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Interactive comment on "Carbon Flux Explorer Optical Assessment of C, N and P Fluxes" *by* Hannah L. Bourne et al.

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Response to Reviewer 1
Thank you for the prompt review of our paper. We appreciate your insight and the paper will be improved as a result. Below, in black are your review comments and our individualized responses are found in italicized blue. We will address all of the major (I through IV) and minor points (1 through 11) as indicated and hope you find them satisfactory.

Comments on Bourne et al. paper

This paper conducts quantitative discussion on the relation between beam attenuation and settling particulate organic carbon / nitrogen / phosphate using Carbon Flux Explorer with time-series particle collector (CFE-Cals). In order to study the biological pump for quantifying CO2 transport to the ocean interior, sediment trap experiment has been conducted all over the world ocean. However, moored or surface-tethered or even neutrally buoyant sediment trap has some specific disadvantages such as trapping efficiency and swimmer effect. In addition, it is hard to say that these "cost-performance" is high (need manpower and "ship time"). Nowadays, application of optical sensors such as transmissometer and backscatter meter to the study of marine particulate materials has been becoming more popular. However, although several scientists including one of co-authors (Prof. Jim Bishop) have been making big efforts to calibrate optical data to actual POC and PIC flux, quantitative conversion of optical data to actual POC data is still on argument because optical observation spatiotemporally synchronized with particle observation has been difficult. Owing to development of CFE-Cals, this study has overcome this problem successfully, succeeding to Estapa et al. (2017). Thus, this paper is valuable for publication. However, I have some question and requests. Especially, discussion on comparison of previous reports is insufficient (explanation of previous papers is ambiguous). I would like to ask authors to make medium revisions as follows.

Major Points

(I) I cannot follow how authors drew Fig.6, especially regression line or previous papers. Please explain how to estimate respective POC: VAF relations of Estapa et al (2017) and Alldredge (1998) (there is no direct description about this relation in the original paper unlike Bishop et al. 2016 (1.0/2.8)) in section 3.4 Comparison to previous studies (or in supplement).

Estapa calculates attenuance by taking the natural log of transmittance. She reports it in units of ATN m2 m-2 d-1. Our data are log10 transforms of transmittance as documented in Bishop et al. 2016 and reported in units of mATN cm2 cm-2 d-1. Therefore, Estapa's data has been divided by 2.303 to convert the natural log attenuance to log10 *attenuance and multiplied by 1000 to scale to mATN units. The dimensional data do not require scaling.*

Bishop et al. 2016 derive the conversion factor for POC:VAF for Alldredge which is 17 times lower than the Bishop et al. 2016 factor of 2.8. Therefore, since axes in the figure are reversed, 2.8/17=.165 compared to our slope of 1. The slope for the Alldredge relationship is 6.

We will clarify section 3.4 as suggested.

(II) According to Figure A4 (Photograph of the surface-tethered BUOY-OSR) in Bishop et al. (2016), it seems that CFE-Cals was installed on the BUOY-OSR. I wonder if this data is not available. Although Bishop et al (2016) concluded that data obtained by BUOY-OSR is underestimated or sampling efficiency is low, if there is data, comparison of optical data and collected settling particle can be possible, POC/ATN relation can be proposed, and comparison of this data and present data can be possible.
At the time of the 2013 experiments with the BUOY-OSR, we had hoped that analysis of the samples for P scaled by the Redfield ratio would yield carbon. We used Supor filters and analyzed the samples for phosphorous by ICP-MS with this in mind. However, we have shown in this paper that the regression of VA:PP when forced through zero (r^2 less than 0) is worse than a random variation around a horizontal line; and only by selecting against the Anchovy pellet dominated sample do we get an r^2 of 0.4. In contrast we have an r^2= .87 for VA:POC or VA:PN for all samples. The material on Supor (polysulphone) filters cannot be analyzed for POC and PN. Given the fact that phosphorous to attenuance relationship is highly scattered and we do not have POC or PN data, we do not think the BUOY-OSR data are useful to include.

We are prepared to mention this in the text, but don't think it adds to the paper.

(III) The configuration figure of CFE-Cals like Figure A1 of Bishop et al (2016) is great helpful for readers to understand CFE-Cals. I strongly recommend authors to add configuration figure of CFE-Cals to this paper.
We agree strongly with this reviewer that platform/sampler documentation should be provided. This detail is usually not found. Figure 2 in the main text shows the sampler in its installed context and the flow path through sampler. In the appendix, we provide an image of the key element of the sampler. Figure A2 and its caption describe sampler and sampler flow logic.

We will include additional appendix image(s) to provide more detail of the overall configuration and the CFE-Cal sampler.

