Spectral light on the seabed matters for macroalgal community composition at the extremities of light limitation

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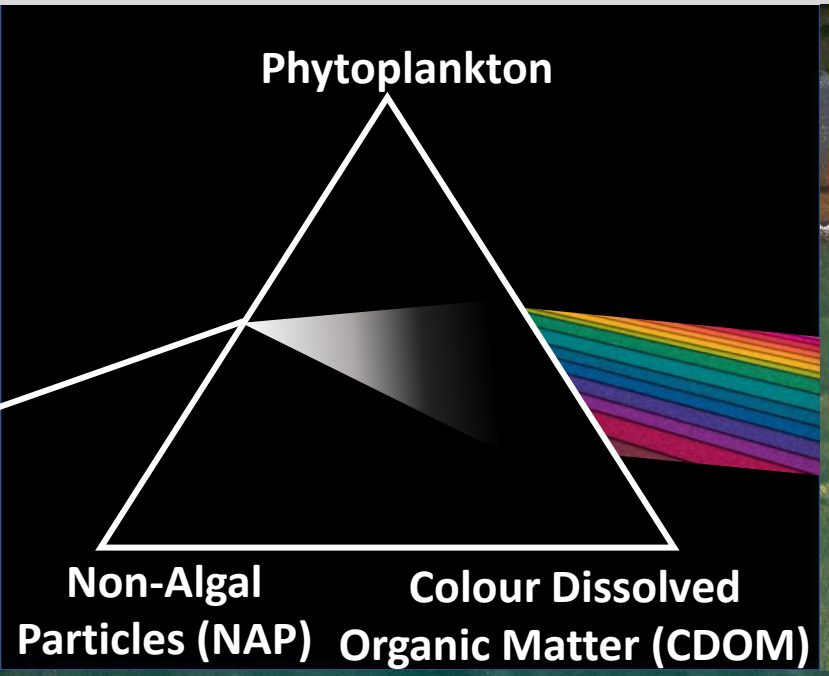
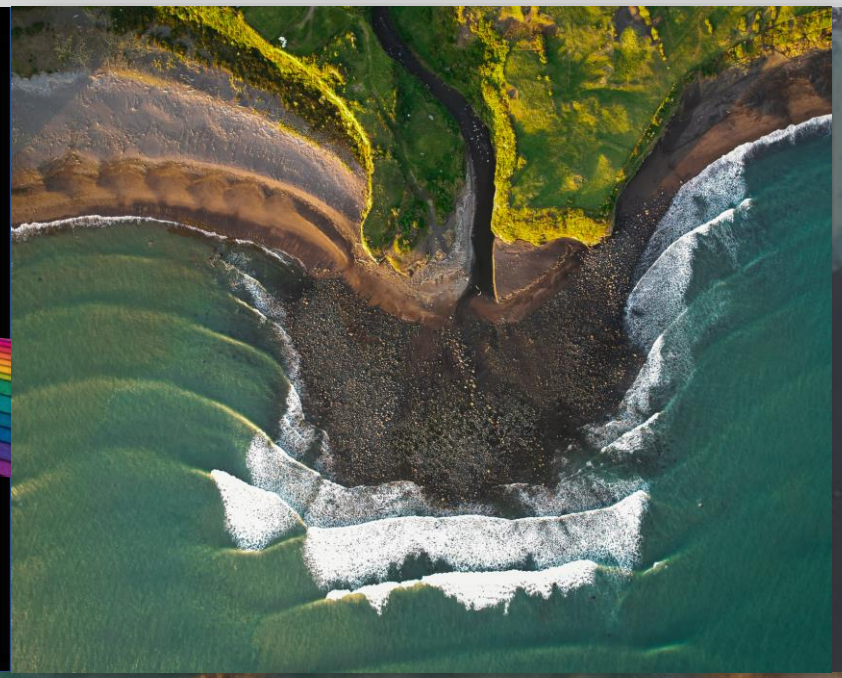
Optically-Active Constituents (OACs) modulate seabed light quantity and quality





→ What are the consequences of diverse optical conditions on macroalgal photosynthetic competition?

Pictures **Jean Thoral**

Fig. 1 – Fifty shades of the ocean.

Light quantity vs quality: an old debate

- **Light** on seabed = **fundamental for macroalgae,** but **highly variable**
- Role of **Quantity** vs **Quality** in macroalgal distribution?

