AGU PUBLICATIONS

[Journal of Geophysical Research: Oceans]

Supporting Information for

[Influence of the phytoplankton community structure on the spring and annual primary production in the North-Western Mediterranean Sea]

[Nicolas Mayot[1], Fabrizio D'Ortenzio[1], Julia Uitz[1], Bernard Gentili[1], Joséphine Ras[1], Vincenzo Vellucci[1], Melek Golbol[1], David Antoine[1,2] and Hervé Claustre[1]]

[[1]Sorbonne Universités, UPMC Univ Paris 06, INSU-CNRS, Laboratoire d'Océanographie de Villefranche (LOV), 181 Chemin du Lazaret, 06230 Villefranche-sur-mer, France.

[2]Remote Sensing and Satellite Research Group, Department of Physics and Astronomy, Curtin University, Perth, Western Australia 6845, Australia.]

Contents of this file

This supporting information document contains the description of the bio-optical primary production model used in this study, and two supplementary figures.

To estimate the phytoplankton carbon production, the bio-optical model of primary production of *Morel* [1991] is used. This model assesses primary production (P) integrated between the surface and the depth of the productive layer (D, 1.5 Z_{eu}), over the duration of the day (L) and within the spectral limits of the photosynthetic domain (λ_1-λ_2, 400 and 700 nm) following Eq. (1):

$$P = 12 \int_{0}^{D} \int_{0}^{L} \int_{\lambda 1}^{\lambda 2} E(z,t,\lambda)\, [Chl-a](z,t)\, a^{*}(z,t,\lambda)\, \phi_c(z,t,\lambda)\; dz\, dt\, d\lambda \qquad (1)$$

with E (mol quanta m^{-2} s^{-1}) the irradiance at a depth z, time t and wavelength λ, [Chl-a] (g m^{-3}) the in-situ measured chlorophyll-*a* concentration, a^* (m^{-2} $[gChl]^{-1}$) the chlorophyll-specific absorption coefficient of phytoplankton, ϕ_c (molC $[mol\ quanta]^{-1}$) the quantum yield of carbon fixation, and 12 a factor to convert moles of carbon into grams of carbon. Here the temporal dependency of [Chl-a], a^* and ϕ_c is not taken into account so these variables are considered constant over the entire day. The irradiance E is expressed as Photosynthetically Available Radiation (PAR, mol quanta m^{-2} d^{-1}) and a daily average value at the ocean surface retrieved from satellite is used and propagated along the water column using a spectral attenuation coefficient of downwelling irradiance derived from the measured [Chl-a] profile as in [*Morel*, 1988].

By convention the photosynthesis rate (P) is normalized with respect to the phytoplankton biomass, P^B (here the [Chl-a] is used as a proxy of the biomass). Then, for a day and at a certain depth (z) the primary production can be obtained as

$$P(z) = [\mathrm{Chl-a}](z) \times P^B(z) \qquad (2a)$$

$$P^B(z) = 12 \int_{\lambda 1}^{\lambda 2} \mathrm{PAR}(z,\lambda)\ a^*(z,\lambda)\ \phi_c(z,\lambda)\ d\lambda \qquad (2b)$$

The spectral coefficient $a^*(\lambda)$ can be described using two parameters: its maximal value (a^*_{max}) and its spectral shape calculated as $a^*(\lambda)$ normalized to a^*_{max} ($A^*(\lambda)$). This allows to use the Photosynthetically Usable Radiation (PUR), rather than the PAR, defined as

$$\mathrm{PUR}(z) = (a^*_{max}(z))^{-1} \int_{\lambda 1}^{\lambda 2} \mathrm{PAR}\,(z,\lambda)\ a^*(z,\lambda) d\lambda = \int_{\lambda 1}^{\lambda 2} \mathrm{PAR}\,(z,t,\lambda)\ A^*(z,\lambda) d\lambda \qquad (3)$$

Therefore, from Eq. (3), P^B can be expressed as

$$P^B(z) = 12\ \mathrm{PUR}(z)\ a^*_{max}(z) \int_{\lambda 1}^{\lambda 2} \phi_c(z,\lambda)\ d\lambda \qquad (5)$$

The action spectrum of photosynthesis is also considered similar to the absorption spectrum [*Lewis et al.*, 1985]. Hence the wavelength dependency of ϕ_c is ignored, and its value is considered proportional to the amount of light usable by the phytoplankton (i.e. PUR). The ϕ_c is then determined according to its maximal value (ϕ_{cmax}) and a function f(x) defined in the interval [1; 0], $\phi_c = \phi_{cmax}$ f(x). This function should depend on the total usable radiation PUR and allows carbon fixation to reach a maximum as the light level x tends to 0, and to decrease towards 0 as x tends to infinity. The formulation of [*Platt et al.*, 1980] is selected, with x representing light in a dimensionless unit (i.e. normalized PUR)

