Title: Joint effect of freshwater plume and coastal upwelling on phytoplankton growth off the Changjiang River (bgd-2013-191)

We gratefully thank Anonymous Referee #2 for the comprehensive comments and suggestions. Please find our replies to all comments below. In addition, the revised contents of the manuscript were showed with blue color. Meanwhile, we apologized unreservedly that we used the wrong unit for displaying the chlorophyll normalized specific APA (APA_{Chl}) in the manuscript. The corrected unit of APA_{Chl} should be [μmol mg Chl^{-1} h^{-1}]. All the relative mistakes have been revised in the manuscript. We also redrew the symbols of the stations in Fig. 1 and Fig. 7 for getting better representation.

Major comment *(p.10366 line 22-24): "none study was conducted for the distributions of APA in this region, particularly, during flood period" This statement is not true. Very recently, Liu et al. (2013) used APA and the maximum quantum efficiency of photosynthesis (Fv/Fm) to evaluate the status of microphytoplankton phosphorus stress during the summer flood seasons on the East China Sea (ECS) shelf, in which the authors found that the phosphorus status of microphytoplankton was largely controlled by the Changjiang plume and coastal upwelling. This would be very interesting to see a comparison between the present work and Liu et al's findings.*

Response

Thanks for providing this instant information. Indeed, both studies stated the co-effects of Changjiang discharge and coastal upwelling on phytoplankton P stress. In the revised Introduction the sentence "To our knowledge, none study was conducted for the distributions of APA in this region, particularly, during flood period." had been removed for avoiding an improper statement. Meanwhile, the comparison between Liu et al.'s findings and our study were arranged in the Section 4.4. The revised paragraph is shown below (p. 18, line 7-18):

"Besides nutrient-replete CJ plume, in ECS, Liu et al. (2010 & 2013) explored the P-stress of microphytoplankton by using APA and the maximum quantum efficiency of photosynthesis (Fv/Fm) assay. Similarly, the expression of APA was blocked in the surface of upwelling region, and high APA was recorded in the surface of CJ plume fringe. Both studies agreed well that physical processes, such as river plume and coastal upwelling, play major roles in regulating phytoplankton P-status and thus APA expression. Note that, the values of APAChl in our study are much lower than those reported in ECS due to methodology. In our study, we analyzed the bulk APA by concentrating the water sample directly, while their analysis in ECS was majorly for microphytoplankton collected by phytoplankton net. More studies are required to discern the major contributors to APA and Chl-a for exploring phytoplankton-driven P dynamics."

Major comment *(p.10373 line 27 to p. 10374 line 15): The NKBC not only injects nutrients into the CJ plume system, but also carries nutrients out of the system. Instead, the CJ River only discharges nutrients into the system. Therefore, I don't think that the estimate can shed light on the conclusion that the NKBC is the most important P supplier to this area.*

Response

Thank you for the comment. In this section we tried to verify that CJ discharge has potential forcing CJ plume ecosystem toward more P-limitation by continuously disproportionate nutrients injection with high N/P ratios. And the simple calculated result from the estimation of relative nutrient contribution by CJ discharge seemed to satisfy the statement (Table 1). We feel very sorry that the incoherent sentence mistook the focus. To make the topic clear we have removed the misleading sentence "however, NKBC is still the most important P supplier to this area" in the article with the revised paragraph shown as follows (p. 11, lines 6-13):

"The estimated fractional contribution of N from CJ discharge increased from 8–19% to 36–58% in past 4 decades. Similarly, P contribution from CJ discharge increased from 1–4% to 11–24%. Obviously, the nutrient entry from CJ discharge had increased significantly and the imbalance of dissolved N/P ratios had developed gravely in CJ plume. This estimate is rough; however, telling us that CJ plume ecosystem has a tendency toward P-limitation and it seems that we have passed the threshold of 16 (N/P=19–25 in present day, Table 1)."