→ **Seminal debate since 1883**

→**"CCA" vs "Intensity Adaptation"**

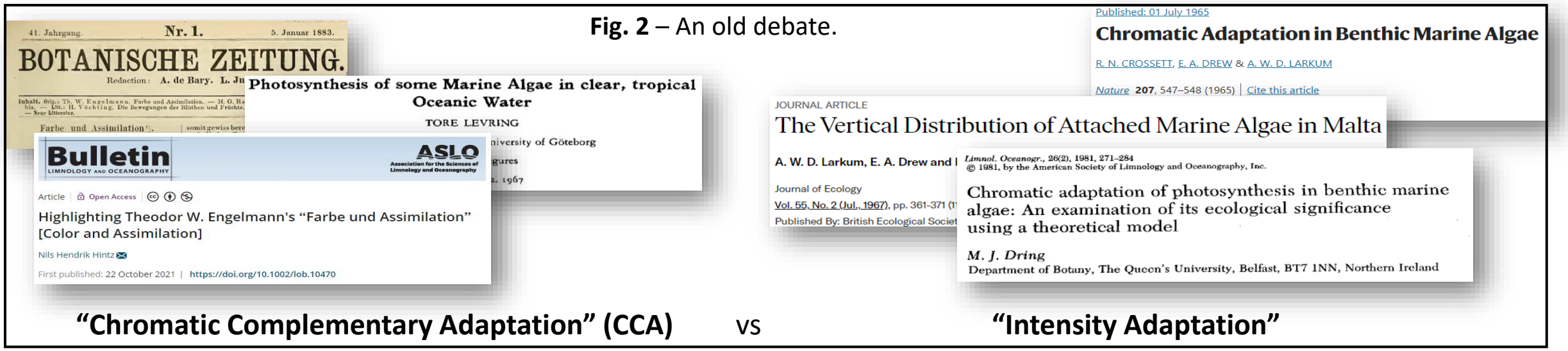


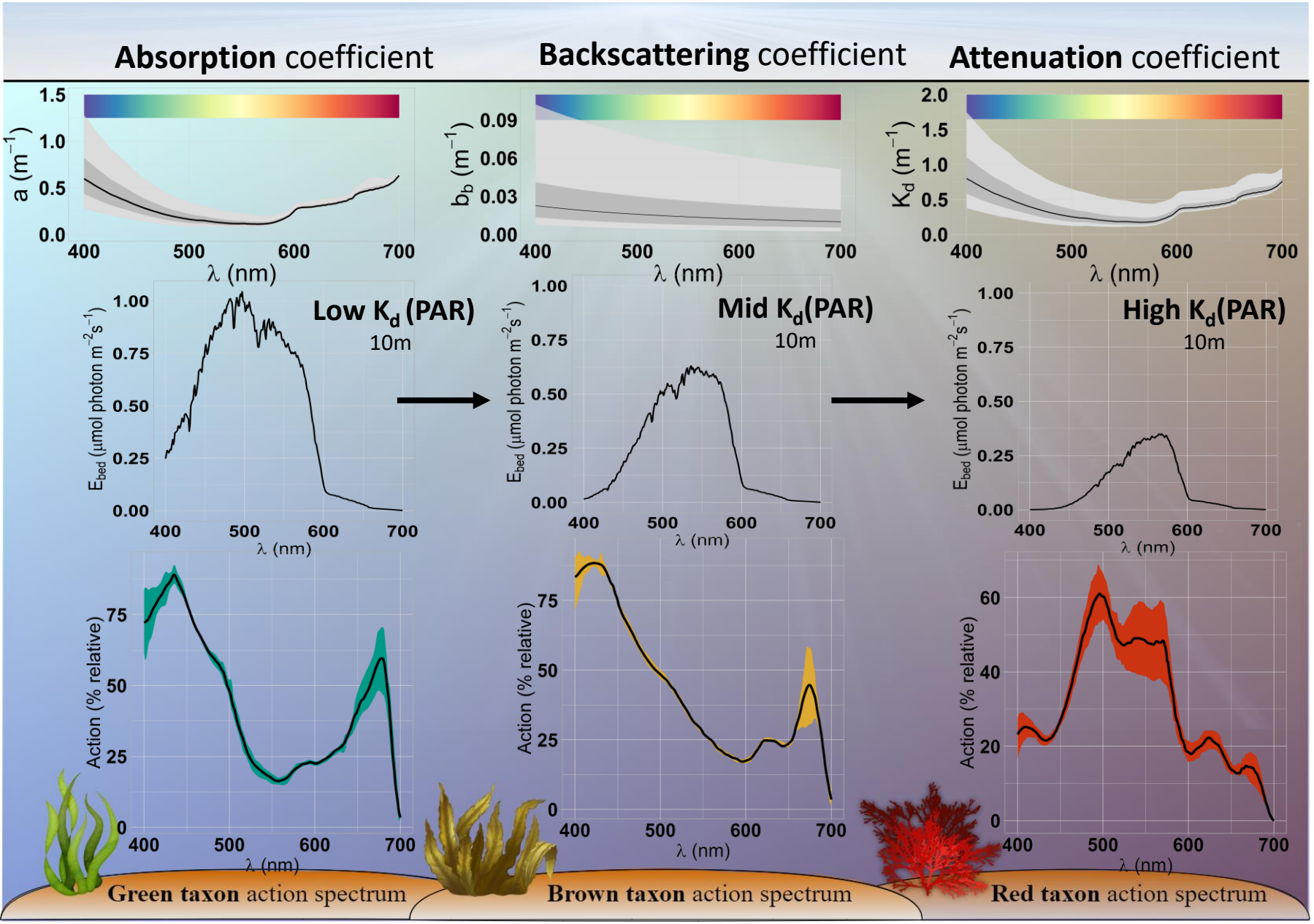
Fig. 2 – An old debate.

