

Point by point response to reviewers' comments

To Gwenaël Abril,

Provide more precise information on the field experiment, and define better the *Fucus serratus* thallus itself (size height...). This will make the paper more readable for a broader community, because it is a bit difficult to imagine the sampling procedure from the actual text. How are “intermediate”, “bottom” layers defined, how many layers in the Thallus, eventually what height? Was the total nb of layers stable seasonally during the experiment?

Information on the *Fucus serratus* thalli and stand has been provided and the definition of the different layers has been specified (see below the line by line comments).

Maybe organize the discussion in 2-3 sections, last paragraph in page 10 can be a conclusion

The discussion has been organized in 3 sections as suggested (Community primary production and photosynthesis, Biochemical acclimation and Conclusion).

Cite more often the figures and tables in the text, and also in the discussion when appropriated.

References to figures and table have been added.

Figures panels have no A,B,C, although they may be useful, for instance to differentiate “mild conditions” from others. Seasonal nomenclature appeared confusing to me, at least at the first reading.

Fig1&3 present 5 sampling dates and Fig3&4 present 2 sampling dates for the same parameters, which I found a bit disappointing at the beginning of the reading.

Readers also have to refer to Table1 to read Fig.5 nomenclature properly.

To facilitate the reading, experiments has been reordered in table and figures as they were first presented in the materials and methods section (i.e. according to environmental conditions rather than chronologically). Furthermore, the two types of experiments are more clearly presented and the nomenclature has been revised (see table 1). The nomenclature is now homogeneous for all figures.

Line by line

P4 How were the chambers fixed to the hard substrate?

Chambers are sealed to the substratum using sand. This is now specified.

“The fluorescence signal was always taken from the same place in the middle of the thallus for three individuals, haphazardly selected among thalli from the top of the canopy and three other individuals from the bottom of the canopy or from an intermediate layer of the canopy.” “Three were placed at the bottom of or inside the canopy, and three were placed at the top of the canopy.” And throughout the MS: Some more precise information on the height of the canopy (and/or total nb of superposed thallus within the canopy?) would be very welcome. It is quite

difficult to imagine how the “intermediate layer” is defined and what is the distance from the top to the bottom.

Thalli were not selected according to the number or height of layers (which were not measured) but according to the PAR reaching them: approximately 1% and 20% of incident PAR at the bottom and within the intermediate layer of the canopy respectively. This is now specified in the Materials and Methods and reminded in the discussion.

P8 Text refers to dates “May”, “August” whereas Fig5 is labelled as M26, M27, A22, etc... The meaning of the nomenclature in Fig. 5 is described only in table 1. One gets lost.

The nomenclature has been revised and homogenized.

P8 “Our physiological measurements validate intraspecific facilitation as a mechanism regulating the production of intertidal macroalgae stands.” Please be more explicit

This has been rephrased as “The previously proposed hypothesis of intraspecific facilitation as a mechanism regulating the production of intertidal macroalgae stands (Bordeyne *et al.*, 2017) is validated by the physiological measurements presented here.” The outcomes of the physiological measurements are explicated in the following part of the paragraph.

P9 “During emersion under mild conditions, photosynthesis, measured as the electron transport rate (rETR), varied in thalli at the top of the canopy in response to changing incident light.” Where and when can we see that? This is not obvious in Fig. 1. What sampling date and hour correspond to “mild” conditions?

This is obvious in the experiment performed on 04 December 2017 (now named Exp E): rETR reached $145 \mu\text{mol e}^- \text{m}^{-2} \text{s}^{-1}$ when PAR peaked at $800 \mu\text{mol m}^{-2} \text{s}^{-1}$. Reference to this experiment has been added in the discussion.

P9 1/3 > “appears to suggest” change to “suggests”

Done.

P9 “Photosynthesis was limited in the lowest layer of thalli due to self-shading which prevented light from reaching them, but was effective in the intermediate layers under relatively low local irradiance.” What is the difference between “intermediate layers” and “lowest layers”? how many layers in total? Does the number of layers vary seasonally?

More detailed information on the number of layers present at the different sampling dates and sites would be very helpful to readers.

The layers haven’t been counted but the intermediate and lowest layers have been identified according to light reaching them: approximately 20% and 1% of incident PAR respectively, whatever the season. This is now specified.

P9 “beneath the canopy” does this correspond to “lowest layers”, “bottom”, “intermediate”, bottom and intermediate?

Beneath corresponds to bottom and intermediate, this is now specified at the first use.

The discussion is sometimes hard to follow because it never refers to figures. Example: “The optimal photosynthetic quantum yield (F_v/F_m) also dramatically decreased during emersion periods of spring and summer in thalli at the top of the canopy, but not in thalli beneath the canopy.” Cite appropriate figure

References to figures and experiments have been added in the discussion.

“The same thalli are, however, unlikely to be at the top of the canopy in consecutive low tides and inhibition can be reversed by self-shading.” Why? How many thalli per sampling point or per m^2 ? It would really be interesting for reader from a broader community to have more basic information on *Fucus serratus* as “studied object”: size of thalli, height of mats, etc. Was the biomass per m^2 the same for all the sampling periods?