(IV) When large amount of settling particle or gigantic settling particle cover over window, settling particle which settle down on covered window cannot be counted and amount of particles or PC must be underestimated with ATN. What do authors think about this?
As light is reduced exponentially as it passes through particles, as long as the overlapping particles do not 100% obscure the transmitted light, attenuance affects are additive. In our analysis, the transmitted light even in the presence of multiple overlaid large aggregates, never went to zero (in other words, attenuance was never saturating, Bishop et al., 2016). Therefore, overlapping is not an issue.

Bishop et al. (2016) discuss the stepwise subtraction of successive attenuance images to derive particle size distribution in the case of overlapped particles (section 2.3). This procedure was required for their estimation of POC to VA. The image set for which this was done is provided in the 2016 supplemental online materials. In the treatment of imagery, we restrict our size-distribution analysis to cases where *overlapping effects are minor - this was how the Bishop et al. (2016) SD's were estimated. This had to be done by eye. We are working to implement such an analysis on the CFE.*

Minor Points

(1)Page 1 Line 12 (P1L12) Why did not authors measure Ca with ICPMS? Because Bishop (co-author) reported that "we have no data on the conversion of PIC(POL) to PIC(flux)" in his previous paper (Bishop et al. 2016).
The VA:PP,PN,POC calibration was the priority for this paper and required by our funding. We did measure Ca with the ICPMS for the samples. As the filters had large amounts of residual sea salt, the separation of the non-salt Ca requires very high accuracy and a separate protocol. We are still working on this and the analysis of the cross-polarized light imagery.

We do have an accurate and physically based measure of particle birefringence (cross polarized photon yield), which is discussed by Bishop et al., (2016). When a calibration becomes available, all previous results can be translated into units of PIC.

We will clarify the text.

(2) P5L14 Please explain why Fluorinet (3M) was selected as initial liquid. *Fluorinert was selected as it is clear (necessary as there was an optical encoder in the pressure compensated chamber), low viscosity (for motor immersion) and inert (necessary as there were electronics in the chamber). We will clarify this in the text of the Appendix.*

(3) P5L16 Please explain how to rotate the sample selector rotator (is there motor and gear?)?
There is a motor with a planetary gear set whose output turns the sampler

(2842S024C; Faulhaber Group, Micromo, Florida). An optical encoder provides feedback as to the proper location for the desired sampling bottle. Included in text.

(4)P9L20 Insert "(2008)" after "Lamborg et al."
Yes, we will fix this.

(5) P10L30 Description "(data for regression in Table S1)" should be placed between "this study" and "vs".
We will move this as suggested.

(6) P14L18 (reference) C.H.Lamborg => Lamborg, C. H.
We will fix this as suggested.

(7) Table 1 (1)What does asterisk (*) of some filters mean? Please explain.
The Asterix indicates the sample is a blank. Bottom of table indicates this.

(8) I think information of "tilt" is important. How about touching upon information of "tilt" when sampling briefly in table caption or in appropriate place in the text?
We will add a figure into the appendix depicting tilt over time, similar to the figure in Bishop et al. (2016). We note that although tilt has negligible effect on particle collection efficiency, our requirement for the minimization of tilt is to facilitate even particle distributions on the sample stage.

(9) Fig. 6 (1) Please explain difference between left figure and right figures. (2) Please explain "Estapa 2017" blue data and "Estapa 150 m" light blue data (150, 300, 500m data set and 150 m data, respectively?) (3) Blue color and light blue color are used not only for different regression lines (forced through zero intercept and allowing for an intercept), but also for different data set (150 m data only and all 150, 300, 500 m data?). This is confusable. Please change color set.

We will label the right graph of figure 6 (A) and the left graph (B), then we will reword the caption for figure 6 as follows:

Regressions of ATN-POC (mATN-cm^2 cm^{-2} d^{-1}) to POC (mmol C m^2 d^{-1}) for this study (orange line; y = 1.03x , R^2=0.874), Estapa et al. (2017, blue, y = 1.56x + 0.434, R^2 = 0.632; light blue line, y = 2.191x, R^2 = 0.47). Bishop et al. 2016 estimated slope (green line) is 0.357 (1.0/2.8). Alldredge (1998) estimated slope (purple line) = 6.25. As this study's calibration is created using samples collected at 150m, we separate out Estapa?s (2017) data point collected in 150m by marking them in light blue for comparison. (A) shows the entire range of VAF and POC flux from this study. (B) expanded graph near the origin ($x < 3$ mmol C m^2 d^{-1}) showing the range of Estapa et al. (2017) data.

(10) Table S2 (1) No description about Table S2 (2) More detail explanation about respective column in caption

We will add a description of Table S2. Table S2 contains the volume attenuance flux and the POC data for all the samples shown in figure 6. It also notes the CFE-Cal each sample was collected with, the dive number, the bottle number and the length of time the sample was collected over.

(11) References There are many mistakes and different description (e.g. Deep. Res., K.O Buesseler <=> Buesseler, K.O.). Please check format.

We will fix all references