"Chromatic Complementary Adaptation" (CCA) vs **"Intensity Adaptation"**

→ **CCA mostly discredited in clear waters**, where photosynthesis saturated

→ Turbid waters: **role of accessory pigments theoretically provide advantage** (*i.e.,* phycobiliproteins)

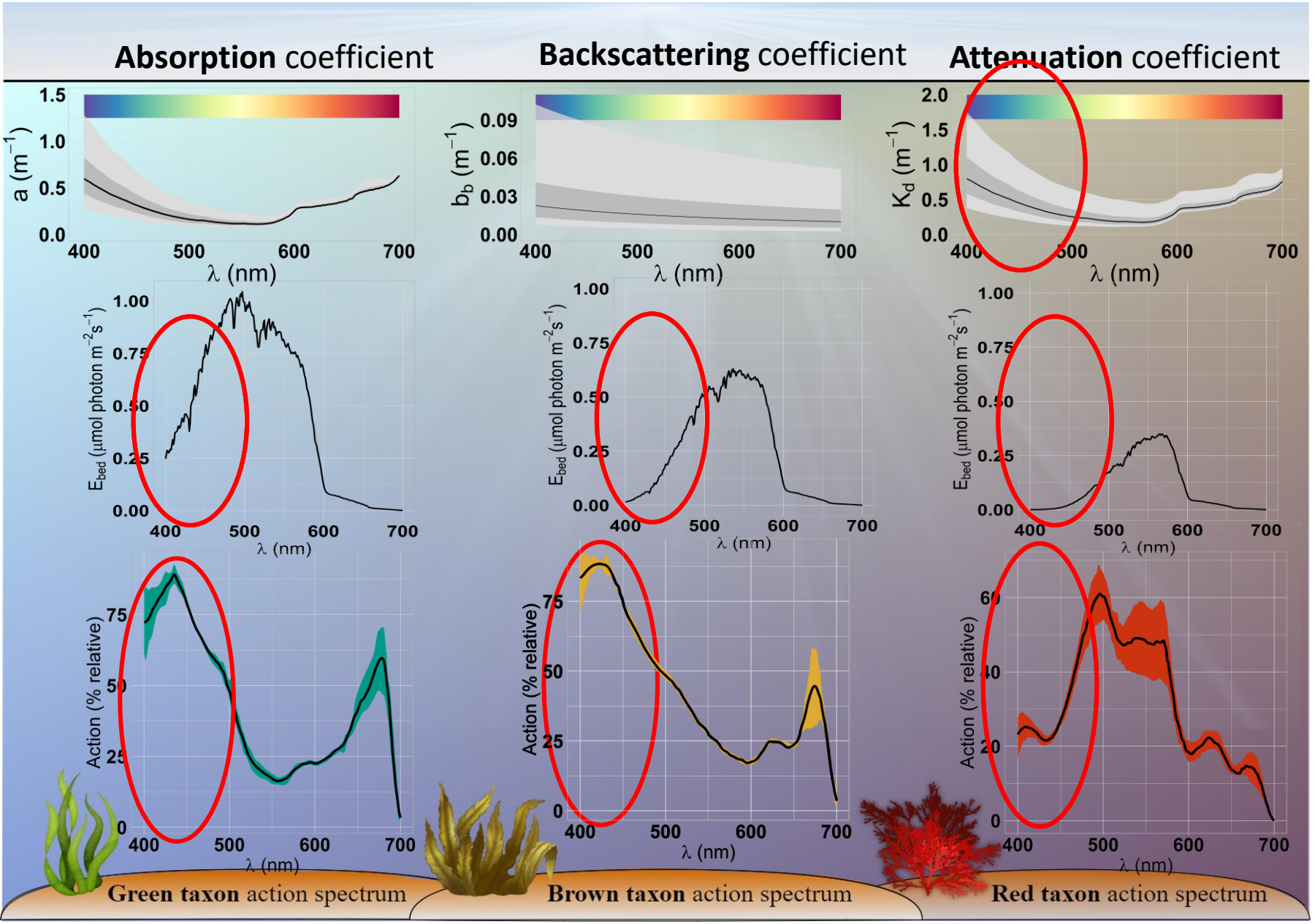
Modelling a changing light environment



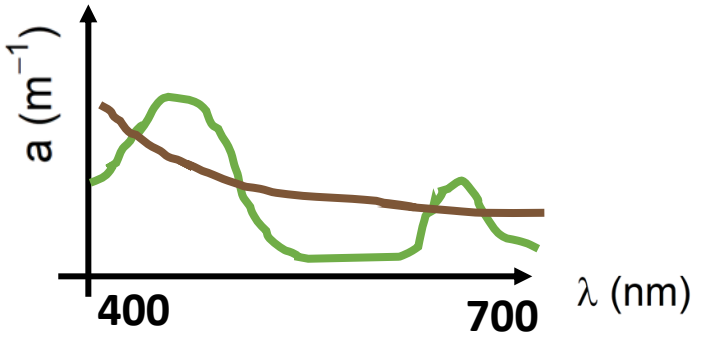
- **Phytoplankton, CDOM and NAP** absorb and scatter light differently
- **1,000,000 scenarios** of seabed light based on credible OACs values
- **Action spectra** of Phaeophyceae, Chlorophyta, Rhodophyta (Enriquez et al., 1994, Kirk, 1994)
- 3 metrics: Photosynthetic **Performance**, **Efficiency**, **Competitive Performance**