Basic information on *Fucus serratus* has been provided with reference to Munda & Kremer (1997) and Bordeyne (2016). The density (about 70 ind m^{-2}), biomass (2 to 13 $kg_{FW} m^{-2}$ according to the season) and length (averaging 38 cm) of thalli and the height of the canopy (reaching several decimeters) have been specified in the Materials and Methods section. The typical morphology of thalli (long, wide, ramified and deeply serrated) is now described in the discussion.

P10 “Because the xanthophyll cycle is the principal non- photochemical quenching mechanism in brown algae,” any reference for that?

The reference to Harker *et al.* (1999), already given in the introduction, has been added.

Table 1: date are probably much more convenient in the text than M26, A22, D4...

The nomenclature of experiments has been revised.

Fig. 5 could be more readable

The figure 5 has been reworked.

To Francesca Rossi,

I, however, find that the large effort taken to do all these measurements is not enough valued using well sounded statistical approaches that can assist in testing the hypotheses declared in the aims of the paper at the end of the introduction. As far as I could understand the hypotheses was that *tFucus* thallis change their strategy from photoprotection to scavenging following changes in environmental conditions, considered as a proxy for climate change and that this mechanisms occur more in the apical than distal part. Therefore, I would design a statistical model that takes into account all these variables and not use merely the sampling dates as explanatory variable.

The hypothesis was that, during emersion under high light and temperature, thalli at the top of the canopy were photoinhibited but photosynthesis was effective beneath the

canopy. Photoprotective and/or scavenging mechanisms were expected to develop in thalli at the top of the canopy but not in thalli beneath the canopy. The experiments were thus designed to highlight the complementarity between thalli from different layers of the canopy depending of environmental conditions (changing according to the sampling dates).

I also wonder if an assessment for colinearity was done for the PCA. It seems from the figure that all variables had a similar importance in structuring points across the first 2 axes of PCA

Variables used in the analysis are independent and not structurally linked by linear relation. Then, calculated correlations are of interest and can be considered. On the 15 correlations calculated to build the PCA, only 5 were significant at 0.05. The highest correlation is now specified in the result section.

To anonymous reviewer,

First, in the introduction, the authors said that “*Fucus serratus* is the lowermost zone-forming furoid”. I do not agree with that as on Brittany shores, you can find either *Himanthalia elongata* and/or *Bifurcaria bifurcata*, which are also furoids, at the lowermost zone on the shore, just below the *F. serratus* zone and above the *Laminariales* zone.

At the western head of Brittany (but not in the study site), *Bifurcaria bifurcata* and *Himanthalia elongata* can indeed form distinct belts below the *Fucus serratus* zone. The sentence has then been corrected as “*Fucus serratus* is usually the lowermost zone-forming furoid”.

In the M&M section, I am surprised that the authors used gallic acid as the standard to assay phenolic compounds of *Fucus serratus*: this phenolic acid is not present in brown seaweeds as opposed to phloroglucinol, which is the monomer of phlorotannins (= phenolic compounds of brown seaweeds). As the standard curve for both phenolic acids are different, the levels of phenolic compounds in *F. serratus* could then be a little different than those presented actually.

Regarding the analysis using the Folin-Ciocalteu assay, it is very hard to find a specific and suitable standard for quantification. Both gallic acid and phloroglucinol standards are used in brown seaweeds and in *Fucus* for the expression of the results (see Mekinic *et al.*, 2019. Phenolic Content of Brown Algae (Pheophyceae) Species: Extraction, Identification, and Quantification. *Biomolecules*, 9: 244). We have chosen to express our results in gallic acid equivalents, as a widely used standard that could allow comparison among studies.

Although the M&M section is quite developed, I think that the method to assay chlorophyll a is missing or the authors used the same method as for xanthophyll pigments (although this method is optimised for those pigments and not for chlorophyll a)?

The same method as for xanthophyll pigments (HPLC) was used to assay chlorophyll a content. This is now specified in the Materials and Methods section.

I did not find the Supplementary material of the manuscript but did the authors present only hydrogen peroxide, ascorbate and glutathione levels? or also the different correlation plots (TBI vs. air temperature, Fv/Fm vs. RWC, DR values vs. PAR just before emersion). If only the levels, the authors could probably add those correlations plots as well.

Data for correlation between TBI and air temperature were provided in table 1 and the correlation has been added in the result section (paragraph Environmental conditions). Correlation between Fv/Fm and RWC is obvious on the ACP plot and has been highlighted in the result section (paragraph Biochemical parameters). Correlation plot between DR and PAR just before emersion has been added in supplementary material as suggested.

To explain the fact that Fv/Fm of seaweeds above the canopy reached 0 on the 13th August 2018, the authors hypothesize the impact of harsh conditions on those seaweeds, conditions that occurred the previous days of the measurements. This assumption may be correct. However, looking at the environmental data (Table 1), it seems that the same conditions were observed on the 22nd August 2017 but Fv/Fm did not reach 0 on that day. Do the authors have another explanation for the difference between these two days?

Contrarily to the 22 August 2017, harsh conditions (notably high air temperatures) occurred not only the day of measurement on 13 August 2018, but also the previous days. This has been specified.

In the conclusion of the manuscript, the authors are talking about the foundation role of this brown macroalga but I think that they should emphasize on the impact that its disappearance will have on the community of alga and fauna living underneath if *F. serratus* could not adapt to thermal extremes predicted in the near future.

Emphasize on the impact of the potential disappearance of the species has been added at the end of the conclusion.