Reviewer 2

1. General comments

This Technical Note presents a technique that is novel to aquatic ecosystem research and may be highly useful. The approach is simple, but appears to be adequate for this first application. The manuscript is well written and concise, but minor changes can improve it. Specifically, the introduction could be improved by focusing, from the first sentence, on the scientific value that light use efficiency measurements can provide. This can be accomplished largely by re-arranging text, but it will also require more citations. In addition, the Boltzmann equation can be more clearly presented. Finally, two additional figures would also improve the manuscript. The first would be of the sigmoidal fit to PAR data. The second would be of a diurnal time series of light use efficiency. A brief discussion of the data quality, patterns, and implications of that last, proposed, figure would be a valuable addition.

Author response: Thank you for taking the time to review our paper. We appreciate the comments and there are some very good suggestions in here which we will implement as best we can. Please find our point-by-point response below.

2. Specific comments

2.1 Introduction

The introduction focuses on the eddy covariance technique, but LUE is important well beyond eddy covariance. The manuscript would address a larger audience if Section 1.3 can be adapted so that it is a suitable first section. The approach you suggest is exciting. It can be used to investigate the physiological and environmental limitation of photosynthetic production. Those measurements will be of interest outside the eddy covariance community. Former Sections 1.1 and 1.2, that focus on eddy covariance, can be adapted to follow the new Section 1.1. Those sections would show that the tight relationship of eddy covariance measurements to PAR suggests that they will be adequate to resolve LUE in aquatic ecosystems. In the new first section, please also introduce quantum yield measurements. Use caution. In aquatic literature, the term commonly refers to the quantum yield of the photochemistry of photosystem II. Those measurements don't directly compare to LUE. However, there has also been extensive research on the quantum yield of phytoplankton photosynthetic production. Those measurements can be compared directly to your own. Both measurements can reveal environmental and

physiological limitations of photosynthesis. Falkowski and Raven (1997) provide a useful summary in Chapter 3.

Author response: We agree that light-use efficiency is important beyond eddy covariance and we will follow the suggestion to move section 1.3 to 1.1 to make the paper attractive to a broader audience. This is a good suggestion. The original sections 1.1 and 1.2 will then follow. In the new section 1.1 we will introduce the quantum yield of phytoplankton photosynthetic production as a comparative measure, as suggested, and we will compare published values to our own in the Results & Discussion section.

2.2 Materials and methods

There are four cumulative PAR terms in the equation (left side, A1, A2, and PAR). For clarity, I suggest writing that A1, A2, xo and dx are all fitting parameters. PAR on the left and PAR on the right can be discriminated with different subscripts. Preferably, the subscript would make it clear that one is observed and the other is predicted. I also suggest that x0 and dx would be more clearly represented with as "t" instead of "x," because they are measures of time.

To clarify how the sigmoidal fit is used, please include a figure that shows the fit to cumulative PAR. With an additional y-axis, this figure could also show a representative increase in daytime R that is predicted with it. Accordingly, please also include evidence that N2 often exceeds N1.

Author response: These are good suggestions- we will implement all of them. We will clarify that A1, A2, x0 and dx are all fitting parameters, we will distinguish between observed and predicted PAR using subscripts, and we will replace the ‘x’ with a ‘t’. We will also include a figure (a new Fig. 1) showing the fit to cumulative PAR. We will show actual numbers for N1 and N2 for all 24 h sections illustrated.

2.3 Results and discussion

Please also add a figure to show a diurnal time series of changes in LUE alongside PAR and GPP. Ik is the irradiance at which the rate of photon absorption matches the maximum turnover rate of photochemistry (Falkowski and Raven, p. 200). Your results can be used to examine if Ik is a point of interest in the diminishment LUE as PAR increases. Assuming the resulting figure is noisy, please also consider techniques that could improve resolution of diurnal variation in LUE.

Author response: OK, we will add another set of panels for both datasets (Figs. 1+3) showing LUE as a function of time, indicating the corresponding Ik value for each dataset. For illustration purposes we will plot hourly LUE using a log y-axis as shown in Fig. 4.

3. Technical corrections

Page 2 Line 20: "offsetting daytime fluxes by the dark rate." "Offsetting" is a vague term. Can you use a more specific one? I suggest "sum" or "summation." You use "offset" again on page 5, line 11.

Author response: Yes, we will correct these sentences to say that they were computed as a sum of dark and light fluxes.

Page 3 line 7: "magnitude of hysteresis is related to light history." "light history" is also vague term. Could you be more specific?

Author response: Yes, we will clarify that 'light history' as defined in the paper by Adams et al. (2016) refers specifically to the lag in the ecosystem's response (in terms of O_2 production through GPP) to changing light levels.

Page 5 Defining a daytime R rate. It is not clear that N1 and N2 are measurements of flux, as opposed to periods of time. I suggest clarifying that they are flux. By convention, J is often used for flux.

Author response: We will clarify that N1 and N2 represent flux measurements corresponding to different time periods of the day (Page 5, L8). Time periods will be denoted as N1 and N2, whereas fluxes corresponding to those time periods will be J_{N1} and J_{N2}.

Page 5 line 17: "...whereas the fourth approach assumed a sigmoidal increase with time." I'd suggest more specifics here too. Perhaps "...whereas the fourth approach assumed that R increased with cumulative PAR. This was represented with a sigmoidal increase..."

Author response: OK, we will implement this suggestion.

Page 7 line 10: Instead of "assuming," I suggest "the assumption that."

Author response: OK, we will implement this suggestion.

Page 7 line 21 PARhourly *fAPAR should be enclosed by parentheses. Again on page 8, line 2.
Author response: Thank you, we will implement this suggestion.

Page 8, line 3 Check the cases of section headings. You may want "Results and discussion"
Author response: OK, we will use lower case ‘d’ for ‘discussion’.

Page 8, line 5 Please describe the habitat types of the dataset from Greenland.
Author response: OK, we will add a few sentences describing the study site in Greenland, something like this: ‘The study site in Greenland is a protected inlet of ~3 km2 with silt-sand sediments and tidally-driven flow velocities typically ranging from 2-10 cm s-1 near the seabed. The instrument was deployed at 3 m water depth.’

Page 9 line 11: In Figure 4 there are a handful of measurements with a very low LUE (0.001 to 0.004). Could you say a few words about these?
Author response: Yes, in the revision we will include a few sentences about these measurements. In general, we would expect higher LUE under low irradiance. In the 72 h-long dataset from the Baltic Sea, 5 of the 1-h fluxes had similar or lower LUE compared to the rest of the day. Following comments from Reviewer 1, we will include an analysis on the direction-dependence of the fluxes to establish whether they originate from a different part of the reef. We will highlight to what extent this may reflect GPP measurement error or environmental factors such as nutrient limitation at this rocky site.

Page 9, line 19. Replace "_" with approximately.
Author response: OK we will replace this.

Captions for Figures 1, 2, and 3: Please provide the habitat types for each of the figures. Also include the location in the caption for Figure 2.
Author response: OK we will provide habitat type and location as requested.

4. Literature Cited

Falkowski, P.G., and Raven, J.A. (1997). Aquatic photosynthesis. Princeton University Press. Note: Page numbers will differ for the second edition.