Figure 3 –*Top row* Spectral absorption, backscattering and attenuation coefficients.
Mid row Light spectra on seabed under increased attenuation, 10m.
Bottom row Action spectra of green, brown and red macroalgal taxa.

Hypotheses



- *H1:* **Increased attenuation** affect green and brown more than red, **leading to red-dominated assemblages** at extremities of light limitation

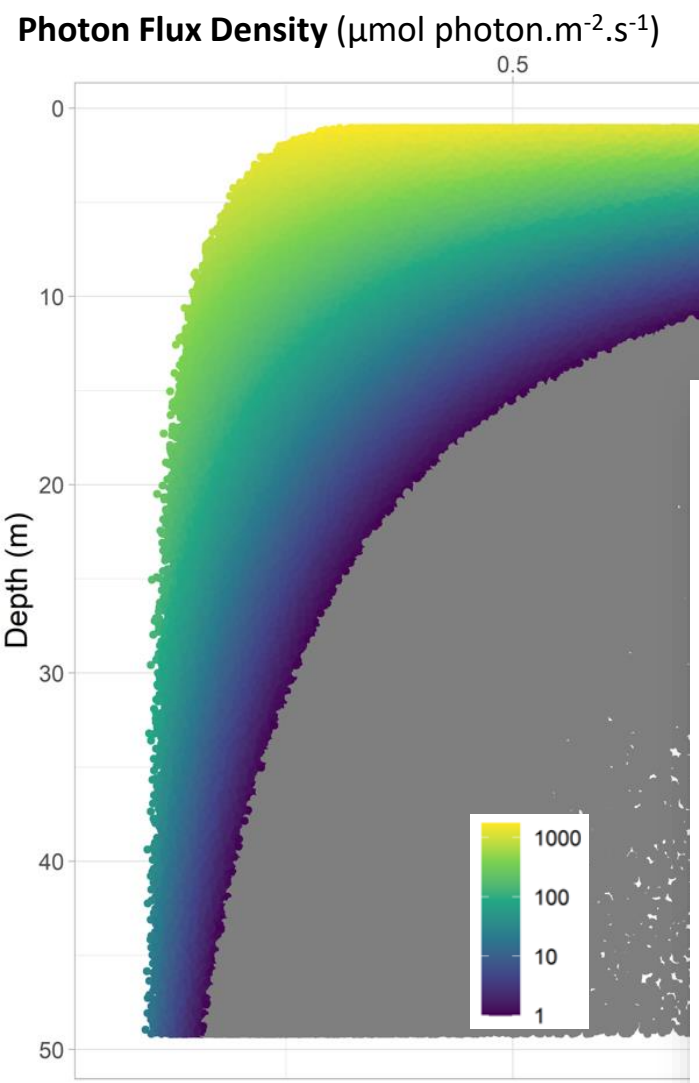


- *H2:* At a given attenuation level, **different** dominating **OACs** (**chla** vs **detritus**) **favour different taxa**

Photon Flux Density (PFD) and Photosynthetic Efficiency

→ Green-Brown vs Red: **Reverse pattern**

→ *H1:* **Increased attenuation** affect Green and Brown more than Red **TRUE**, [**leading to red-dominated assemblages** at extremities of light limitation] PENDING



