

Dear reviewer,

We deeply appreciate your comments and efforts towards improving our manuscript. We have revised the manuscript seriously according to your valuable criticisms and suggestions. For the revision, please kindly refer to the point-to-point responses and the revised manuscript.

Responses to Referee #2

General comments

In this paper, 1st, the authors concluded the high CHL values in the seawater bring the low efficiency of light absorption caused by the package effect. But the authors should understand the difference & similar of “package effect” and “Self-shading effect”. It seems that the “Total chlorophyll concentration” (Tchl-a) values influence on the Package effect. But “Self-shading effect” is more close to explain low efficiency of light absorption. (section 4.1). Maybe this is a reason why you have low relationship between a_{ph}^* and T chl-a.

Response: Thank you for your valuable comments. We agree with you that both the “package effect” and “self-shading effect” can lower the efficiency of phytoplankton light absorption. We understand for package effect, the reason is heterogeneity in the distribution of algal pigments within a cell which is related to cell size and intracellular pigment concentration. We believe for self-shading effect there are several reasons; 1) shading of cells that aggregate in a colony; 2) shading of cells caused by high density of particles remained on the filter. Subramaniam et al. (1999) reported that aggregation of *Trichodesmium* led to a self-shading effect which reduced $a_{ph}^*(\lambda)$, while this kind of situation was not encountered in our study because we did not find *Trichodesmium* during the observation. During data collection, we adjusted filtration volume of water samples (0.3–1 L) to avoid high density of particles on the filter. The optical density of particles was kept below 0.3 which was also consistent with the data range used by Mitchell (1990) and Cleveland and Weidemann (1993). So, we believe this is also not the problem.

According to previous studies in the global ocean and also our results in the Tsushima Strait (TS), large phytoplankton which have strong packaging effect dominate in high Tchl *a* waters, and small phytoplankton which have low packaging effect dominate in low Tchl *a* waters. This makes Tchl *a* value like an index of packaging effect, and

correlate with $a_{ph}^*(\lambda)$.

However, in the East China Sea (ECS), the correlations of size-fraction with Tchl a were not observed. At high Tchl a levels, high fractions of pico- and/or nano-phytoplankton and low micro-phytoplankton were observed. Consistently, the $a_{ph}^*(\lambda)$ was higher than values derived from the global regressions between $a_{ph}^*(\lambda)$ and Tchl a , and these samples resulted in low correlations between $a_{ph}^*(\lambda)$ and Tchl a . These findings supported that, in general, phytoplankton size structure, therefore the packaging effect should be an important factor influencing $a_{ph}^*(\lambda)$ and then the correlations between $a_{ph}^*(\lambda)$ and Tchl a .

We have added filtration volume and the maximum of optical density of particles to ensure avoiding of the high density of particles on the filter, and also added some discussions about self-shading effect in the revised manuscript.

2nd, the conception of package effect is not only exist in the light absorption but also in the light scattering. So you should express at least in first time you mention the “package effect on light absorption” After that you can say just “package effect”

Response: Thanks for this suggestion. We have revised accordingly.

3rd, the package effect is explained, in other word, “effect on discreteness”(Morel & Bricaud, 1981). And please explain who the first user is for the term of “package effect”.

Response: Duysens (1956) described that the absorption spectrum of a suspension particles was flattened due to heterogeneity in the distribution of algal pigments within a cell. This phenomenon was sometimes referred to as the “sieve effect”. Kirk (1975) suggested a better name for the phenomenon as the 'package effect', and stated this was essentially the same as ‘packaging effect’ which was named in earlier study of Bannister (1974). In conclusion, for the term of “package effect”, Dr. Kirk should be the first user.

We have included this point in the revised manuscript.

The filter technique (Kiefer & Kishino) has lot of problem to measure the real phytoplankton absorption coefficient (a_{ph}). i.e, optical path amplification (β) and

self-shading effects. Of course, you corrected the a_{ph} by using Cleveland & Weidemann(1993) equation. It's the only easy way to measure the separated a_{ph} from a_{total} .

Response: Thanks for this comment. As you pointed out, although the filter technique has some problems, it is a practical and widely used method to measure $a_{ph}(\lambda)$. In this study, we corrected optical path amplification following the calculation of Cleveland and Weidemann (1993). As described above, to avoid high density of particles on the filter which may lead to self-shading effects, we adjusted filtration volume according to experiences for water conditions.

In your final results, you say that a_{ph}^* was poorly correlated with Tchl-a in coastal region. But you don't have any proof caused by influence of "river discharge". This conclusion is too much a jump in the logic (see also question-1). The reason can be possible from the low saline water but also turbid water (bad absorption measurement), nutrients from bottom or other hydrological reasons. So I recommend you change of title;

□ Phytoplankton light absorption properties: a case study in the East China Sea and Tsushima Strait

Response: Thanks for these comments. In our study, we found $a_{ph}^*(440)$ was poorly correlated with Tchl a in surface low salinity waters and SCM waters taken just beneath them, and $a_{ph}^*(440)$ was higher than values from the global regression. These absorption properties can be generally explained by phytoplankton size structure. But honestly, what exact factors influencing phytoplankton size structure in ECS is not easy to ascertain at this stage. As you suggested, the reason may be interactions of a couple of factors. We speculated the nutrients structure (high N/P ratio) changed by the Changjiang might be a possible factor.

