Reply to Referee#3.
We would like to thank the referee for constructive and clarifying comments and suggestions that have improved the manuscript. We have addressed all the reviewer's comments and suggestions below. Our replies are shown in italics.

RC3: 'Comment on egusphere-2026-1718'
Anonymous Referee #3, 20 Oct 2026

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This manuscript presents an interesting field study of light-associated variation in phytoplankton photophysiology in the North Sea, Irminger Sea, and subtropical Sargasso Sea, with the most extensive sampling conducted in the North Sea. The authors assess photoinhibition by comparing maximum PSII photochemical quantum yield before and after four hours of low-light incubation. The observed relationship between irradiance and the recovery-based photoinhibition metric, particularly in the upper water column, is clear and potentially useful for understanding variability in photosynthetic physiology and its implications for primary production estimates. A particular strength is the combination of paired physiological measurements, spatial sampling, diel observations, and measurements of the physical environment.
I offer the following comments to improve the clarity, reproducibility, and interpretation of the study.

1. Notation:
Please consider adding a table defining the principal symbols, their units where applicable, and their physiological interpretations. In particular, distinguishing the initial and corrected (F_v/F_m), their difference, and the normalized photoinhibition metric would help readers follow the analyses.
We have followed the suggestion by the reviewer and added a table with notations and descriptions (Table 1).

2. Dataset provenance, documentation, and reproducibility (Sections 2.1–2.3 and data availability statement):

■ Please clarify which observations were collected specifically for this study and which, if any, were previously reported or analysed elsewhere. For previously published observations, identifying the relevant publications and explaining their use here would help establish the provenance of the dataset.
All the reported PI-values from the three cruises are new. Hydrography and nutrients are described in section 2.2 and it contains the Bendtsen and Richardson (2018) reference that contains background information on the distribution of temperature, salinity, chlorophyll a and nutrients from the VERMIX cruise.We have added further information on the previously reported FvFm-measurements in section 2.5:"A subset of F_v/F_m-data from the VERMIX cruise was reported earlier in Cordier et al. (2025) in relation to zooplankton distributions, and F_v/F_m-data from the Sargosso Sea was reported in Richardson and Bendtsen (2017) in relation to eddy pumping of nutrients."

■ The supplementary spreadsheet provides station coordinates and fluorescence measurements, while the accompanying .dat file includes North Sea environmental variables such as nutrients, temperature, salinity, fluorescence, and PAR. A clearer description of how these files relate to one another would improve their accessibility. In particular, please identify the observations used in the PCA, Equation 3, and the light-history analyses, including any exclusions or missing-data treatment.
The supplementary docx-file (bendtsen_et_al_photoinhibition_supplementary.docx) describes the usage of the two datafiles: Table S1 (in the file bendtsen_etal_supplementary_table_S1.xlsx) contains stations information and measurements of Fv/Fm. TableS2 (in the file

bendtsen_etal_supplementary_table_S2.dat) contains measurements of Fv/Fm, light and nutrients used in the PCA and in the regression analysis. Further details on the measurements have been added to the file.

■ I encourage the authors to provide a README or data dictionary explaining identifiers, units, missing-value codes, and links between files, together with the analysis code and any additional inputs needed to reproduce the results. Archiving these materials in a repository such as Zenodo and citing a persistent DOI would facilitate reproducibility and future reuse.
A description of the data-files is provided in the supplementary docx-file (bendtsen_et_al_photoinhibition_supplementary.docx), similar to a README-file as suggested by the reviewer. All data used in the PCA and in the regression analysis are contained in the file: bendtsen_etal_supplementary_table_S2.dat. This file is self-contained, including metainformation with reference to further details in Table S1. The dat-file is formatted and can be applied directly for a PCA and a regression analysis. We prefer to keep the data in these supplementary files together with the manuscript.

1. Sampling depths and sample sizes (Section 2.1)
For the statement describing sampling "at 3 stations at multiple depths" in the Irminger Sea, please specify the sampled depth range. A table summarizing the number of stations, depth ranges, and numbers of paired fluorescence measurements for each region would also be helpful. Where feasible, please distinguish the number of stations, sampling events, and individual observations, particularly for the time-series stations.
We have now added the depth ranges of the Fv/Fm-measurements from the 3 cruises in section 2.1, as suggested by the reviewer. A reference is given to Table S1 in the beginning of the section, and this table contains all information about the data. The number of stations of each cruise is also described in section 2.1.