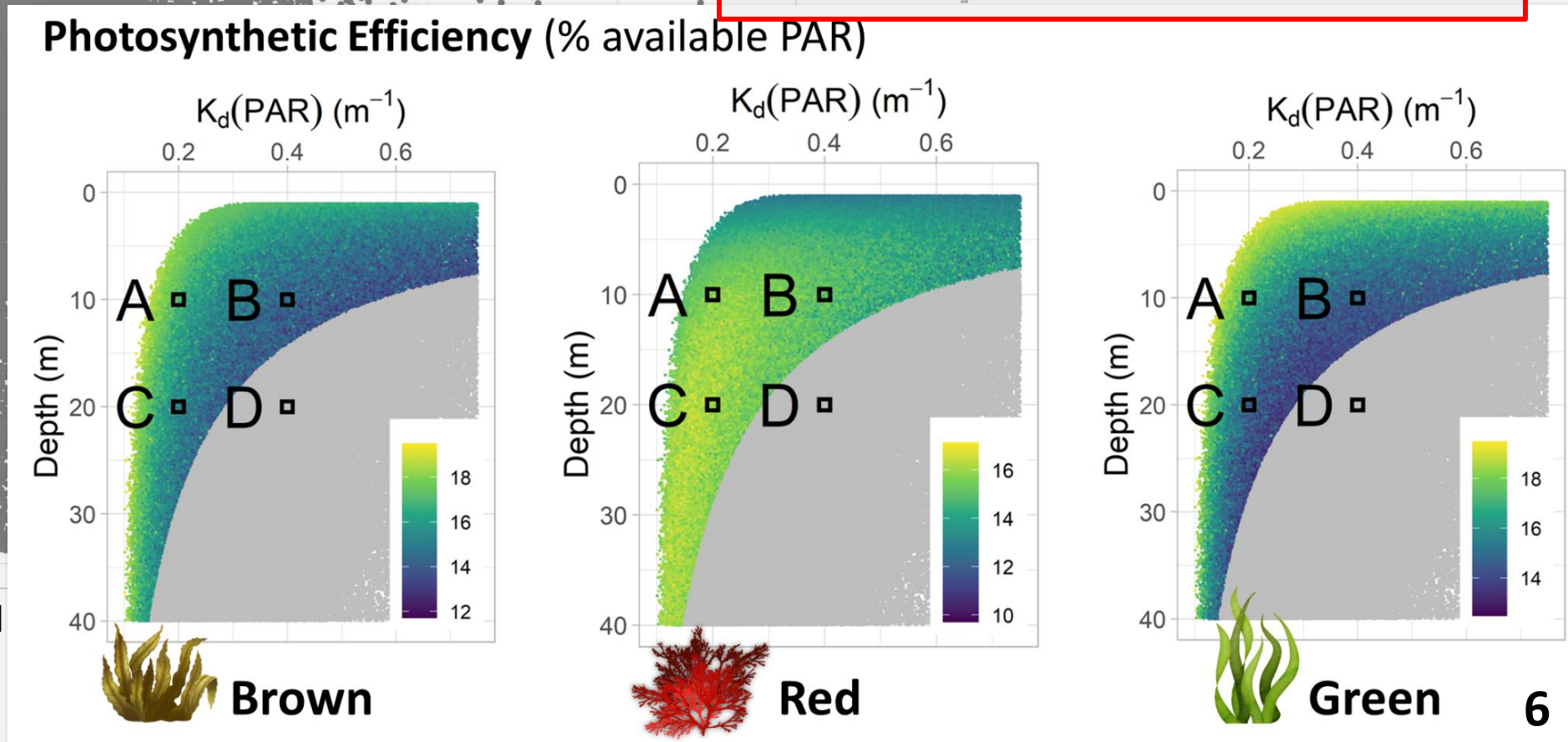


Figure 4 – Modelled PFD (top) and photosynthetic efficiency for 3 macroalgal taxa (right).