We have revised the abstract, discussion and conclusions to straighten out the logic. Accordingly, the title has also been changed to "Phytoplankton absorption properties in river-influenced region: a case study in the East China Sea".

Key Questions:

1) Page 14480, section 2.2;

You subtracted the absorption values at 750nm, assuming no absorption in this wavelength. It is true if the seawater is CASE-I water where the phytoplankton absorption dominate total absorption. But in the ECS where you sampled water are not CASE-I water. It exist obviously the mineral particles. In case, your assumption can make a mistake, because the mineral absorption curve is not flat with wavelength. It can make seriously error absorption coefficient in the blue bands. Please explain clearly & logically the assumption is valid.

Response: Thanks for these comments. We agree with you that non-phytoplankton particles may have absorption at 750 nm in case II waters. Values at 750 nm may also come from baseline shift. In our measurements, absorption of non-phytoplankton particles which were measured after pigments extraction showed clear exponential shape, but some baseline shift. We subtracted values at 750 nm just wanted to correct the baseline shift.

We understand that the commonly used way to calculate phytoplankton absorption coefficient ($a_{ph}(\lambda)$) is:

- 1) Calculate $a_{ph}(\lambda)$ as the difference between absorption coefficient of total particles ($a_p(\lambda)$) and non-phytoplankton particles ($a_{nph}(\lambda)$).
- 2) Correct baseline shift by subtracting value at 750 nm from the whole spectrum (assuming $a_{ph}(750)$ of 0).

During our data process, we attempt to obtain not only reasonable $a_{ph}(\lambda)$ but also $a_p(\lambda)$ and $a_{nph}(\lambda)$ with correction of baseline. So, we

- 1) Correct baseline shift for $a_p(\lambda)$ and $a_{nph}(\lambda)$ by subtracting values at 750 nm from the whole spectrum.
- 2) Then, calculate $a_{ph}(\lambda)$ as the difference between $a_p(\lambda)$ and $a_{nph}(\lambda)$.

Actually, these two ways give the same phytoplankton absorption coefficient. If we use $a_{ph}^1(\lambda)$ to stand for phytoplankton absorption coefficient in commonly used calculation way; and $a_{ph}^2(\lambda)$ to stand for phytoplankton absorption coefficient in our current calculation, our calculation can be expressed as

$$\begin{aligned}
 a_{ph}^2(\lambda) &= [a_p(\lambda) - a_p(750)] - [a_{nph}(\lambda) - a_{nph}(750)] \\
 &= [a_p(\lambda) - a_{nph}(\lambda)] - [a_p(750) - a_{nph}(750)] \\
 &= a_{ph}(\lambda) - a_{ph}(750) \\
 &= a_{ph}^1(\lambda)
 \end{aligned} \tag{R1}$$

It can be seen that $a_{ph}^2(\lambda)$ equals $a_{ph}^1(\lambda)$.

We have to admit that our current data processing method may underestimate absorption coefficient of total particles and non-phytoplankton particles, since in turbid waters $a_p(750)$ and $a_{nph}(750)$ may not be 0 as you suggested, while anyhow they are not the focus of this study.

2) Page 14481, section 2.2

It is very confusing process for the absorption coefficients calculation. You subtracted the 750nm values in all wavelengths. It means that already you removed $a_d(\lambda)$ values, but in Eq.(3) you subtract again the $a_d(\lambda)$ by using the Kishino technique. In case you will have negative values at 750nm and naturally the blue band absorption coefficient will be distorted.

Response: Thanks for these comments. As explained in question 1, we subtracted values at 750 nm from all wavelengths in order to correct baseline shift for $a_p(\lambda)$ and $a_{nph}(\lambda)$. Then we calculated $a_{ph}(\lambda)$ as the difference between $a_p(\lambda)$ and $a_{nph}(\lambda)$ as described in Eq. R1. In this case, $a_p(\lambda)$ and $a_{nph}(\lambda)$ may be underestimated as you suggested, but they were not the focus of this study.

We deleted the confusing sentence that “OD_f(750) was subtracted from all wavelengths to minimize the difference between the sample and reference filters, assuming no absorption at 750 nm”.

<Suggestion>

The values 750nm by QFT comes from by 2 reasons ;

1. Optical base line shift in the dual-beam spectro-radiometer during the absorption measurement. => It's ghost value.
2. Detritus particles absorption (including mineral & biological particles).
=>It's real absorption values.

In case-1. Your assumption is OK

In case-2. Your assumption is bad.

<Suggested technique>

1. Neglect your assumption; $a_p(750) = 0$.

2. Use directly Kishino technique.

3. If you have still $a_d(750) \text{ nm} \geq 0$

Consider this as real values

4. Calculate $a_{ph}(\lambda)$ using Eq.3

5. Make new base line with assumption $a_{ph}(750) = 0$.

Maybe it is possible to explain why you have bad relationship between a_{ph}^* & TChl-a in the ECS (Fig. 9). In your conclusion, your logic was jumped without any proof.

Response: Thanks for your suggestions. There are great help. We have revised the abstract, discussion and conclusions to make logical statements.

Reference

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