2. Section 3.2 and Discussion:
■ The model-derived reduction of approximately 45% in maximum PSII photochemical yield at a PAR of approximately 1000 μmol photons m^{-2} s^{-1} is an interesting result.
We agree with this comment from the reviewer.

■ The discussion could benefit from considering complementary evidence from carbon-based photosynthesis–irradiance experiments, such as Amirian et al. (2025; https://doi.org/10.1038/s43247-025-02686-3 & 2026; https://doi.org/10.5194/essd-2026-651), where relevant. These studies may provide useful context for discussing photoinhibition in natural phytoplankton communities. However, fluorescence-derived changes in maximum PSII quantum yield and high-light reductions in carbon fixation represent different quantities. A brief discussion of how these approaches complement one another would strengthen the manuscript.
We agree that the relation to carbon-based photosynthesis-irradiance parameterizations are relevant, and we have added the following sentence, including a reference to the review-paper by Sathyendranath et al. and the recent study by Amirian et al., to the final paragraph in the Discussion section: "The impact from photoinhibition on photosynthetic parameters has also been parameterized from primary production measurements based on ^{14}C-incubations (Sathyendranath et al., 2020; Amirian et al., 2025)."

1. Interpretation of the PCA: I share Referee #2's concern about using the PCA to infer the relative influence of light and nutrients.

We have considered the comments on inferring the relative influence of the variables from the PCA, and modified (changes in non-italic) the sentence accordingly (cf. the reply to Referee #2): "However, the strong correlation between PI and PAR identified from the PCA supported that light exposure explained a major fraction *of the variability in PI."*

2. Quantitative summary of Figure 7
Please consider supplementing Figure 7 with the numbers and percentages of observations for which (\ Delta F_v/F_m) is positive, zero, or negative, separately for the two depth groups shown. This could be presented in the caption or a supplementary table. Please also discuss the possible explanations for negative values, including measurement variability and the possibility that the incubation irradiance adversely affects samples acclimated to lower light. These percentages should be described as the frequency of positive or negative measured responses; a value above zero does not, by itself, establish statistically significant photoinhibition in an individual sample.
We have added the suggested information to the figure legend, and now it reads:"Figure 7 VERMIX-observations of (a) in situ PAR, and (b) $\Delta F_v/F_m$ versus local time of day. Colors show observations from the upper 5 m (red, n = 98 with 83 positive values) and below (blue, n = 90 with 67 positive values). ". The potential impact of adverse effects of PAR on deeper samples is discussed in the analysis of PI vs PAR calculated from SPAR, and this was also the motivation for disregarding deeper samples with permanently low light levels from the analysis.

3. Figure 8
■ Several aspects of this figure suggest opportunities to refine the statistical model. First, samples from different stations may respond differently to changes in PAR. A linear mixed-effects model with station-specific intercepts and, where supported by sufficient within-station observations, slopes could account for this variation and facilitate comparisons among stations.
We agree that a station per station analysis could provide information that, together with other environmental variables, could explain some of the variation at individual stations. However, our analysis is focused on the general relationship with environmental variables and the strong correlation with PAR across the entire data set (excluding the very low-light samples) support a general relation both for Delta F_v/F_m and PI. It should also be noted that community composition also may play a role in the photosynthetic response and this variation would not be resolved in a more detailed analysis. Therefore, we have kept the general analysis in Figure 7 as it is to keep the focus on the general relationship between PI and PAR.

■ Second, have the authors explored transformations of PAR and the response variable? Although a conventional log–log transformation cannot accommodate zero or negative values, a log1p transformation, defined as (\ln(1+x)), can accommodate zeros and negative values greater than −1. Such a transformation may help address nonlinearity or unequal residual variance, although its suitability should be assessed using residual diagnostics rather than assumed to improve model performance.
We acknowledge this comment and interest in the statistical relationship between PI and PAR, however, we have kept the regression analysis because the linear regression provides use with a simple estimate of PI versus PAR. We find that a further statistical analysis of non-linearity or unequal residual variance will go beyond the focus of this study.