manuscript as follows:

"A high macronutrient concentration core (i.e., nitrate concentration with > 20 μM) deeper than 26.5 σ_θ, extended to the STG."

Reviewer#2-18
Line 231: It can not be discerned from the current color scheme that a "nitrate flux is downward" in Figure 5. It looks to be around zero in the STG below sigma 27.0.

Thank you for the comment. As the order of nitrate flux in the STG below 27.0 σ_θ is 10^{-11} – 10^{-8}, it is hard to show the color in the figure, so it seems like the value is zero.

Reviewer#2-19
Figure 7: It would be nice to see a line which indicates the depth of maximum diatom-derived chlorophyll-a on the section plot. This could be drawn between profiles for where diatoms are present.



Thank you for the suggestion. The white line has been added to indicate the depth of SDM and a sentence has been added to the caption of Figure 7 in the revised manuscript:

"Section profiles of (a) diatom-derived Chl a concentration (mg m^{-3}), (b) the subsurface diatom-derived Chl a maximum (SDM) concentration (mg m^{-3}) at each station. In Figure 7a, the white line indicates the depth of SDM. Figure 7a was drawn using the ODV."

Reviewer#2-20
Line 276: "…dFe flux…"

Thank you for the comment. We have modified the sentence in the revised manuscript as follows:

"between dFe flux, macronutrient fluxes, and phytoplankton abundance…"

Reviewer#2-21
Line 279: What is meant by "…influence the diatom-derived Chl a…"? You could describe the trend in the plot.

Thank you for the comment. We have modified the sentence in the revised manuscript as follows:

"Based on the values of r^2 and p-values, dFe and Si fluxes are more highly correlated with diatom-derived Chl a concentration than nitrate and phosphate, indicating that dFe and Si fluxes had higher impacts on the diatom abundance."

Reviewer#2-22
Line 283: In fact, I think these were diatoms which responded to the Fe additions (silicate was drawn down). A feature that is often seen in HNLC and HNLC-like waters.

Thank you for the comments. We have cited some previous studies, including Fe fertilization experiments and Fe-addition bottle incubation experiments, which indicated that dFe addition stimulated the diatom growth and supported our conclusions.

Reviewer#2-23
Line 285: "…diatoms form silicified frustules…"

Thank you for the comment. We have corrected it accordingly.

Reviewer#2-24
Line 314: Please indicate what is meant by "nitrate plus nitrite".

Thank you for the comment. In this study, we used nitrate concentration solely to calculate the nitrate flux. On the other hand, Endo and Suzuki (2019) used "the combined concentration of nitrate and nitrite" for their discussion.

Reviewer#2-25

Line 338: It is well-known that diatoms occupy high nutrient regimes due to their competitive advantage over slow-growing small cells. Diatoms have high affinity uptake of nitrate and have many strategies to store nutrients when available. I wonder if you could include some discussion of how *pro* occupies oligotrophic conditions (where negative flux can occur) due to their ability to deal with lower nutrients through small cell size, slow growth rates, and lower nutrient requirements. Some discussion of these well-known features which drive phytoplankton distributions would provide more context of these great findings. Few studies connect supply ratios with phytoplankton, which is more indicative of the conditions phytoplankton experience (compared to static concentration measurements).

Thank you for the comments and suggestions. We have added the following sentences to the end of this paragraph in the revised manuscript:

"Additionally, Prochlorococcus are generally expected to deal with lower nutrients due to their small cell size, lower nutrient requirements, and lower maximum growth rates (Patensky et al., 1999). The ecophysiological features of Prochlorococcus could make them more adapted or acclimated in the N-limited STG (Fig. 6a) with lower nutrient conditions (Fig. 4a-d)."

References

FAO: The State of World Fisheries and Aquaculture 2020. Sustainability in action, FAO, Rome, Italy, 244 pp., ISBN 9789251326923, 2020.

Partensky, F., Hess, W. R., Vaulot, D.: *Prochlorococcus*, a marine photosynthetic prokaryote of global significance. Microbiol. Mol. Ecol. Rev., 63, 106-127, https://doi.org/10.1128/mmbr.63.1.106-127.1999, 1999.

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