$$x = \frac{\mathrm{PUR}}{\mathrm{KPUR}} \qquad (6a)$$

$$f(x) = x^{-1}(1 - e^{-x})e^{-\beta x} \qquad (6b)$$

with KPUR (mol quanta m^{-2} s^{-1}) the light level at which the light-saturated production regime starts, derived from the photosynthesis versus irradiance curve (the so-called "P^B vs I" curve, **Fig. S1**), and β (gC $[gChl]^{-1}$ h^{-1} [mol quanta m^{-2} $s^{-1}]^{-1}$) a parameter describing the process of photoinhibition. Now, P^B can be expressed as

$$P^B(z) = 12\ a^*_{max}(z)\ \phi_{cmax}\ \mathrm{KPUR}\ [x.f(x)] = \mathrm{KPUR}\ \alpha^B\ [x.f(x)] \qquad (7)$$

with [x.f(x)] representing the normalized "P^B vs I" curve (**Fig. S1**) and α^B (g C [g Chl-a]$^{-1}$ h^{-1} [mol quanta m^{-2} $s^{-1}]^{-1}$) the initial slope of this normalized "P^B vs I" curve. One of the key parameters of this curve is the maximum rate of carbon fixation (P^B_{max}),

$$P^B_{max} = \mathrm{KPUR}\ a^*_{max}\ 12\ \phi_{cmax}\ [x.f(x)]_{max} \qquad (8)$$

with $[x.f(x)]_{max} = \beta^{\beta}(1+\beta)^{(-1+\beta)}$ for x = log((1+β)/β).

Here the Morel's model is applied at the level of phytoplankton groups using the group-specific photophysiological parameters proposed by *Uitz et al.* [2008].

Figures

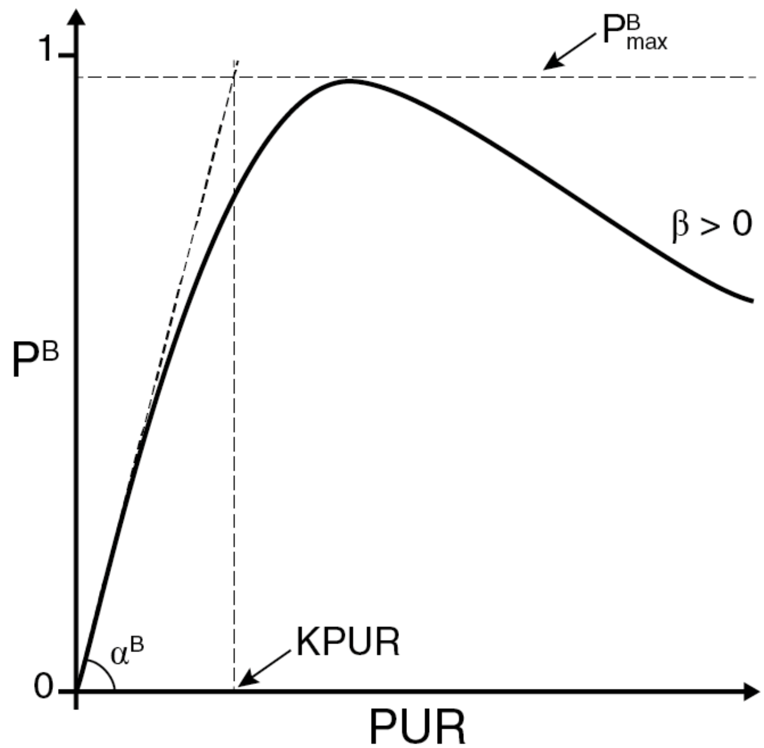

Figure S1. Idealized curve of the normalized photosynthetic rate versus the irradiance available ("P vs I" curve). The photosynthetic rate is normalized by the phytoplankton biomass (P^B) and the irradiance is represented as PUR (instead of PAR). KPUR, represents the light level at which the light-saturated regime starts. The parameter β allow the parametrization of the photoinhibition.

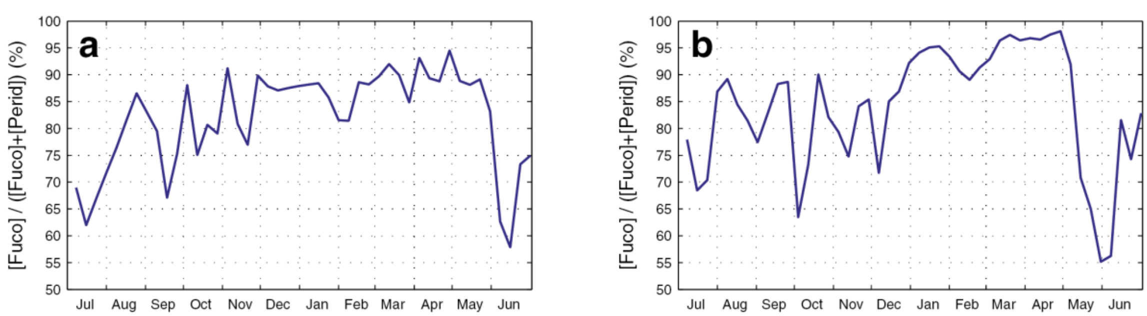

Figure S2. Climatological annual cycle of the [Fuco/(Fuco + Perid)] × 100 pigment ratio, for the two studied trophic regimes: "Bloom" (a) and "High Bloom" (b).