

The role of bio-optical traits for phytoplankton biogeography

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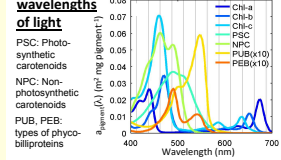


1. Motivation

Phytoplankton community structure results from competition and selection between species with different characteristics, or traits. For example, they contain species-specific combinations of pigments that absorb different wavelengths of light. The efficiency of light absorption is important for phytoplankton growth rates at low light. However, the exact role of pigments for setting phytoplankton biogeography on global scales remains unclear.

...we assess the importance of pigments for driving phytoplankton distributions in the ocean

Fig1. Pigments absorb different wavelengths

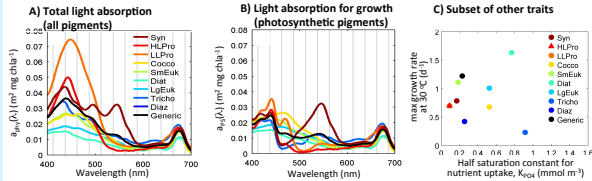


2. The model

Phytoplankton with realistic (species-specific) pigments are resolved in a global biogeochemical and ecosystem model (Dutkiewicz et al. 2015):

- 1° resolution, 23 levels, ECCO-GODAE (Wunsch & Heimbach 2007)
- Radiative transfer in 25nm wavebands between 400-700nm (Gregg & Casey 2009)
- Absorption and/or scattering by water, CDOM-tracer, detritus and 9 phytoplankton types (Fig1, Fig2) (Dutkiewicz et al. 2015, Hickman et al. 2010)
- Phytoplankton have unique growth dependencies (e.g. on N, P, Si, Fe), growth and grazing rates (Ward et al 2012). LLPro are susceptible to photoinhibition, Diatoms have high max Chl-a:C. Each phytoplankton is assigned realistic pigments and light absorption spectra.

Fig2: Phytoplankton traits



...the model resolves absorption and /or scattering by water, CDOM, detritus and 9 phytoplankton types

3. Pigment distributions

Model fields including phytoplankton pigment concentrations and community structure compare well to observations made along an Atlantic meridional transect and globally.

Fig 3. Primary production

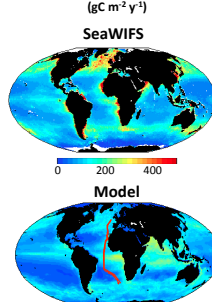
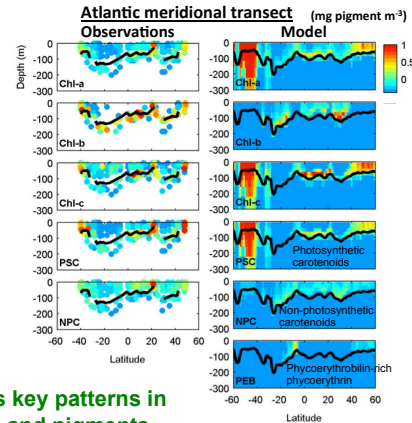


Fig 4. Pigment concentrations along



...the model captures key patterns in community structure and pigments

4. Role of bio-optical traits

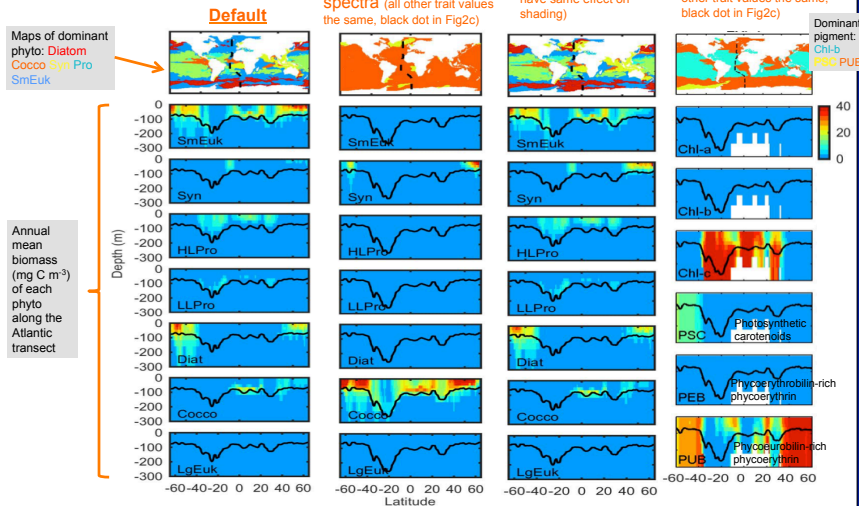
All growth dependencies the same as default, except...

We used a suite of experiments to explore how the pigments help set the biogeography

Expt1: ...the only difference between phyto is their absorption spectra (all other trait values the same, black dot in Fig2c)

Expt2: ...all phyto have same light attenuation (i.e. have same effect on shading)

Expt3: ...six phyto each absorb with only one pigment (all other trait values the same, black dot in Fig2c)



Expt 1:

- Light absorption at blue-green wavelengths give Syn an advantage in high biomass regions with shallow mixed layers
- Light absorption at blue wavelengths give Cocco is an advantage in intermediate biomass regions with deep mixed layers

Expt 2:

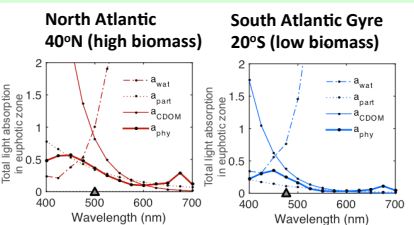
- Species-specific shading of particular wavelengths has a small, though regional, impact on biogeography

Expt 3:

- The ubiquitous pigment Chl-a is not well suited to ocean light spectrum
- Accessory pigments provide complimentary advantages in different regions of the ocean

5. Conclusions

- Pigments are important for biogeography but can act either in concert with or antagonistically to other traits
- Self shading by particular pigments is less important for distributions than efficient absorption of available light.
- The light spectrum is principally set by the total concentrations of phytoplankton, CDOM and non-algal particles
- The common pigments are not very well suited to the bluest light at depth in the oligotrophic gyres



References:

Dutkiewicz et al. 2015 Biogeosciences; Gregg and Casey 2009 J Mar Syst; Hickman et al. 2010 Mar Ecol Prog Ser; Ward et al. 2012 Limnol Oceanogr; Wunsch & Heimbach 2007 Physica D.