Major comment *(p.10379 line 6-7): The criteria used to separate all surface waters into three categories (turbidity-influenced, upwelling-influenced, and plume fringe) should be clearly defined.*

Response

Thanks for the mention. In the revised manuscript, we have added the criteria for identifying the three categories. We also redrew the station symbols in Fig. 1 for displaying the three categories. The inserted and revised sentences were shown as follows (p. 15, lines 21-30):

"In addition, the stations were classified into three categories—turbidity-influenced, upwelling-influenced, and plume fringe (Fig. 1), based on physical and geographical features mentioned before for further comparison. The stations shallower than 10 m with visible TSM were classified as the turbidity-influenced region. According to the temperature variation, we recognized that the upwelling outcropped at the seaward side of the turbidity front due to the geographically dramatic changes. Thus the stations located on the sharp geophysical uplift were classified as the upwelling-influenced region. Other stations with the surface salinity higher than 29.5 were classified as the plume fringe region."

Minor comment (*p.10368 line 1; p.5 line1): a typo "warped"*

Response: We have revised "warped" to "wrapped" in the manuscript (p. 4, line 26).

Minor comment (p.10371 line 6-7): Please explain why the trend in QT estuary was above that of CJ estuary.

Response

Thanks for the comment. We have added the explanation in the article (p.8, lines 4-7). The inserted sentence is "We suggested that such high nutrient trend in funnel-shaped QT estuary was caused by procrastinated water exchange due to strong tidal effects and/or prohibited biological consumption by phytoplankton due to high water turbidity." Basically, estuary is a dynamic ecosystem with a free connection between freshwater and seawater. Thus, the nutrient concentrations in estuary are mainly controlled by physical mixing between freshwater and seawater masses. QT estuary is a typical funnel-shaped estuary frequently suffered by intense tidal actions. The water exchange in QT estuary would be procrastinated by the strong tidal effect. Therefore, the nutrient trends of QT estuary following with the salinity might be higher than those of CJ estuary due to its poor water exchange. In addition, chemical transformation and biological consumption are two common forces shaping the nutrient status in estuaries. During the study period, higher TSM concentrations were observed in QT estuary than in CJ estuary within the salinity 0—15. In addition, we recorded relative low Chl-*a* concentrations, implying the growth of phytoplankton was limited in QT estuary. We suggested that the nutrient utilization from biological consumption in QT estuary might be slower than that in CJ estuary. Therefore, we would see higher trends of nutrients in QT estuary comparing to those in CJ estuary.

Minor comment *(p.10372 line 3-4): CDW was defined as water with salinity <31 by Gong et al (1996).*

Response: Thanks for the revision. We have revised the CDW definition in the manuscript (P. 9, lines 3-4).

Minor comment *(p.10374 line 6): a typo "appled".*

Response: We have revised "appled" to "applied" (p. 11, line 3).

Minor comment *(p.10375 line 27-28): Is there any reference that can explain why allochthonous APA is so high in the nutrient-replete freshwater (both N and P)?*

Response

Thank you for the comment. We have added the critical reference and restated the paragraph in Section 4.2. The relative sentences are shown below (p. 12, line 19-27):

"For the inner estuary, APA decreased as salinity increased (Fig. 4f), indicating the dilution of allochthonous APA had occurred. Meanwhile, increase of Chl-a concentrations happened at the same time (Fig. 4e). Under such condition of high nutrient availability, the inverse relation between APA and Chl-a indicated phytoplankton growth did not suffer from P-limitation. We suggested that the high allochthonous APA was likely sourced from limnetic heterotrophic bacteria (Cao et al., 2010). Studies have confirmed that bacteria would excrete AP to utilize C from DOM in nutrient-repleted but light-limited environments for satisfying their C-demand instead of P-demand (Van Wambeke et al., 2002).