Pair-wise Competition

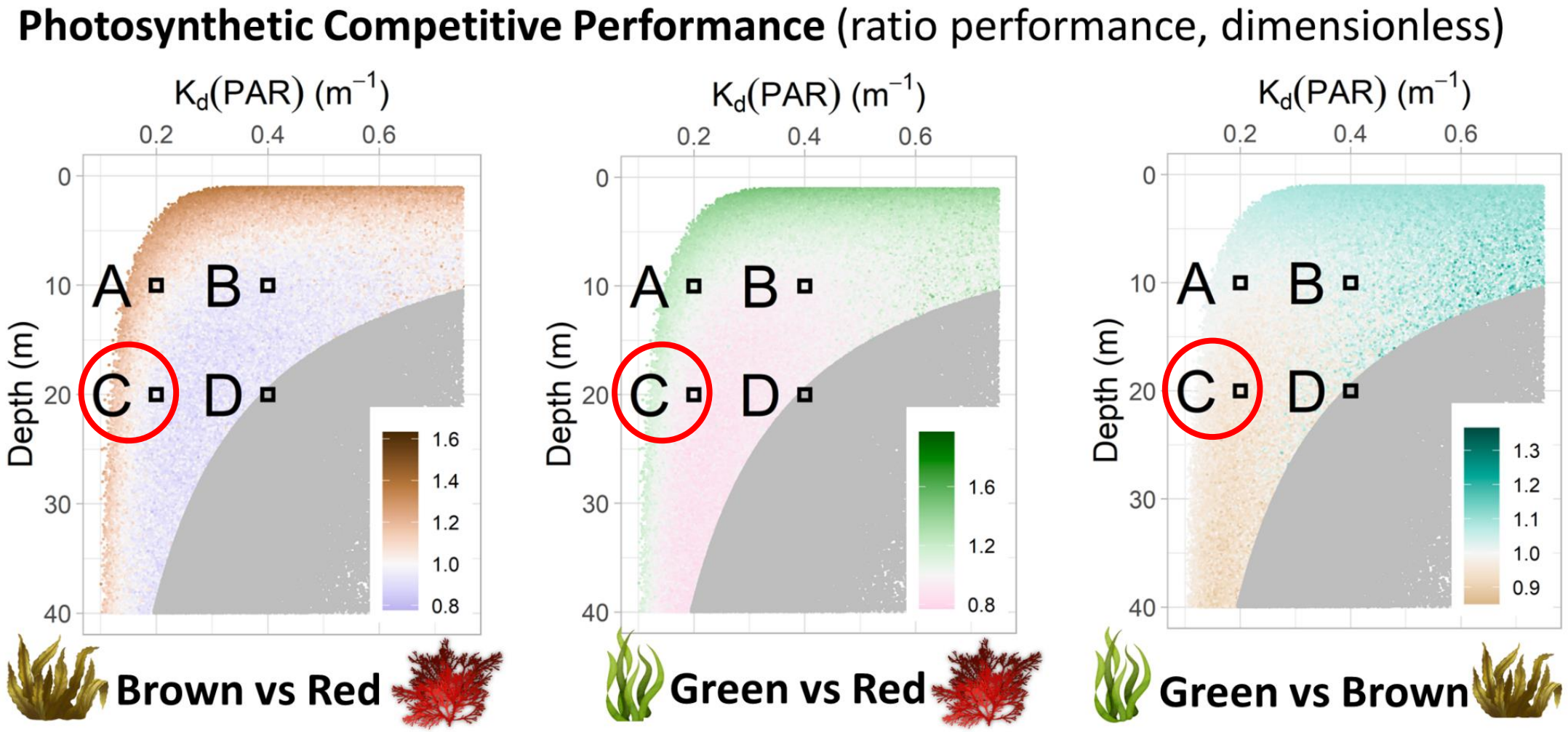
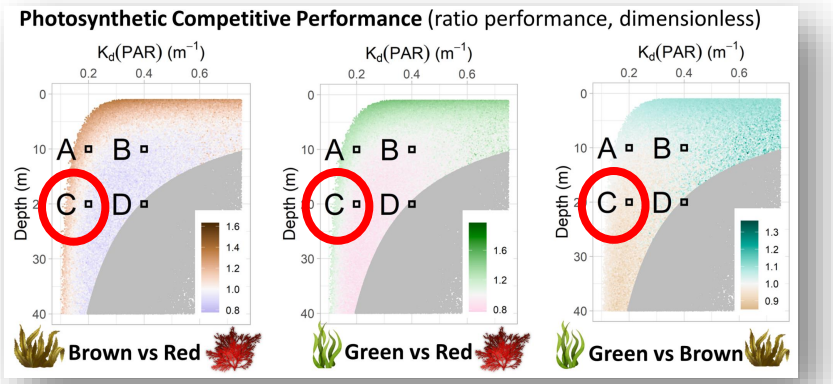


Figure 5 – Pair-wise photosynthetic competitive performance (ratio performance).

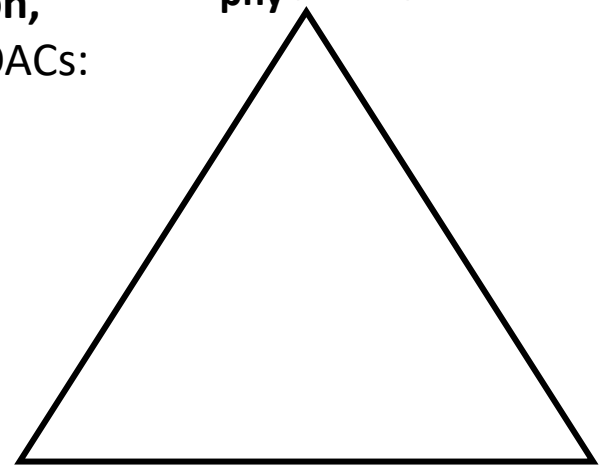
H2: At a given attenuation level, **different** dominating **OACs** (**chla** vs **detritus**) **favour different taxa**

→ Same level of attenuation can be produced by different OACs, focus on **C**

Pair-wise Competition for Same Total Attenuation



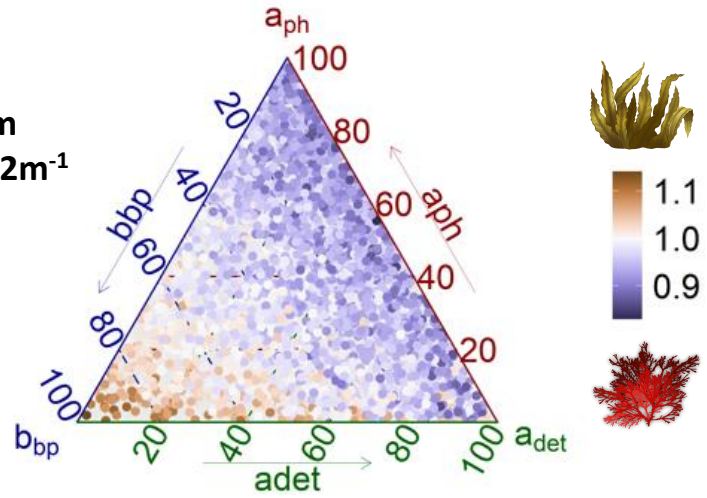
Same attenuation, different OACs:

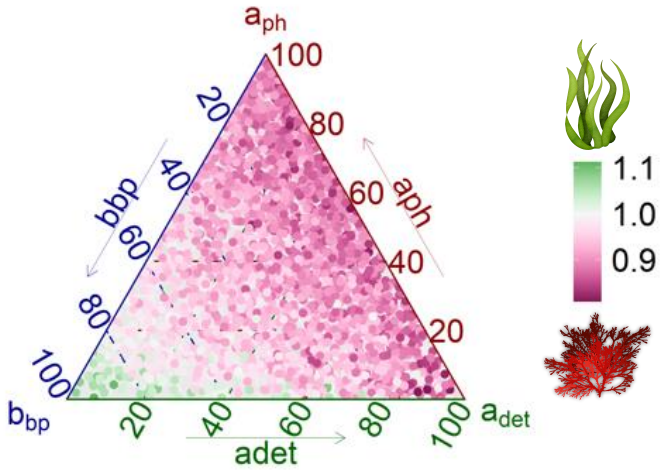


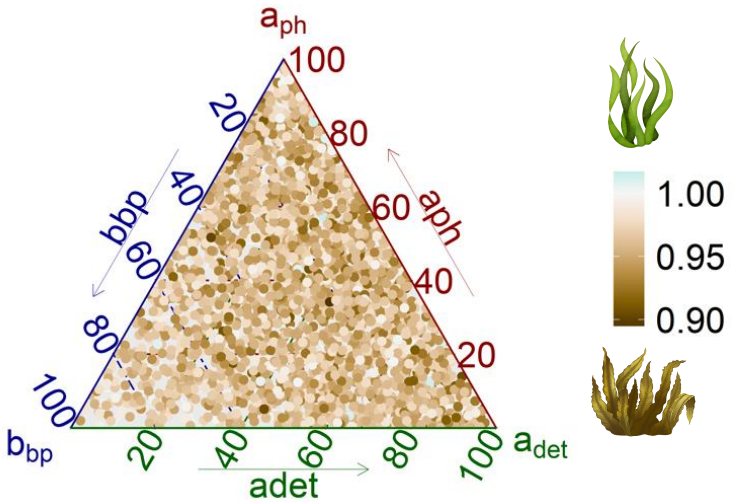
C

Depth = 20m

K_d(PAR) = 0.2m^{-1}





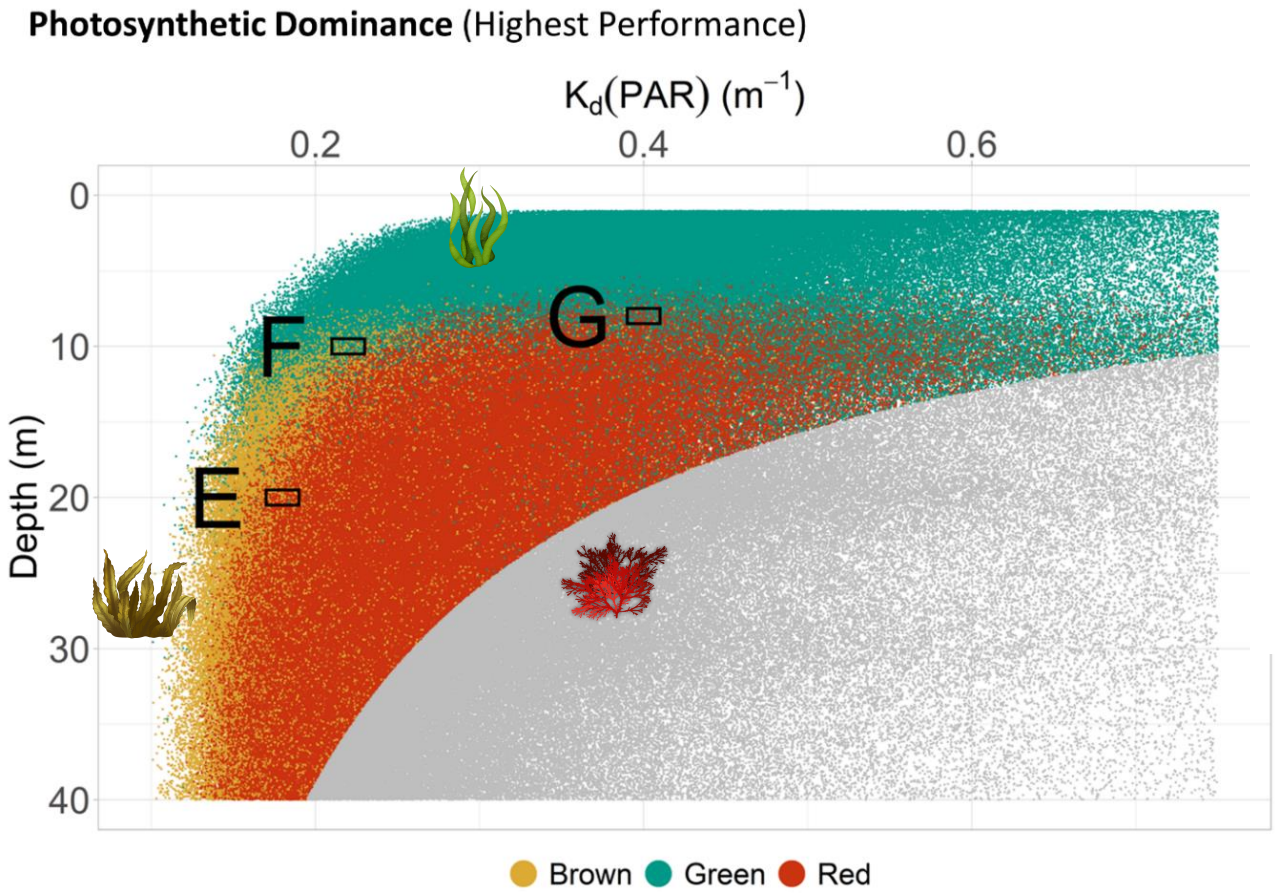


→ Red taxon favoured by a_{ph} vs Green/Brown favoured by b_{bp}

H2: At a given attenuation level, **different** dominating **OACs** (**chla** vs **detritus**) **favour different taxa TRUE** but condition dependent (depth and attenuation)

Figure 6 – Pair-wise photosynthetic competitive performance (ratio performance) in ternary plots.

Ecological implication of a changing light environment



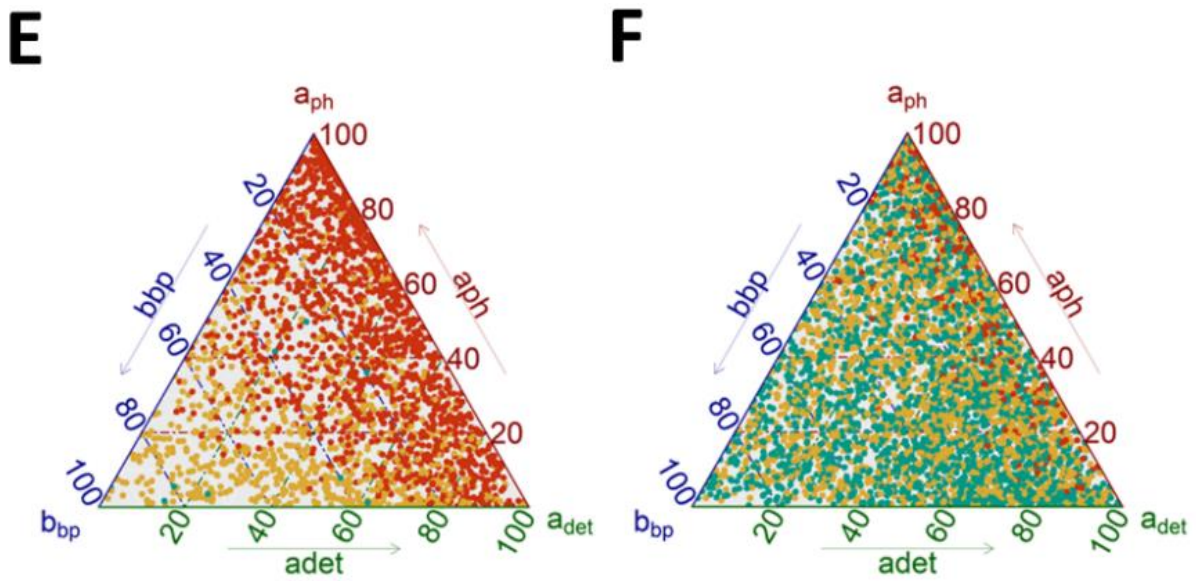


Figure 7 – Photosynthetic dominance (highest performance) of macroalgal taxon in the modelled space. Note that photosynthetic dominance is only one facet of the realised ecological niche.

→*H1:* **Increased attenuation** affect Green and Brown more than Red TRUE,
leading to red-dominated assemblages at extremities of light limitation **TRUE**

Recap – How are you going?

- **Increasing light attenuation removes crucial "colours"** affecting taxa differently (***H1 TRUE***)
- **The nature of optically active constituents matters for macroalgal competition** (***H2 TRUE***)
- **"CCA"** might be **applicable in certain attenuation scenarios**, where light is limiting
- **Light quality only 1 facet of realised niche**
- **No photoadaptation** here, only 1 snapshot in time modelled

Opportunities:

- Satellite-derived a_{ph}, b_{bp}, a_{det} + seabed light = allows 20-year long monitoring (MODISA)
- New satellite-product of competitive threshold macroalgal community?
- Lab-work to simulate different light environment (quantity + quality) and macroalgal response
- Check out Shiny app: https://frantoto.shinyapps.io/Thoral2022_SpectralLightSeabed_Macroalgae/

Thank you!

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