Minor comments *(p.10377 line 15-16): I don't understand why fast nutrient consumption would cause high N/P ratios in surface waters in the bloom area, unless the organic matters are produced with an extremely low N/P ratio. Additionally, is* *there any published N/P ratio of particulate organic matter in this area?*

Response

This is indeed an incomprehensible point and your suggestion is highly reasonable. Phytoplankton, as one of the major biotic reservoir of nutrient in aquatic ecosystems, their elemental inventories have fundamental capacity in shaping the dissolved C/N/P ratios in water. Arrigo (2005) explained the consequence of diverging nutrient stoichiometry within phytoplankton by adopting the "optimal phytoplankton stoichiometry model" developed by Klausmeier et al. (2004). Basically, phytoplankton bloomers contain low N/P ratios (<10) in bodies since they comprise high proportion of growth machinery for adaption during the exponential growth. The growth machinery, such as ribosomal RNA, owns its unique stoichiometric properties with a low N/P ratio. Consequently, biological remove with low N/P ratios would force high dissolved N/P ratios in systems. In our study, we observed relative high N/P ratios in the surface water accompanying with the phytoplankton bloom emerged. We suggested that the distinct nutrient stoichiometry of phytoplankton bloomers could sharply modified the dissolved N/P ratios of the surrounding water by atypical nutrients absorption. Unfortunately, there are limited articles describing the N/P ratios of POM in this area (PON/POP = 3.3－18; Yu et al., 2012). The necessary reference has been cited in the article (p. 14, lines 4-7).

Minor comment *(p.10379 line 17-19): As mentioned by the authors, the upwelled water is featured by low N/P ratio. So, I don't understand why upwelling may lead to low APA values corresponding to high N/P ratios.*

Response

Thanks for the critical comments. Although the upwelled water brought abundant nutrients with low N/P ratios to the surface, it seems that the water just satisfy the P-demand of phytoplankton for continuing growth. In the upwelling zone (Stations Y9 and Y9a), we observed phytoplankton blooms taking place at the surface. However, we noticed that the phosphate concentrations were below the detect limitation while the DIN concentrations still remained. This might be explained by the strong phosphate utilization of phytoplankton during blooming period (Arrigo, 2005). In that case, we would see high N/P ratios but still low APA values. The APA results are consisted with Liu et al. (2013). We have aggregated the necessary information in the section 4.3 of the manuscript (p.16, lines 12-15).

References

Arrigo, K. R.: Marine microorganisms and global nutrient cycles, Nature, 437, 349－355, 2005.

Cao, X., Song, C., and Zhou, Y.: Limitations of using extracellular alkaline phosphatase activities as a general indicator for describing P deficiency of phytoplankton in Chinese shallow lakes, J. Appl. Phycol., 22, 33－41, 2010.

Gong, G. C., Lee Chen, Y. L., and Liu, K. K.: Chemical hydrography and chlorophyll a distribution in the East China Sea in summer: implications in nutrient dynamics, Cont. Shelf Res., 16, 1561–1590, 1996.

Klausmeier, C. A., Litchman, E., Daufresne, T., and Levin, S. A.: Optimal nitrogen-to-phosphorus stoichiometry of phytoplankton, Nature, 429, 171－174, 2004.

Liu, H. C., Gong, G. C., and Chang, J.: Lateral water exchange between shelf-margin upwelling and Kuroshio waters influences phosphorus stress in microphytoplankton, Mar. Ecol. Prog. Ser., 409, 121－130, 2010.

Liu, H. C., Shih, C. Y., Gong, G. C., Ho, T. Y., Shiah, F. K., Hsieh, C. H., and Chang, J.: Discrimination between the influences of river discharge and coastal upwelling on summer microphytoplankton phosphorus stress in the East China Sea, Cont. Shelf Res., 60, 104－112, 2013.

Yu, Y., Song, J., Li, X., Yuan, H., and Li, N. Distribution, sources and budgets of particulate phosphorus and nitrogen in the East China Sea, Cont. Shelf Res., 43, 142－155, 2012.

Van Wambeke, F., Christaki, U., Giannakourou, A., Moutin, T., and Souvemerzoglou, K.: Longitudinal and vertical trends of bacterial limitation by phosphorus and carbon in the Mediterranean Sea, Microb. Ecol., 43, 119–133, 2002.